CHROMIUM

By John F. Papp

In the United States, chromium apparent consumption was about 480,000 tons of contained chromium. Supply consisted of recycled and imported chromium materials—about 579,000 tons, gross weight, of stainless steel scrap was recycled, and about 753,000 tons of chromite ore and chromium ferroalloys, chemicals, and pigments valued at about $463 million was imported. The United States exported about 136,000 tons of chromium materials valued at about $111 million. Compared with those of 1995, the quantity and value of chromium materials imports decreased while exports increased.

The reported consumption of chromite ore by the chemical, metallurgical, and refractory industries decreased; consequently imports also decreased. Reported consumption of chromium ferroalloys decreased, as did imports.

Chromium has a wide range of uses in metals, chemicals, and refractories. Its use in iron, steel, and nonferrous alloys enhances hardenability and resistance to corrosion and oxidation; the production of stainless steel and nonferrous alloys are two of its more important applications. Other applications are in alloy steel, plating of metals, pigments, leather processing, catalysts, and surface treatments.

Because the United States has no chromite ore reserves and a small reserve base, domestic supply has been a concern during every national military emergency since World War I. World chromite resources, mining capacity, and ferrochromium production capacity are concentrated in the Eastern Hemisphere. In recognition of the vulnerability of long supply routes during a military emergency, the National Defense Stockpile (NDS) contains chromium in various forms, including chromite ore, chromium ferroalloys, and chromium metal. As a result of improved national security, stockpile goals have been reduced, and inventory is being sold. Recycling is the only domestic supply source of chromium.

The U.S. Geological Survey (USGS) has conducted mineral-resource-surveys of the United States to assess the potential for occurrences of chromium and other mineral resources. Alternative materials research is conducted by the National Aeronautics and Space Administration, the National Institute of Standards and Technology, the U. S. Department of Defense, and the U. S. Department of Energy.

Chromium is an essential trace element for human health. Some chromium compounds, however, are acutely toxic, chronically toxic, and/or carcinogenic. Chromium releases into the environment are regulated by the U. S. Environmental Protection Agency (EPA). Workplace exposure is regulated by the Occupational Safety and Health Administration.

World chromite ore reserves are more than adequate to meet anticipated world demand.

Legislation and Government Programs

The Defense Logistics Agency (DLA) disposed of chromium materials under its fiscal year 1996 (October 1, 1995, through September 30, 1996) Annual Materials Plan (AMP). DLA's fiscal year 1996 AMP (as revised in April) set maximum disposal goals for chromium materials at 90,700 metric tons of chemical-grade chromite ore, 499,000 tons of metallurgical-grade chromite ore, 90,700 tons of refractory-grade chromite ore, and 22,700 tons of chromium ferroalloys. DLA's fiscal year 1997 calls for the disposal of 90,700 tons of chemical-grade chromite ore, 227,000 tons of metallurgical-grade chromite ore, 90,700 tons of refractory-grade chromite ore, and 22,700 tons of chromium ferroalloy. At the end of 1996, the NDS contained 2.2 million tons of chromium material comprising 1.2 million tons of chromite ore, 1.1 million tons of chromium ferroalloys, and 7,700 tons of chromium metal. *(See table 8.)*

EPA reported chromium releases and transfers from manufacturing and fabrication facilities. *(See table 2.)*

Production

The major marketplace chromium materials are chromite ore and chromium ferroalloys, metal, and chemicals. The United States produced chromium ferroalloys, metal, and chemicals, but no chromite ore.

Domestic data for chromium materials are developed by the USGS by means of two separate surveys—"Chromite Ores and Chromium Products" (consumers, monthly) and "Ferroalloys" (producers, annual). Production by the metallurgical companies listed in table 3 represented 100% of the domestic production shown in the current year of table 4.

Chrome Corporation of America planned to develop ferrochromium production facilities in Canada and then to develop stainless steel production capacity there. The company also planned to purchase a 6-megawatt direct-current furnace (Metal Bulletin, 1996).

Macalloy Corp. started a new, $3.5 million briquetting facility. This facility will permit Macalloy to use lower cost chromite ore fines and to increase ferrochromium production capacity from 55,000 to 60,000 tons per year (Ryan's Notes, 1996a, 1996b).

American Chrome & Chemicals Inc. started up a new sodium dichromate production process. Traditionally, sodium dichromate is produced from sodium chromate by acidification. American Chrome's new process will make the conversion electrolytically. The electrolytic process is cleaner and increases

American Chrome's production capacity from 50,000 to a range of 55,000 to 60,000 tons (Chemical Marketing Reporter, 1996).

The man who established the first chromite mines in the United States and started the first U.S. chromium chemicals plant, the Baltimore Chrome Works, in Baltimore, MD, in 1845, Isaac Tyson, Jr. (1792-1861), was inducted into the National Mining Hall of Fame and Museum in Leadville, CO. He studied geology, mineralogy, and chemistry n France, where chromium had been discovered in 1797. Some of Tyson's mines are preserved in the Soldiers Delight environmental area northwest of Baltimore.

Consumption

Domestic consumption of chromite ore and concentrate was 282,000 tons. Chromium has a wide range of uses in the three primary consumer groups—the metallurgical, refractory, and chemical industries.

In the metallurgical industry, its principal use was in stainless steel. Of the 333,000 tons of chromium ferroalloys, metal, and other chromium-containing materials reported as being consumed, stainless steel accounted for 72.9%; full-alloy steel, 9.31%; carbon steel, 4.15%; high-strength, low-alloy, and electric, 3.44%; tool steel, 1.52%; cast iron, 1.00%; superalloys, 3.24%; and other end uses, 4.43%. The primary use of chromium in the refractory industry was in the form of chromite to make refractory bricks to line metallurgical furnaces.

The chemical industry consumed chromite for manufacturing sodium dichromate, chromic acid, and other chromium chemicals and pigments. A wide range of chromium chemicals are made sodium dichromate. (*See tables 5 and 6.)*

Stocks

Domestic consumer stocks of chromite ore at consumers' plants reported by consumers to the USGS was 173,000 tons. At the 1996 rate of annual chromite ore consumption, these stocks represented 7.4 months of supply. Producer and consumer stocks of chromium ferroalloys, metal, and other chromium materials were 6,450 and 27,600 tons, respectively. At the 1996 rate of annual chromium ferroalloy, metal, and other chromium material consumption, producer plus consumer stocks represented 1.2 months of supply. In addition to privately held stocks, the government maintained the NDS. *(See tables 4, through 8.)*

Prices

Chromium materials are not openly traded. Purchase contracts are confidential information between buyer and seller. Trade journals, however, report composite prices that are based on interviews with buyers and sellers, and importers declare the value of the materials they trade. Thus, industry publications and U.S. import data are sources of chromium material prices and values, respectively. *(See tables 1, 9, and 10 and figures 1 and 2.)*

Foreign Trade

Chromium material exports from and imports to the United States included chromite ore and chromium chemicals, ferroalloys, metal, and pigments. *(See tables 11 through 14.)* The amount of foreign trade of these chromium materials, measured in dollars, was$111 million for exports and $463 million for imports.

World Review

The major world producers of chromite ore are India, Kazakstan, South Africa, and Turkey. Also significant but smaller are Brazil, Finland, and Zimbabwe. Most chromite ore is smelted in an electric arc furnace to produce ferrochromium for use by the metallurgical industry. Stainless steel manufacture is the major end use of ferrochromium. A small amount of chromite is kiln roasted to produce sodium bichromate, a chemical industry product. A very small amount of chromite ore is used, without chemical modification, as a refractory material. The major producer of ferrochromium is South Africa. China, Finland, India, Japan, Kazakstan, and Zimbabwe are smaller but significant producers. The major producers of stainless steel—Europe (especially Western Europe and Scandinavia), Japan, and the United States—account for about 70% of world production. The major world producers of chromium chemicals are Kazakstan, Russia, the United Kingdom, and the United States. *(See tables 17 through 21.)*

The ferrochromium industry developed in close proximity to the stainless steel industry and later moved to chromite-producing areas. The chromium industry operated with supply capacity in excess of demand. The last time demand exceeded supply was in 1989-90 when ferrochromium demand exceeded supply, causing prices to increase appreciably. The industry used its profits from the price increase in 1989-90 to expand capacity by about 15% in 1991-92. Capacity expansions took place primarily in chromite-producing countries; South Africa was the major benefactor. With a growth rate in the consumption of stainless steel of about 3% per year, it would take an estimated 5 years of average growth in the demand for stainless steel to bring ferrochromium supply and stainless steel demand back into equilibrium. The dissolution of the former Soviet Union (FSU) in 1991 and subsequent reorganization resulted in declining chromium demand in the FSU but no loss of chromium-material production capacity. As a result, significant quantities of chromium raw materials, including chromite ore, ferrochromium, chromium chemicals, and chromium-containing scrap, entered Western markets from the FSU. The integration of the former Eastern Block with the West exacerbated the already excess production capacity in the West. During this same time period, China began to use its ferroalloy production capacity for ferrochromium production.

In 1992 and 1993, significant rationalizations took place in western chromite mining and ferrochromium industries. Not all added capacity from 1991-92 could be brought into production

or, if brought into production, could be fully utilized. The South African chromite ore and ferrochromium industries operated at between 50% and 60% of design capacity to reduce supply in excess of world demand. Several ferrochromium producers either idled their furnaces or converted them to ferromanganese production. The ferrochromium industry in Japan continued to be rationalized.

As 1994 drew to a close, the chromium material supply from Kazakstan and Russia diminished. Western stainless steel demand for chromium materials strengthened appreciably. Chromium demand moved closer to balance with supply, and ferrochromium prices started to recover. Companies planned to restart their furnaces, thereby increasing ferrochromium production. Even before all existing ferrochromium production capacity could be brought back into production, some new furnaces were planned in South Africa, and chromium recovery from slag processes were planned or implemented.

Further vertical integration of the chromium industry is taking place as Finland and South Africa increase their stainless steel production capacities. Two industry processes that improve chromium recovery efficiency were evolving—chromium recovery from slag in the ferrochromium industry and supply of molten ferrochromium to stainless steel industry.

In 1995, demand for chromium resulting from strong growth in the production of stainless steel that started in 1994 resulted in the strengthening of chromite ore and ferrochromium prices. Ferrochromium production capacity was increased in South Africa through the renovation of idle equipment and the startup of new furnaces. Construction of more capacity was started. Chromite mine capacity was increased or planned to meet demand from current and future ferrochromium consumers. Vertical integration of the chromium industries of Finland and South Africa were implemented, resulting in increased stainless steel production capacity, especially in South Africa. By yearend, world demand for stainless steel decreased as did ferrochromium prices.

In 1996, new furnaces were brought into production in South Africa and new ferrochromium recovery from slag processes were brought into production in South Africa and Zimbabwe. Southern African ferrochromium producers continued to enter into joint ventures with Asian stainless-steel-producing companies. After two years of double digit annual growth in the production of stainless steel, 1996 saw a decline in production. Chromite ore and high-carbon ferrochromium prices trended downward during the year. Low-carbon ferrochromium prices peaked about midyear and ended lower than they began.

Industry Structure.—The chromium industry comprised primarily producers of chromite ore, ferrochromium, and stainless steel as well as chromium chemical and chromite refractory. Finland, India, and Republic of South Africa are countries that have a fully vertically integrated chromium industry. These countries mine chromite ore, produce ferrochromium and stainless steel under a single ownership structure. Brazil, China, Japan, Kazakstan, Russia, Turkey, and Zimbabwe are countries that have partially integrated chromium industries. These countries either mine chromite ore and produce ferrochromium or produce ferrochromium and stainless steel under a single ownership structure.

In Finland, Outokumpu Oy, a major share of which is state-owned, owns and operates the only chromite mining, ferrochromium production, and stainless steel production facilities, making it completely vertically integrated. In India, chromite mining and ferrochromium production are mostly vertically integrated. Ferro Alloys Corp. is the only stainless steel producer in India that is fully vertically integrated from chromite ore mining through ferrochromium and stainless steel production. The chromium industry is comprised large and small producers; about 20 chromite mines produced ore. Major ferrochromium plants are licenced, and small plants, of which there are many, are independent. There are many small chromium chemical plants in India. In the Republic of South Africa, chromium-related companies are privately owned. Typically, major shares of a company are owned by other companies, and the remainder, if any, is openly traded. Samancor Ltd. owns and operates chromite mining and ferrochromium production and co-owns major stainless steel production facilities. Other chromite operations in South Africa are also vertically integrated. For example, Bayer AG (Germany) owns a chromite mine and is constructing a chromium chemical plant to produce chemicals from ore. Most ferrochromium producers own chromite mines or are owned by an entity that also owns such mines.

In Brazil, the mining and smelting of chromium is vertically integrated, but stainless steel production is independent of the mining-smelting operations. The major mining companies are subsidiaries of Cia. de Ferro-Ligas da Bahia S.A. Stainless steel is produced primarily by Companhia Acos Especiais Itabira. Other chromite operations in Brazil are also vertically integrated. For example, Bayer AG (Germany) owns a chromite mine and chromium chemical plant. Refractory chromite operations are also vertically integrated from chromite production through refractory material production. In China, the chromium industry is concentrated on ferrochromium production from imported ore. Only minor amounts of chromite ore and stainless steel are produced. A few major plants, as well as many small plants, produce ferrochromium or chromium chemicals. In Japan, chromite ore production is minor and primarily for use by the refractory industry. Ferrochromium production is significant but declining, while stainless steel production is significant. Some ferrochromium producers are associated with stainless steel plants by location, ownership, or both. Russia produces large quantities of ferrochromium and chromium metal and moderate quantities of chromite ore. In Kazakstan, chromite ore mining and ferrochromium production are vertically integrated. Russia produces large quantities of ferrochromium and chromium metal and moderate quantities of chromite ore. In Turkey, the chromium industry comprises large and small chromite ore producers, with one major producer, Etibank, integrated from mining through ferrochromium production. The chromium industry of Zimbabwe comprises large companies vertically integrated from chromite mine production through ferrochromium production, small

independent chromite mines, and chromite mines operated independently on behalf of the large vertically integrated companies.

Capacity.—Rated capacity is defined as the maximum quantity of product that can be produced in a period of time at a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving labor, energy, materials, and maintenance. Capacity includes plants that are operating and those that are temporarily closed, which, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Because not all countries or producers make production capacity information available, historical chromium trade data have been used to estimate production capacity. Variations in rated production capacity result from changes in facilities or in knowledge about facilities. Capacities have been rated for the chromite ore, ferrochromium, chromium chemical, and chromium metal industries. *(See table 18.)*

Reserves.—The United States has no chromite ore reserves. The United States, however, has a reserve base and resources that could be exploited. Domestic and foreign reserve estimates are reported by the USGS in other publications.

Production.—World chromite ore production was estimated to be about 12.2 million tons, a 15% reduction from that of 1995. World ferrochromium production was estimated to be about 4.06 million tons, an 8.9% reduction from that of 1995. *(See tables 16 and 17.)*

Albania.—A joint venture between Albania and Japan in 1995 resulted in the identification of chromite ore reserves in the Shebinik area. The project identified chromite ore deposits containing 3 million to 5 million tons of ore. Albania continued negotiations for a joint venture with foreign investors to develop its chromium industry. Albania and Preussag Stahl AG (Germany) negotiated a joint venture wherein Preussag would invest in Albania's chromite ore mining and ferrochromium-producing industries. The Federation of Miners, Geologists and Energy Workers and the Syndicate of Miners objected to privatizing the chromite mines. Negotiations will continue in 1997.

Australia.—Dragon Mining NL studied the feasibility of mining and processing chromiferous laterite resources at Range Well. The project involved the mining of 40,000 tons per year of ore from a 31-million-ton resource to produce 20,000 tons per year of 12% chrome-iron grinding media. Valiant Consolidated Limited formed a joint venture with Danelagh Resources Pty. Ltd. to mine chromite from the Coobina Deposit on a trial basis. Danelagh has smelted ore satisfactorily in China.

Brazil.—Cia. Ferroligas do Amapa reported expanding its chromite ore beneficiation plant capacity from 150,000 to 200,000 tons per year. Ferroligas also reported closing its smelter, which has been producing ferromanganese.

Canada.—Coleraine Mining Resources discontinued development of its chromite properties in the Thetford Mines area of Quebec Province. Coleraine had planned to produce chromite ore of 48% Cr_2O_3 at the rate of 20,000 tons per year from the Hall and the Montreal deposits, but the results of a feasibility study indicated that current reserves were inadequate for a profitable venture.

China.—China reported imports of chromite ore 769,147 tons, mostly from India, Iran, South Africa, and Turkey and record exports of ferrochromium at 122,115 tons, mostly to Japan, the Netherlands, and the Republic of Korea. China reported trade statistics for 1995 as follows: chromite ore imports of 1.38 million tons and exports, 3,975 tons; ferrochromium imports of 880 tons; exports, 320,950 tons; and chromium metal imports of 449 tons and exports, 10,577 tons. On the basis of these trade data and chromite ore production of 70,000 tons, China's chromium apparent consumption in 1995 was 240,000 tons of contained chromium.

Croatia.—Dalmacija Ferroalloy works reported shutting down in May.

Finland.—**Chromite Ore.—**Outokumpu Chrome Oy's (Outokumpu) Kemi Mine produces about 500,000 tons of chromite products (including metallurgical and foundry grade material) from about 1 million tons of run-of-mine ore extracted from surface operations. Kemi's proven and probable reserves were reported to have been 70.4 million tons graded at 26% chromic oxide. Outokumpu operated two (Elijarvi and Nuottijarvi) of three pits and planned to extend mining to underground.

Ferrochromium.—Outokumpu produces ferrochromium by a process optimized for the Kemi ore and subsequent stainless steel production. Chromite concentrate from Kemi is ground and pelletized with coke and bentonite in 10- to 15-millimeter-diameter pellets. The pellets are preheated and sintered by using carbon monoxide gas from the smelting process as a fuel. The hot-charged, sintered-pellet process permits Outokumpu greater chromium recovery and ferrochromium-production capacity, reduced energy consumption, and smoother arc furnace operation.

Stainless Steel.—Outokumpu Polarit, the stainless-steel-producing division of Outokumpu Oy, takes liquid and crushed ferrochromium from the Outokumpu Chrome Oy ferroalloy plant. A chrome converter furnace is used to combine liquid ferrochromium with stainless steel scrap before feeding the material to an argon-oxygen converter. Outokumpu Steel Oy increased its stainless steel slab production capacity to 540,000 tons and planned to increase its stainless steel slab production capacity to 1.2 million tons over a 10-year period.

France.—Delachaux invested more than 40 million francs in a new chromium metal factory at Valenciennes. In 1993, Delachaux moved its chromium metal production from Gennevilliers to Pau but, this year started renovation of a factory site in Valenciennes to house its chromium metal division. The Valenciennes plant was scheduled to start production in 1997. Delachaux planned to operate three vacuum degassing furnaces with a collective annual production capacity of about 4,500 tons per year. Market demand permitting, increased production

could range from 6,000 to 7,000 tons per year.

Germany.—Bayer AG planned a joint venture with Sentrachem (South Africa) to produce sodium dichromate at Sentrachem's Karbochem plant, Newcastle, KwaZulu-Natal. The plan was for the South African plant to start up when the Leverkusen plant in Germany closes. (See South Africa section.) The new plant was planned to have a production capacity of 70,000 tons per year of sodium dichromate and 11,000 tons per year of chromic acid. South African chromite ore has been used for sodium dichromate production since before 1900. A major chromium chemicals plant has, however, never been built in South Africa because sodium dichromate production requires soda ash, which was not readily available in South Africa before 1991. Since 1900, the sodium dichromate production industry has been characterized by consolidation of suppliers and concentration of production capacity because chromium chemical demand has shown slow growth. As a result, opportunities to install new sodium dichromate production capacity have been few. Consequently, with the closing of Bayer's Leverkusen plant, an opportunity has arisen. In addition, soda ash is now available from Botswana Soda Ash (Botswana), and the Karbochem plant has underutilized industrial infrastructure. Also, Bayer mines chromite ore in South Africa and produces chromium chemicals from sodium dichromate. The new plant at Newcastle was estimated to have cost 150 million rands and will use an improved production process. Chemical production cost was estimated to be divided nearly equally among the costs of chromite ore, soda ash, energy, and other. The Newcastle plant will use less than the international average of 1.5 units of soda ash per unit of chromite ore by roasting ore in an oxygen-rich atmosphere and recycling sodium units. The Newcastle process also uses carbon dioxide instead of sulfuric acid, thereby improving reaction yield of sodium dichromate. Because carbon dioxide will be used, sodium sulfate will not be a byproduct, and caustic soda will be generated as a byproduct of chromic acid production by electrolysis of sodium dichromate. Process gasses were to be used, thus improving energy efficiency. Residual hexavalent chromium was to be converted to trivalent chromium.

India.—India resolved a dispute over access to chromite ore reserves in Orissa State. Tata Iron and Steel Co. Ltd. sought to renew its chromite ore mining lease covering 1,261 hectares of land in Sukinda Valley in 1992 after holding that lease for 20 years. The High Court of Orissa State awarded 406 hectares to Tata and ruled that the remaining 855 hectares were to be divided among Ferro Alloys Corp. Ltd., Jindal Ferro Alloys Ltd., Indian Metals & Ferroalloys, and Ispat Alloys Ltd. Tata was expected to continue to produce at the annual rate of 750,000 tons of chromite ore and 150,00 tons of chromite concentrate.

India imposed antidumping duties on low-carbon ferrochromium from Russia and Kazakstan. Average annual production of low-carbon ferrochromium by Ferro Alloys Corp. Ltd. and Industrial Development Corp. dropped from about 12,000 tons in 1993 to about 4,500 tons 1995 as import duties fell from 80% to 40% then to 30%. The tariff on Kazakstani material was set at 18,500 Rupees; Russian material, from 10,900 to 18,600 Rupees.

Power rates continue to rise in Madhya Pradesh, Andhra Pradesh, Karnataka, Maharashtra, and Orissa States. National Thermal Power Corp. supplied power at rates lower than those of the national grid.

Ferrochromium.—Indian Charge Chrome Ltd. closed its Choudwar, Orissa, ferrochromium and electrical powerplants after sustaining about $2.79 million worth of damage resulting from a worker-management disagreement over wages and tenure issues.

Ispat Alloys Ltd. operated four furnaces (two rated at 15 megavolt-amperes and two at 7.5 megavolt-amperes), two of which were used to produce high-carbon ferrochromium at a rate of about 36,000 tons per year. Ispat's plant is located at Balgopalpur, Balasore, Orissa. It is adjacent to National Highway 6 and connected to the railway. Ispat obtains chromite ore from Orissa Mining Corp. Ltd. and Mysore Mineral Ltd., which are in Sukinda Valley about 160 kilometers from the plant. Ispat exports through Paradip or Calcutta, which are about 250 kilometers from the plant.

Jindal Ferro Alloy Ltd. operated ferrochromium plants at Vizag and Raigad, Madhya Pradesh, with a production capacity of 30,000 tons per year each. The Vizag plant was producing at a rate of 20,000 tons per year, whereas the Raigad plant closed. Both plants were expected to operate at higher capacities when a new stainless steel expansion begins production. Jindal expected to produce chromite ore in Orissa once legal barriers to its getting a lease are cleared.

Stainless Steel.—India's stainless steel production was estimated to be more than 500,000 tons. Jindal planned to increase capacity at its Hissar, Haryana, plant to about 200,000 tons. Upon completion of this project, India's annual stainless steel production capacity will be about 1 million tons. Sail's Alloy Steel Plant at Dugapur, West Bengal, planned to increase its stainless steel production capacity to about 105,000 tons per year in 2000, and Salem Steel Plant was studying the feasibility of introducing stainless steel production.

Indonesia.—Krakatau Steel and Krupp Thyssen Nirosta planned a joint venture to produce stainless steel at Krakatau's plant by adding an argon-oxygen decarburization converter. Krakatau planned to expand its stainless steel production capacity to 50,000 tons per year by the end of 1997 and ultimately to 250,000 tons per year.

Iran.—Iran produced chromite ore from three mines (Faryab, Esfandagheh, and Foroumad) and ferrochromium from one smelter at Roudan.

Japan.—Japan imported 686,451 tons of chromite ore, 718,567 tons of ferrochromium, 1,916 tons of chromium metal, and 165,153 tons of stainless steel scrap. Domestically, the ferroalloy industry produced 211,053 tons of ferrochromium, a decrease of 11% compared with that of 1995. (Between 1980 and 1996, the ferrochromium production has ranged from about 211,000 to 360,000 tons per year with the lower limit set in 1996.) Hot rolled stainless steel production was reported to be 3.23 million tons a decrease less than 1% compared with that of

1995. Ferrochromium imports represented 77% of market share. Japan exported 1,191 tons of ferrochromium and 1.15 million tons of stainless steel, representing 36% of production. Japan's ferrochromium industry loss of market share in 1996 is consistent with the world trend to rationalize ferrochromium production in countries that consume ferrochromium in favor of expansions in countries that produce chromite ore. On the basis of chromite ore, ferrochromium, and chromium metal trade, chromium apparent consumption in Japan was 602,408 tons contained chromium. At yearend, ferrochromium stocks at steel plants totaled 157,642 tons—149,642 tons of high-carbon (2.27 months of supply) and 7,502 tons of low-carbon ferrochromium (1.87 months of supply).

Ferrochromium.—Japan continued to buy into foreign ferrochromium operations as it rationalized its domestic ferrochromium industry. In 1993, Tubatse Ferrochrome Division (Samancor Ltd., South Africa) and Nippon Denko Co. Ltd. formed NST Ferrochrome to produce high-carbon ferrochromium. In 1995, two new joint ventures were formed between Japanese and South African companies for the production of ferrochromium in South Africa. Mitsui and Co. bought a share of Lydenburg ferrochromium plant [Consolidated Metallurgical Industries Ltd. (CMI), South Africa] to get a share of its high-carbon ferrochromium production. Mitsui carried out its acquisition via its newly formed wholly owned subsidiary in South Africa, Mitsui Minerals Development of South Africa Pty. Ltd. Mitsui chose this method instead of a joint venture, possibly positioning itself for further investments in the South African minerals industry. Showa Denko K. K. and Marubeni Corp. formed Technochrome, a joint venture with Middelburg Ferrochrome Pty. Ltd. (Samancor Ltd., South Africa), to produce low-carbon ferrochromium in South Africa. In addition to investments in South Africa, Japan invested in Zimbabwe. Japan Metals and Chemicals (JMC) and Mitsui and Company established a joint venture with Zimbabwe Alloys Ltd. to use an idle furnace for the production of low-carbon ferrochromium in Zimbabwe. Low-carbon ferrochromium production in Zimbabwe was expected eventually to displace JMC's low-carbon ferrochromium production at its Oguni plant. (See Zimbabwe section.)

JMC restricted electric furnace operation to take advantage of the lower electrical energy cost during low-demand time periods at its Kyushu plant. As a result, annual production was expected drop from 73,000 to 40,000 tons.

Stainless Steel.—Kawasaki Steel, Chiba Steel Works, and NKK Corp., Fukuyama Works, continued to test stainless steel production by using chromite ore directly, thus displacing the necessity of getting chromium units from ferrochromium. Kawasaki acquired high-chromic oxide chromite ore from India and low-chromic oxide byproduct from platinum production in South Africa.

Kazakstan.—Japan Chrome Corp. (JCC), the management organization that took control of Kazakstan's ferrochromium industry under a 5-year contract through Kazchrome, started reorganizing the industry to improve service, reliability, and supply and to reduce cost. The industry comprises Donskoy Mine, Aktubinsk Ferroalloy Works, and Aksu Ferroalloy plant. Trans-World Group, a trading company that is the selling agent for JCC, is a major share holder of JCC and has other interests in Kazakstan. Under JCC management, crushing and sizing equipment has been introduced, product chemical specifications have been modified to meet user requirements, and a new ferrochromium furnace was installed. To stabilize electrical energy supply, JCC invested in an electrical power plant. Electrical power for Aksu is secure; Aktubinsk, however, faced reduced electrical energy supply. JCC reorganized plant product mixes to assure the low cost of production and the availability of product. Aksu was targeted for high-carbon ferrochromium production, while Aktubinsk was to produce medium- and low-carbon ferrochromium and ferrochromium-silicon. Aksu 1 works was to produce manganese ferroalloys. Aksu 2 works was to produce ferrochromium from eight electric furnaces (four rated at 16.5 megavolt-amperes and four at 21 megavolt-amperes) with production capacity of 330,000 tons per year. The No. 4 works produced ferrochromiumsilicon with a capacity of 70,000 to 80,000 tons per year.

Korea, Republic of.—The Republic of Korea reported imports of ferrochromium to have been 180,161 tons, a 9% increase over that of 1995. Pohang Iron and Steel Company installed new stainless steel production equipment, raising its production capacity to 820,000 tons per year.

Norway.—Low rainfall and the subsequent shortage of electrical energy caused Elkem A/S to purchase electrical energy on the spot market. Higher energy costs, the necessity for equipment maintenance, and weak demand caused the to closure of its furnaces at yearend.

Philippines.—Three private mines, Loreto Mining Corp., Chrominco, and Naradeco, were reported operating. Loreto mined chromite from the Kongking ore body. Loreto had reserves that range from 150,000 to 200,000 tons of 48% to 52% Cr_2O_3 lumpy ore. Adequate rainfall made hydroelectric power available. Increased electrical energy cost, however, made ferrochromium production noncompetitive at world ferrochromium prices.

Russia.—Russia reported 1995 ferrochromium trade to have been as follows: high-carbon ferrochromium exports, 166,822 tons, and imports, 11,607 tons, and low-carbon ferrochromium exports, 98,551 tons, and imports, 7,492 tons.

Chromite Ore.—B&D Industrial Group B.V. (Netherlands) (B&D) developed the Agonoziorski Chrome Mine, near Pudovski, Karelia Region. The mine's proven reserves were 85 million tons graded about 30% Cr_2O_3; reserves were estimated to be 700 million tons. The mine was to supply chromite ore to B&D's Tikhvin ferrochromium plant, about 250 kilometers away by railroad. Rights to develop a chromite deposit in the Yamal Peninsula, Yamalia, were awarded to Polar Mining & Prospecting, a local company. The deposit was thought to have reserves of 50 million tons.

Ferrochromium.—B&D, a Dutch incorporated holding company, started construction of Northeast Ferro Alloy Works, a new ferrochromium plant at Tikhvin. Northeast was owned by

B&D (68%), Transmash Heavy Machine Building Works (25%), and AOZT VAO High Speed Railroad (7%). The plant will comprise four 16.5-megavolt-ampere furnaces with combined production capacity of 170,000 tons per year. Production from two furnaces was planned to start in the second quarter of 1997, followed by the remaining two furnaces in the third quarter.

The Serovsk Ferroalloy Works and the Chelyabinsk Electrometallurgical Works were forced to reduce production, because of high electrical energy cost and lack of raw materials supply, respectively. Chelyabinsk supplemented its chromite ore supply from Kazakstan with chromite ore from Turkey and from Verkhny Ufalei Mining Combine, a local producer.

Chromium Metal.—Klyuchevsk Ferroalloy Works reported aluminothermic production ranging from about 1,800 to 2,400 tons per year. Klyuchevsk planned to produce low-carbon ferrochromium.

Slovenia.—Tovarna Dusika Ruse Metalurgija d.o.o. produced high-carbon ferrochromium with a capacity of 15,000 tons per year and low-carbon ferrochromium a with capacity in the range of 3,300 to 3,400 tons per year.

South Africa, Republic of.—The South African Minerals Bureau reported chromium industry performance for 1995. Chromite ore production was 5.086 million tons from a reserves base of 3.1 billion tons and a production capacity of 2.4 million tons distributed among 20 mines. Exports accounted for 25% of production. Ferrochromium production was 1.386 million tons, of which 37% was exported.

Chromite Ore.—Anglovaal Ltd. operated its newly opened Ntuan Mine about 40 kilometers west of Sun City in North-West Province. Run-of-mine production was 120,000 tons per year from reserves of 6.6 million tons in the LG6 seam and 2.5 million tons in the MG4 seam. Anglovaal supplies its Feralloys smelter and exports chromite ore. B&D purchased Buffelsfontein Mine from National Manganese. The mine was producing at 150,000 tons per year from reserves of 37 million tons. B&D planned to build a 140,000-ton-per-year smelter at the mine.

Consolidated Metallurgical Industries (CMI) purchased mineral rights to Thorncliffe Farm in Northern Province from Johannesburg Consolidated Investment Ltd. for 64.8 million rands. The mine had reserves of 27 million tons down to 300 meters. CMI started surface mining at Thorncliffe and planned to develop the mine by adding underground operations and upgrading beneficiation facilities. CMI planned Thorncliffe to have a chromite production capacity of 1 million tons per year by 1999 and 2 million tons per year by 2001. Thorncliffe production will displace material formerly purchased from Samancor. CMI worked on constructing a highwall in preparation for driving shafts while performing surface mining. CMI was investigating the adjacent Helena farm, which has reserves of 100 million tons.

Chrome Resources (Pty.) Ltd (Chrome Resources) opened a new mine at Wonderkop covering 1,700 hectares to feed its smelter at that location. Wonderkop Mine was designed to produce about 60,000 tons per month run-of-mine from the LG6 seam, which is about 1.4 meters thick and inclines at 12 degrees. Run-of-mine ore production is transported by conveyor to the beneficiation plant with output of from 32,000 to 36,000 tons per month of marketable product. The marketable chromite ore is 44% to 46% Cr_2O_3 with 1.5 Cr:Fe. Wonderkop uses a room-and-pillar mining method from three inclined shafts of from 380 to 450 meters in length and going to a depth of from 80 to 90 meters. The mine uses 12- by 6-meter pillars spaced 10 meters in one direction and 4 meters in the other to recover 72% of in situ material. Chrome Resources continued mining at the Waterval (30,000 tons per month run-of-mine) and Kroondal (70,000 tons per month run-of-mine) sections near Rustenburg. Chrome Resources reported production of 1.2 million tons from these sections in 1995.

Northern Province Development Corp negotiated a joint venture with East Asian Metal Investment which was to include the Dilokong Mine and a proposed ferrochromium smelter at or near the mine site.

Ferrochromium.—The South African ferrochromium industry is dynamic and innovative. Vertical integration of the chromium industry has resulted in the expansion and planned expansion of ferrochromium production in South Africa by using abundant supplies of domestic chromite ore and coal-based electrical energy. Japan continued to buy into the South African ferrochromium industry, this year joined by China and the Republic of Korea. South Africa's ferrochromium industry was expanding to meet a world demand driven by a growing stainless steel market and a local demand driven by recently installed or expanded stainless steel production facilities. Expansions and/or new plants added six furnaces comprising 239 megavolt-amperes in electrical energy capacity and 415,000 tons per year ferrochromium production capacity. These additions to South Africa's ferrochromium production capacity are about 30% of 1995 capacity. In addition to production capacity resulting from the installation of new furnaces, South Africa increased its ferrochromium production capacity through improvements in the production process; for example, briquetting furnace-feed materials and ferrochromium from slag recovery.

Feralloys, an Anglovaal subsidiary, reported production of high-carbon ferrochromium from its three 24-megavolt-ampere furnaces at Machadodorp, KwaZulu-Natal Province. Feralloys installed a ferrochromium-from-slag recovery process.

Hernic Ferrochrome (Pty.) Ltd. (Hernic) commissioned a new ferrochromium plant near Brits with two 37-megavolt-ampere furnaces of combined production capacity in the range of 130,000 to 140,000 tons per year. One furnace was built by Titaco, the other by Elkem. Hernic reported its production cost to have ranged from $0.27 to $0.32 per pound. Hernic planned a $53 million pelletizing plant, which would reduce production cost by $0.01 per pound and double production capacity. Hernic is privately owned by Wilfried Pabst, Herman Van Rooyen, ELG Haniel (Germany), and Nittetsu Shoji (Nippon Steel, Japan).

CMI operated ferrochromium plants at Rustenburg, North-West Province, and Lydenburg, Mpumlanga Province.

Rustenburg capacity was 120,000 tons. A fourth furnace was commissioned at Lydenburg increasing its production to 310,000 tons per year. Unlike the other three furnaces, the new one does not require solid-state reduction of the chromite ore feed. The new furnace had an electrical energy capacity of 39 megavolt-amperes and was planned to have a production capacity of 70,000 tons per year. CMI operated the Purity Mine near its Rustenburg smelter and the Thorncliffe Mine near its Lydenburg smelter.

At Wonderkop Mine, Chrome Resources constructed a smelter consisting of two furnaces with electrical capacity of 44 megavolt-amperes and ferrochromium production capacity of 160,000 tons per year; two more furnaces are planned in 1997. The smelter includes a pelletizing plant and can use byproduct UG2 chromite ore from nearby platinum mining operations. The smelter produces charge grade ferrochromium (52% to 55% chromium) and uses up to 18% of chromite ore feedstock in the form of UG2 seam chromite ore byproduct from platinum mining. The UG2 material is 41% Cr_2O_3 with 1.4 Cr:Fe, from which, by itself, ferrochromium of 47% to 48% chromium, a nonstandard grade, would be produced.

At Ferrometals Division, Samancor formed Poschrome under a joint-venture agreement with Postrade (a subsidiary of Posco Iron and Steel, Republic of Korea) and Samsun (Republic of Korea) to Samancor contributes 50% to the projects assets, and the others, 25% each. The joint venture was to upgrade the Ferrometals No. 6 furnace by adding pelletizing, sintering, and preheating facilities at a cost of $40 million. Under a joint-venture agreement with NSA Metals in which Samancor holds 51%, Samancor formed Crometals (Pty.) Ltd., to upgrade furnace No. 5 at Ferrometals by adding pelletizing, sintering, and preheating facilities, increasing furnace production capacity by 15,000 tons per year. NSA Metals is an investment firm owned 55% by Nisshin Steel (Japan) and 45% by Nissho Iwai (Japan). Samancor contracted with Outokumpu Engineering Contractors Oy to provide the pelletizing and sintering plant and the preheating shaft kilns at a cost of $24 million. The pelletizing plant was to have a production capacity of 520,000 tons per year and to be completed in 1997. The preheating shaft kiln was to be completed in 1998.

At Tubatse, Samancor added a sixth furnace and a ferrochromium-from-slag recovery plant at its plant. The new furnace had electrical capacity of 37 megavolt-amperes and increased ferrochromium production capacity by 55,000 tons per year at a cost of 92 million rands. The ferrochromium-from-slag recovery plant increased ferrochromium production capacity by 20,000 tons per year at a cost of 23 million rands.

At Middelburg, Samancor commissioned a plasma-arc furnace for use with the chromite direct reduction process. The kiln used for direct reduction was to be completed in 1997.

Stainless Steel.—Columbus Joint Venture and ISCOR Limited developed their stainless steel production facilities. Columbus completed its plant in 1995 and optimized its operations in 1996; production was estimated to be 250,000 tons. The company planned to reach production of 400,000 tons per year in 1997 from a capacity of 500,000 tons per year. ISCOR proceeded to convert its Pretoria and Durban steel plants to stainless steel production. The Pretoria works was designed to produce stainless steel slab from liquid iron, with a capacity of 480,000 tons per year. The Durban Works was designed to produce billets and ingots from steel scrap, with a capacity of 100,000 tons per year.

Chemicals.—Bayer AG (Germany) entered a joint venture with Sentrachem to produce sodium dichromate and chromic acid at Newcastle, KwaZulu-Natal Province. The new facilities were to be built at Sentrachem's currently active Karbochem plant site in Newcastle at a cost of $114 million shared equally between the joint-venture partners. The plant was planned to start production in 1998 with a production capacity of 70,000 tons per year of sodium dichromate and 10,000 tons per year of chromic acid. The major feed materials, chromite ore and soda ash, were to come from Bayer's Rustenburg Chrome Mine near Rustenburg, North-West Province, and Botswana, respectively. Typical ratio of soda ash to chromite ore in the production of sodium dichromate is 1.5:1. The new plant is designed to reduce this ratio. Other design features of the new plant include maximization of energy efficiency by using process gases, reduction of waste residue by maximizing reaction yields, conversion of residual hexavalent chromium to trivalent, and soda ash recovery by converting sodium monochromate to dichromate by carbon dioxide acidification. Carbon dioxide replaces the commonly used sulfuric acid in the acidification process, thereby avoiding the production of hexavalent chromium contaminated sodium sulfate. Chromic acid was to be produced from sodium dichromate by electrolysis, which would result in a caustic soda byproduct that would be recovered and reused. Bayer already produces chromium tanning compounds from sodium dichromate in South Africa at its Merebank plant in Durban, KwaZulu-Natal Province. Most (80% to 90%) of the new plant's chemical compounds are destined for export through Durban.

Spain.—Acerinox reported operating a second argon-oxygen-decarburization converter, which was installed in 1995, and modernizing their original converter, thus increasing its hot metal production capacity from 721,000 to 831,000 tons per year.

Taiwan.—Taiwan reported imports of 186,637 tons of ferrochromium to supply its stainless steel producers and exports of 48,237 tons of stainless steel scrap. Major primary stainless steel producers include Yieh United, Tang Eng, and Walsin-Car Tech.

Turkey.—Etibank reported that it was considering changes to chromium operations. Included were the possibility of privatizing chromite mines and ferrochromium smelters, and the possible construction of a stainless steel plant at Elazig, the location of its high-carbon ferrochromium plant.

United Kingdom.—British Chrome & Chemicals Ltd. (BCC) started construction of a new chromic acid plant, which cost as much as $18 million at its Eaglescliffe site, with production capacity of 25,000 tons per year. The new plant is a joint venture with Nippon Denko Co. Ltd. (Japan). The new plant was expected to start production in 1998 at which time the

old plant, with production capacity of 13,000 tons per year, was to be shut down. BCC's new plant was expected to produce 3- to 4-millimeter chromic acid crystals; acid is used in metal finishing, plating, and wood preservation.

BCC is the only Western producer of chromic oxide for aluminothermic chromium metal production. In the United Kingdom, cost of production rose as a result of increased costs of soda ash and ammonium sulfate and the United Kingdom landfill tax. As a result of these added costs, BCC raised the price of aluminothermic chromium metal-grade chromic oxide by 20%.

London & Scandinavian Metallurgical Co. Ltd. planned a new chromium metal plant at its Rotherham site. This new chromium metal plant was expected to come into production in 1997, at which time the old plant was to be shut down. The new plant was to have a production capacity in the range of 3,600 to 4,800 tons per year compared with current production capacity of 3,000 to 4,000 tons per year.

Zimbabwe.—Zimbabwe suspended exports of chromite ore after permitting such exports a year ago.

Chromite ore.—Zimbabwe Alloys Ltd. reported 1995 mine production, in tons, as follows: Great Dyke Mine, 9,471; Great Dyke Outcrop, 6,108; Inyala Mine, 4,545; north Dyke co-operatives, 57,051. Other sources supplied 85,346 tons putting Zimbabwe alloys receipts at 162,514 tons (The TEX Report, 1996). Zimbabwe Alloys reported 1995 production of 29,594 tons of low-carbon ferrochromium and 42,284 tons of ferrochromiumsilicon. At the Great Dyke Mine, Zimbabwe Alloys extended the shaft to greater depth. At its Inyala and Sutton Mines, Zimbabwe Alloys explored the deposits in preparation for deepening the shafts and commissioned a heavy media separation plant.

Ferrochromium.—Zimbabwe Mining and Smelting Co. Ltd. reported production of 213,000 tons per year (190,000 tons per year from furnaces, 23,000 tons per year recovery from slag), compared with production of 218,000 tons in 1995.

Zimbabwe Alloys signed a joint venture agreement with JMC and Mitsui to produce low-carbon ferrochromium. The joint venture, to be called JM Alloys (Private) Ltd., is intended to supply low-carbon ferrochromium to Japanese consumers, replacing that produced by JMC as it closes down its Oguni plant in Japan. JMC and Mitsui each have a 25% share. Technology transfer from JMC to Zimbabwe Alloys was expected to raise low-carbon ferrochromium production capacity by 5,000 tons per year. Among the technological improvements to raise productivity are preheating of chromite ore feed and other changes to the material flow processes.

Current Research and Technology

Mineral Processing and Industrial Applications.—Research on the recovery of chromium from low-grade chromite concentrate by a low-temperature soda-roasting method found that chromite ore from the Mouat Mine, Stillwater Complex, Montana, is not amenable to traditional chemical processing (roasting at high temperature with soda ash) owing to its silicon content (Chandra and others, 1996). Bubbling oxygen and tumbling during roasting were reported to improve an alternate method (roasting at low temperature with sodium hydroxide) of chemical processing. This research was conducted by the former U.S. Bureau of Mines in support of the Strategic and Critical Materials Stock Piling Act of 1946, as amended; the Defense Production Act of 1950, as amended; the Mining and Minerals Policy Act of 1970; and the National Materials and Minerals Policy, Research and Development Act of 1980.

The Council for Mineral Technology (Mintek) of the Republic of South Africa conducts government and commercially sponsored and cosponsored research and development on chromite ore and ferrochromium. Recent Mintek research has included chromite beneficiation, agglomeration, smelting, chromium recovery from slag, and stainless steel alloying. Ferrochromium-from-slag recovery by using a hydropneumatic coarse jigging process is being implemented in Southern Africa. The process developed jointly by Mintek and Titaco recovers more than 95% of chromium contained in slag with less than 2.5% of slag in the product. Processing plants with slag processing capacity in the range of 100 to 200 tons per hour have been built. The process contains (that is, prevents dispersal of) the material being processed while it is processed, recovers metal values in usable form, and results in a more environmentally acceptable slag byproduct (Mining Weekly, 1996).

Sermatech reported the results of a high-velocity thermal spray process that used chromium carbide to repair worn Tennessee Valley Authority power-generation equipment (Sielski and Sahoo, 1997). Chromium carbide has a thermal expansion coefficient near that of iron and nickel, the major constituents of base materials subject to solid-particle erosion. The coating was demonstrated to be an economic alternative to upgrading the base material in some applications.

Environmental.—Environmental concerns about chromium have resulted in a wide variety of studies to determine chemical characteristics, natural background levels, sources of environmental emissions, movement of chromium in the environment, interaction of chromium with plants and animals, effect of chromium on plants and animals, measurement methods, and recovery technology.

A new electrode suited to electrokinetic remediation of soils (chromium removal) not saturated with water is being investigated at Sandia National Laboratories (Mouché, 1996). Sandia is testing the technique by using four electrodes to remediate a chromic acid pit measuring 18 feet by 45 feet. Electrodes cost about $12,000 each, but their use does not require digging up the site.

Outlook

On average (from 1983 through 1992), U.S. chromium consumption, by end-use industry, has been: metallurgical, 87%; chemical, 10%; and refractory, 3% (Papp, 1994). About 70% of metallurgical industry chromium consumption is as feed

material for stainless steel production. Thus, stainless steel production accounts for about 60% of the chromium consumed in the United States. The remainder of metallurgical industry consumption is for the production of other ferrous and nonferrous alloys. Some chemical and refractory products are consumed in steel production. The average chromium content of stainless steel produced in the United States from 1962 through 1983 was 17% (Papp, 1991). Stainless steel, by definition, contains at least 11% chromium but may contain as much as 36% is chromium.

In 1989, it was estimated that, on average internationally, the metallurgical industry consumed about 79% of chromium; the chemical industry, 13%; and the refractory industry, 8% (Granville and Statham, 1989). Of the chromium consumed in the metallurgical industry, about 60% was consumed in stainless steel. Thus, stainless steel production accounted for about 50% of the chromium consumed internationally. In 1993, it was estimated that, on average internationally within market economy countries, the metallurgical industry consumed about 77% chromium; the chemical industry, 14%; and the refractory industry (including foundry sand), 9% (Boyle and others, 1993). A comparison of world production of chromite ore, ferrochromium, and stainless steel as reported in contained chromium in table 1 shows that, on average, from 1992 through 1996, chromium contained in ferrochromium was about 79% of chromium contained in ore production and about 87% of that in stainless steel.

The outlook for chromium consumption in the United States and internationally is about the same as that for stainless steel, which is the major end use for chromium worldwide. Thus, stainless steel industry performance largely determines chromium industry demand worldwide.

The trend to supply chromium in the form of ferrochromium by chromite mining countries is expected to continue. With new, efficient ferrochromium production facilities and excess capacity in chromite-producing countries, production and capacity are expected to diminish in traditional nonore-, but ferrochromium-producing countries. Production by small, less efficient producers, except where domestic industries are protected by quotas and tariffs is also expected to decline. Further upward integration of the chromium industry is expected as countries that produce chromite expand ferrochromium or stainless steel production capacity.

China has emerged as a potential major factor in the world chromium market. Because China produced only a minor amount of chromite ore, it is primarily a processor and consumer of chromium and supplies substantial quantities of ferrochromium and chromium metal to world markets. Continued industrial growth in China could result in increased demand for stainless steel there because its use is characteristic of the larger and more technologically developed economies.

Ferrochromium.—Ferrochromium production is electrical energy intensive. Charge-grade ferrochromium requires from 3,800 to 4,100 kilowatt-hours per ton of product, with efficiency varying with ore grade, operating conditions, and production process. Thus, ferrochromium plant location reflects a cost balance between raw materials and electrical energy supply. The South African share of ferrochromium production increased to 48% from about 35% in 1992. It was expected of exceed 50% in 1997.

Stainless Steel.—Analysis of the stainless steel industry based on historical performance and announced production capacity increases indicated that from 1982 to 1995, world annual stainless steel production grew from 7.5 to 15 million tons, an annual growth rate of 5.5%. Annual demand reportedly grew even faster. Planned expansions in nine countries (Brazil, China, India, Indonesia, Malaysia, the Republic of Korea, South Africa, Taiwan, and Thailand) were expected to add 4 million tons of crude stainless steel production capacity (3.66 million tons, rolled product) by 2000 (Mole and Armitage, 1996).

Western stainless steel production showed double-digit percentage growth in 1994 and 1995. In 1995, strong demand for stainless steel resulted in excessive production, which resulted in large stocks of stainless steel in 1996. At the same time, capacity expansion projects already under way continued to come into production. From 1994 through 1996, an estimated 3.865 million tons of stainless steel production capacity was added. Excess stocks forced prices and production down. Reported prices declined by 45% from peak prices in 1995, while production declined by as much as 5%.

Price for stainless steel is demand sensitive, and an important part of it is the cost of nickel (about 70% of stainless steel requires nickel). Nickel availability and cost have been viewed as potential limitations to increased stainless steel production. The discovery and development of new nickel deposits projected to produce at nearly one-half the cost of that of current deposits mitigate this potential limitation to stainless steel production growth.

Chromium Chemicals.—Chromium chemical production is geographically concentrated in developed economies. Major producing countries where large plants (capacity in excess of 100,000 tons per year of sodium dichromate) operate include Kazakstan, Russia, the United Kingdom, and the United States. Moderate-sized production facilities are located in Brazil, China, Germany, Japan, Romania, and Turkey. Moderate-scale plant development to displace production in Germany is underway in South Africa. Small-scale local producers operate in China and India.

Sodium dichromate apparent consumption in 1994 was estimated to be 110,000 tons in the United States, 137,000 tons in Western Europe, and 42,000 tons in Japan (Will, Leder, and Mori, 1996). In the United States, most sodium dichromate is converted to chromic acid; some, however, is used directly by several industries. Major enduse markets for sodium dichromate— wood preservation, leather tanning, and metal finishing—are mature markets showing slow growth. Other enduses showing declining use include chromate pigments, corrosion control agents, and water-treatment chemicals. Newer, faster growing markets include magnetic recording media and catalysts and represent a small part of the market. In Europe, leather tanning was a major enduse. In Japan, electroplating and metal finishing were major enduses.

The domestic chemical industry has restructured over the years. In 1951, demand distribution among major enduses was leather tanning and metal finishing, 25% each, and pigments, 35%. Today, demand distribution among major enduses is: wood preservation, 42%; metal finishing, 14%; pigments, 13%; and leather tanning, 9%. Sales during the time period were estimated to have grown by 20%. Demand is expected to continue the same slow growth rate (Barnhart, 1977). In 1996, the enduses of sodium dichromate were estimated to have been chromic acid, 64%; leather tanning, 12%; chromic oxide, 10%; chrome pigments, 5%; wood preservative, 3%; miscellaneous, 6% (Mannsville Chemical Products Corp., 1997).

Chromium Metal.—Tosoh, the Japanese electrolytic chromium metal producer, ceased production in 1995, leading to an anticipated restructuring of the chromium metal industry. It was not until December 1996 that the company finally sold off its stocks. To a degree, Tosoh stocks have become consumer stocks. Restructuring of the chromium metal supply market will start in earnest in 1997, with the remaining electrolytic producers (Russia and the United States) competing with the major aluminothermic producers (France and the United Kingdom) for the Japanese market. Both aluminothermic producers are in a position to expand production. The price of chromium metal was expected to increase as raw material (chromic oxide) price increases are passed on to metal consumers. The price of low-grade chromium metal relative to ferrochromium in Japan permitted stainless steel producers to substitute chromium metal for ferrochromium. This substitution is expected to be curtailed as metal prices increase.

Chromite Foundry Sand.—At last count, about 3,100 foundries were active in the United States. These foundries tend to be small, independent operations. Chromite sand found a place in the casting industry in the 1960's when it substituted for zircon sand, which was in short supply. Since then, chromite sand has gained recognition as being technically suited to manganese steel and stainless steel casting because it produces a finish superior to that of zircon sand. Performance of the foundry industry is tied to that of the general economy, which has been strong and is expected to so continue. The automotive industry is a major demand sector for castings. Demand was good, stable, and expected to grow moderately. The use of nonmetallic materials could displace demand for metallic castings in the long term (Bolger, 1996).

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT CHROMIUM STATISTICS 1/

(Metric tons, contained chromium unless otherwise specified)

		1992	1993	1994	1995	1996
World production:						
Chromite ore (mine) 2/		3,350,000 r/	2,880,000 r/	3,050,000 r/	4,320,000 r/	3,690,000 e/
Ferrochromium (smelter) 3/		1,990,000 r/	1,800,000 r/	1,940,000 r/	2,460,000 r/	2,240,000 e/
Stainless steel 4/		2,180,000 r/	2,150,000 r/	2,350,000 r/	2,660,000 r/	2,650,000 e/
U.S. supply:						
Components of U.S. supply:						
Domestic mines		--	--	--	--	--
Secondary		102,000	92,000	99,000	112,000 r/	98,400
Imports:						
Chromite ore		67,700	84,300	59,600	81,400	79,200
Chromium chemicals		4,320	6,210	9,210	8,360	7,060
Chromium ferroalloys		247,000	233,000	198,000	319,000	267,000
Chromium metal		5,450	6,170	6,520	7,040	8,730
Stocks, Jan. 1:						
Government		1,250,000	1,280,000	1,210,000	1,170,000	1,120,000
Industry		117,000 r/	118,000	103,000	101,000	80,100
Total U.S. supply		1,800,000	1,820,000	1,690,000	1,790,000	1,660,000
Distribution of U.S. supply:						
Exports:						
Chromite ore		2,180	3,310	14,000	5,740	21,900
Chromium chemicals		9,210 r/	8,170	11,700	14,700	18,200
Chromium ferroalloys and metal		6,530	9,420	7,600	6,260	10,800
Stocks, Dec. 31:						
Government		1,280,000	1,210,000	1,170,000	1,120,000	1,060,000
Industry		118,000	103,000	101,000	80,400	74,300
Total U.S. distribution		1,420,000	1,340,000	1,300,000	1,230,000	1,180,000
Apparent industry demand		378,000	484,000	390,000	566,000	480,000
Reported consumption (gross weight):						
Chromite ore		362,000	337,000	322,000	351,000	282,000
Chromium ferroalloys		367,000	357,000	346,000	334,000	328,000
Chromium metal		3,820	4,060	3,960	4,600	4,620
Stocks, Dec. 31 (gross weight):						
Government						
Chromite ore		1,850,000	1,640,000	1,470,000	1,320,000	1,170,000
Chromium ferroalloys		1,090,000	1,080,000	1,080,000	1,070,000	1,040,000
Chromium metal		6,150	7,060	7,690	7,690	7,720
Industry, producer		5,720	5,610	8,070	8,430	6,450
Industry, consumer:						
Chromite ore		321,000	275,000	266,000	205,000	173,000
Chromium ferroalloys		17,200	16,000	14,700	22,500	27,300
Chromium metal		438	481	292	264	211
Industrial releases and transfers: 5/						
Released		11,600	11,300	10,500	10,500	NA
Transferred		55,300	69,600	77,000 r/	69,300	NA
Total		66,900	80,900	87,500 r/	79,700	NA
Prices, average annual:						
Chromite ore, 6/ $/ton gross weight		51	55	55	60	75
Ferrochromium, 7/ $/lb chromium content		0.46	0.37	0.37	0.70	0.51
Chromium metal, 8/ $/lb gross weight		3.70	3.70	3.70	3.97	4.15
Value of trade:						
Exports	thousands	$56,200	$64,900	$69,900	$83,200	$111,000
Imports	do.	$330,000	$279,000	$254,000	$545,000	$463,000
Net trade 9/	do.	($274,000)	($214,000)	($184,000)	($461,000)	($352,000)

e/ Estimated. r/ Revised. NA Not available.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Calculated assuming chromite ore to average 44% Cr_2O_3 that is 68.42% chromium.

3/ Calculated assuming chromium content of ferrochromium to average 57%.

4/ Calculated assuming chromium content of stainless steel to average 17%.

5/ Data on industrial releases and transfers from Environmental Protection Agency, Toxic Release Inventory (July 1997.)

6/ Time average price of South African chromite ore as reported by Platt's Metals Week.

7/ Time average price of imported high-carbon chromium containing 50%-55% chromium as reported by Platt's Metals Week.

8/ Time average price of electrolytic chromium metal as reported by Platt's Metals Week.

9/ Number in parenthesis indicates that imports are greater than exports.

TABLE 2
CHROMIUM 1/ RELEASED TO THE ENVIRONMENT AND TRANSFERRED BY INDUSTRY AND BY MODE 2/

(Kilograms, contained chromium)

	SIC 3/	1994				1995			
		Released	Transferred	Total		Released	Transferred	Total	
Industry:									
Food products	20	4,670	43,200	47,800		5,230	8,140	13,400	
Tobacco products	21	--	--	--		--	--	--	
Textile mill products	22	3,480	28,800	32,300		2,080	57,200	59,300	
Apparel	23	--	--	--		--	--	--	
Lumber and wood products	24	3,420	66,100	69,500		2,480	59,500	62,000	
Furniture	25	24,300	275,000	300,000		1,400	326,000	328,000	
Paper and allied products	26	47,700	13,900	61,500		43,100	9,400	52,500	
Printing and publishing	27	116	3,970	4,090		--	5	5	
Chemical and allied products	28	8,000,000	1,120,000	9,130,000		7,930,000	759,000	8,690,000	
Petroleum and coal	29	35,400	127,000	162,000		21,500	64,200	85,600	
Rubber and plastic	30	4,090	355,000	359,000		4,000	250,000	254,000	
Leather and leather products	31	8,600	814,000	823,000		7,940	725,000	733,000	
Stone, clay, glass, and concrete	32	88,400	800,000	888,000		137,000	986,000	1,120,000	
Primary metals	33	1,970,000	39,700,000	41,700,000		2,040,000	30,200,000	32,300,000	
Fabricated metals	34	199,000	12,900,000	13,100,000		88,700	14,600,000	14,600,000	
Machinery and computer equipment	35	50,800	8,500,000	8,550,000		51,600	8,390,000	8,440,000	
Electrical and electronic equipment	36	8,540	884,000	893,000		1,910	900,000	902,000	
Transportation equipment	37	63,600	9,600,000	9,660,000		134,000	10,300,000	10,400,000	
Instruments	38	2,360	527,000	530,000		2,500	462,000	465,000	
Miscellaneous manufacturing	39	2,070	887,000	889,000		2,150	955,000	957,000	
Other		4,000	376,000	380,000		3,440	264,000	267,000	
Total		10,500,000	77,000,000	87,500,000		10,500,000	69,300,000	79,700,000	
Mode:									
Releases:									
To air		536,000	XX	5	4/	546,000	XX	5	4/
To water		81,600	XX	1	4/	69,700	XX	1	4/
To underground		17,300	XX	(5/)	4/	27,600	XX	(5/)	4/
To land:									
Fill		1,450,000	XX	14	4/	1,320,000	XX	13	4/
Treatment		41,000	XX	(5/)	4/	35,400	XX	(5/)	4/
Impoundment		8,330,000	XX	79	4/	8,460,000	XX	81	4/
Other		67,200	XX	1	4/	18,200	XX	(5/)	4/
Total releases		10,500,000	XX	12	6/	10,500,000	XX	13	6/
Transfers:									
To POTW		XX	195,000	(5/)	7/	XX	359,000	(5/)	7/
To off-site location:									
Disposal		XX	7,340,000	10	7/	XX	9,780,000	14	7/
Recycling		XX	67,000,000	87	7/	XX	56,700,000	82	7/
Treatment		XX	2,440,000	3	7/	XX	2,500,000	4	7/
Other		XX	83,000	(5/)	7/	XX	106,000	(5/)	7/
Total transfers		XX	77,000,000	88	6/	XX	69,300,000	87	6/
Total releases plus transfers		XX	87,500,000	XX		XX	79,700,000	XX	

XX Not applicable.

1/ Chromium contained in U.S. Environmental Protection Agency categories chromium and chromium compounds.

2/ Data are rounded to three significant digits; may not add to totals shown.

3/ Standard industrial classification code.

4/ Releases as percent of total releases.

5/ Less than 1/2 unit.

6/ Totals as percent of total releases plus transfers.

7/ Transfers as percent of total transfers.

NOTE: Air included point and nonpoint (that is, stack and fugitive) sources. POTW is publicly owned treatment works.

Source: U.S. Environmental Protection Agency, Toxic Release Inventory (July 1997).

TABLE 3
PRINCIPAL U.S. PRODUCERS OF CHROMIUM PRODUCTS IN 1996, BY INDUSTRY

Industry and company	Plant
Metallurgical:	
Elkem A/S, Elkem Metals Co.	Marietta, OH.
Macalloy Corp.	Charleston, SC.
Refractory:	
General Refractories Co.	Lehi, UT.
Harbison-Walker Refractories, a subsidiary of Global Industrial Technologies	Hammond, IN.
National Refractories & Minerals Corp.	Moss Landing, CA, and Columbiana, OH.
North American Refractories Co. Ltd.	Womelsdorf, PA.
Chemical:	
American Chrome & Chemicals Inc.	Corpus Christi, TX.
Occidental Chemical Corp.	Castle Hayne, NC.

TABLE 4
PRODUCTION, SHIPMENTS, AND STOCKS OF CHROMIUM FERROALLOYS AND METAL, AND OTHER CHROMIUM MATERIALS IN THE UNITED STATES 1/

(Metric tons)

	Net production			
Year	Gross weight	Chromium content	Net shipments	Producer stocks, Dec. 31
1995	72,500	49,500	72,100	8,430
1996	36,800	26,400	38,800	6,450

1/ Data are rounded to three significant digits.

TABLE 5
CONSUMPTION OF CHROMITE AND TENOR OF ORE USED BY PRIMARY CONSUMER GROUPS IN THE UNITED STATES 1/

	Chemical and metallurgical industry		Refractory industry		Total	
Year	Gross weight (metric tons)	Average Cr_2O_3 (percentage)	Gross weight (metric tons)	Average Cr_2O_3 (percentage)	Gross weight (metric tons)	Average Cr_2O_3 (percentage)
1995	W	43.9	W	42.1	351,000	43.8
1996	W	45.6	W	35.2	282,000	45.2

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

1/ Data are rounded to three significant digits; may not add to totals shown.

TABLE 6
U.S. CONSUMPTION OF CHROMIUM FERROALLOYS AND METAL, BY END USE 1/

(Metric tons, gross weight unless noted)

End use	Ferrochromium		Ferro-chromium-silicon	Other	Total
	Low-carbon 2/	High-carbon 3/			
1995:					
Steel:					
Carbon	4,140 r/	7,660 r/	163 r/	W	12,000 r/
Stainless and heat-resisting	7,970 r/	209,000	32,800	W	250,000
Full-alloy	3,930 r/	28,700 r/	1,380	W	34,000 r/
High-strength, low-alloy, and electric	1,280 r/	2,210 r/	7,320 r/	--	10,800 r/
Tool	W	4,140	W	W	4,140
Cast irons	969 r/	3,220 r/	W	384	4,570 r/
Superalloys	2,290 r/	4,940	--	3,360 r/	10,600 r/
Welding materials 4/	W	89	W	W	89
Other alloys 5/	607 r/	363	--	1,530	2,500 r/
Miscellaneous and unspecified	1,730 r/	223	5,840	1,470	9,260 r/
Total 6/	22,900 r/	261,000 r/	47,500	6,740 r/ 7/	338,000
Chromium content	15,400 r/	154,000 r/	18,100	5,350 r/	193,000
Stocks, Dec. 31, 1995	1,940 r/	16,500 r/	3,810 r/	513 r/ 8/	22,800 r/
1996:					
Steel:					
Carbon	3,850	9,230	163	555	13,800
Stainless and heat-resisting	7,990	202,000	32,400	W	243,000
Full-alloy	3,750	25,600	1,620	47	31,000
High-strength, low-alloy, and electric	2,090	2,110	7,240	--	11,400
Tool	W	5,040	W	W	5,040
Cast irons	W	3,020	W	312	3,340
Superalloys	2,200	5,040	--	3,540	10,800
Welding materials 4/	83	67	1	294	445
Other alloys 5/	318	360	--	1,330	2,010
Miscellaneous and unspecified	2,910	305	8,900	163	12,300
Total 6/	23,200	253,000	50,300	6,240 9/	333,000
Chromium content	15,600	151,000	17,800	5,190	190,000
Stocks, Dec. 31, 1996	1,790	23,900	1,560	349 10/	27,600

r/ Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Low-carbon ferrochromium contains less than 3% carbon.
3/ High-carbon ferrochromium contains 3% or more carbon.
4/ Includes structural and hard-facing welding material.
5/ Includes cutting materials and magnetic, aluminum, copper, nickel, and other alloys.
6/ Includes estimates.
7/ Includes 4,600 tons of chromium metal.
8/ Includes 264 tons of chromium metal.
9/ Includes 4,620 tons of chromium metal.
10/ Includes 211 tons of chromium metal.

TABLE 7
U.S. CONSUMER STOCKS OF CHROMITE, CHROMIUM FERROALLOYS, AND METAL, DECEMBER 31 1/

(Metric tons, gross weight)

Industry	1995	1996
Chromite:		
Chemical and metallurgical	194,000	165,000
Refractory	10,900	7,890
Total	205,000	173,000
Chromium ferroalloy and metal:		
Low-carbon ferrochromium	1,940 r/	1,790
High-carbon ferrochromium	16,500 r/	23,900
Ferrochromium-silicon	3,810 r/	1,560
Other 2/	513 r/	349
Total	22,800 r/	27,600

r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes chromium briquets, exothermic chromium additives, and other miscellaneous chromium alloys. Also includes chromium metals stocks of 211 tons in 1996 and 264 tons in 1995.

TABLE 8
U.S. GOVERNMENT STOCKPILE YEAREND INVENTORIES 1/ AND CHANGE FOR CHROMIUM 2/

(Metric tons, gross weight)

Material	1995	1996	Change 3/	
			Quantity	Percent
Chromite:				
Chemical	220,000	220,000	--	--
Metallurgical	773,000	645,000	(128,000)	(20%)
Refractory	328,000	322,000	(6,140)	(2%)
Chromium ferroalloys:				
Ferrochromium-silicon	52,900	52,700	(253)	(4/)
High-carbon ferrochromium	738,000	718,000	(20,100)	(3%)
Low-carbon ferrochromium	283,000	283,000	--	--
Chromium metal:				
Aluminothermic	2,670	2,670	--	--
Electrolytic	5,020	5,050	36	1%

1/ Includes specification- and nonspecification-grade materials.

2/ Data are rounded to three significant digits.

3/ Number in parentheses indicates decrease.

4/ Less than 1/2 unit.

Source: Defense Logistics Agency.

TABLE 9
TIME-VALUE 1/ RELATIONS FOR CHROMITE ORE, FERROCHROMIUM, AND CHROMIUM METAL 2/

(Average annual value, dollars per metric ton)

Material	1995		1996	
	Contained chromium	Gross weight	Contained chromium	Gross weight
Chromite ore:				
Not more than 40% chromic oxide	630	153	594	135
More than 40% but less 46% chromic oxide	262	74	327	98
46% or more chromic oxide	232	76	282	91
Total	247	80	293	93
Ferrochromium:				
Low-carbon 3/	1,880	1,230	2,270	1,440
High-carbon 4/	1,220	731	976	564
Total	1,320	805	1,180	690
Chromium metal	XX	6,450	XX	7,010

XX Not applicable.
1/ Customs value per ton of chromium contained in imported material.
2/ Data are rounded to three significant digits.
3/ Carbon not more than 4%.
4/ More than 4% carbon.

TABLE 10
PRICE QUOTATIONS FOR CHROMIUM MATERIALS AT BEGINNING AND END OF 1996

Material	January	December	Year average
Dollars per metric ton of product:			
Chromite ore:			
South Africa	70 - 80	70 - 80	75
Turkey	220 - 230	220 - 230	225
Cents per pound of chromium:			
High-carbon ferrochromium:			
Imported:			
50% to 55% chromium	62 - 64	39.8 - 42.9	51
60% to 65% chromium	62 - 64	41 - 42.5	43
Low-carbon ferrochromium:			
Domestic:			
0.05% carbon	95	95	95
0.015% carbon (Simplex)	166	166	166
Imported:			
0.05% carbon	119 - 123	112 - 120	137
0.10% carbon	110 - 112	97 - 103	118
Cents per pound of product:			
Chromium metal (domestic):			
Electrolytic	415.0	415.0	415.0
Elchrome	490.0	530.0	515.0

Source: Platt's Metals Week.

TABLE 11
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE 1/

HTSUSA 2/	Type	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)	Principal destinations, 1996
2610.00.0000	Chromite ore and concentrate, gross weight	17,800	$3,430	69,400	$11,100	China (53%); Russia (21%); Canada (20%); Mexico (4%).
	Metal and alloys:					
8112.20.0000	Chromium metal, gross weight 3/	714	7,820	1,330	12,800	Japan (47%); Canada (18%); Belgium (17%); Germany (12%).
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium, gross weight 4/	6,610	8,120	12,800	9,650	Japan (40%); Mexico (36%); Canada (21%).
7202.41.0000	High-carbon ferrochromium, contained weight 4/	4,060	8,120	7,800	9,650	
7202.49.0000	Low-carbon ferrochromium, gross weight 5/	2,010	3,490	2,780	4,020	Netherlands (31%); Canada (28%); Mexico (28%); Sweden (4%).
7202.49.0000	Low-carbon ferrochromium, contained weight 5/	1,220	3,490	1,630	4,020	
7202.50.0000	Ferrochromium-silicon, gross weight	741	860	252	286	Canada (100%).
7202.50.0000	Ferrochromium-silicon, contained weight	259	860	88	286	
	Total ferroalloys, gross weight	9,360	12,500	15,800	14,000	
	Total ferroalloys, contained weight	5,540	12,500	9,520	14,000	
	Chemicals: (gross weight)					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	7,590	14,500	11,000	21,000	Brazil (23%); Canada (21%); Mexico (13%); Australia (9%); Japan (7%); South Africa (6%); Korea, Republic of (5%).
2819.90.0000	Other	2,460	14,600	2,110	11,100	Canada (36%); Netherlands (22%); Japan (9%); Malaysia (5%); Australia (4%); Hong Kong (4%).
2833.23.0000	Chromium sulfates	187	412	1,060	3,330	Mexico (45%); Canada (44%); Germany (12%).
	Salts of oxometallic or peroxometallic acids:					
2841.20.0000	Zinc and lead chromate	969	3,280	928	2,620	Canada (96%).
2841.30.0000	Sodium dichromate	25,800	18,900	31,500	26,300	Mexico (43%); China (16%); Thailand (11%); Uruguay (6%).
2841.40.0000	Potassium dichromate	35	102	66	122	Brazil (49%); Canada (32%); Japan (11%).
2841.50.0000	Other chromates, dichromates, and peroxchromates	410	1,620	385	1,640	Canada (67%); Australia (9%); United Kingdom (9%); Mexico (8%).
3206.20.0000	Pigments and preparations, gross weight	1,260	6,020	2,100	6,920	Canada (66%); Mexico (9%); Singapore (7%); Japan (5%).

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States of America code.
3/ Articles thereof and waste and scrap.
4/ More than 4% carbon.
5/ Not more than 4% carbon.

Source: Bureau of the Census.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF CHROMITE ORE, BY COUNTRY 1/

Country	Not more than 40% Cr_2O_3 (HTSUSA 2/ 2610.00.0060)			More than 40% but less than 46% Cr_2O_3 (HTSUSA 2/ 2610.00.0040)			46% or more Cr_2O_3 (HTSUSA 2/ 2610.00.0020)			Total		
	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Cr_2O_3 content (metric tons)	Value (thou-sands)
1995:												
Canada	--	--	--	--	--	--	39	24	$9	39	24	$9
India	--	--	--	--	--	--	25,400	12,400	4,090	25,400	12,400	4,090
Philippines	11,100	4,000	$1,700	--	--	--	--	--	--	11,100	4,000	1,700
South Africa	171	39	27	14,800	6,110	$1,100	201,000	96,400	13,200	216,000	103,000	14,300
Venezuela	321	80	49	--	--	--	--	--	--	321	80	49
Total	11,600	4,120	1,780	14,800	6,110	1,100	226,000	109,000	17,200	253,000	119,000	20,100
1996:												
Canada	20	8	3	--	--	--	--	--	--	20	8	3
Philippines	7,940	2,620	1,060	--	--	--	--	--	--	7,940	2,620	1,060
South Africa	--	--	--	25,400	11,100	2,480	217,000	102,000	19,700	242,000	113,000	22,100
Venezuela	46	18	16	--	--	--	--	--	--	46	18	16
Zimbabwe	23	9	3	--	--	--	--	--	--	23	9	3
Total	8,030	2,650	1,080	25,400	11,100	2,480	217,000	102,000	19,700	250,000	116,000	23,200

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States of America code.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY 1/

Country	Low-carbon (not more than 3% carbon) (HTSUSA 2/ 7202.49.5000)			Medium-carbon (more than 3% carbon but not more than 4% carbon) (HTSUSA 2/ 7202.49.1000)			High-carbon (more than 4% carbon) (HTSUSA 2/ 7202.41.0000)			Total (all grades)		
	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)
1995:												
Albania	--	--	--	--	--	--	8,700	5,240	$5,170	8,700	5,240	$5,170
Argentina	70	51	$107	--	--	--	--	--	--	70	51	107
Brazil	--	--	--	--	--	--	7,000	3,690	4,660	7,000	3,690	4,660
Canada	--	--	--	--	--	--	19	11	22	19	11	22
China	5,240	3,350	6,830	227	151	$127	12,400	8,020	11,000	17,800	11,500	17,900
Croatia	--	--	--	6	4	9	14,300	8,820	10,800	14,300	8,820	10,800
Estonia	123	87	140	--	--	--	--	--	--	123	87	140
Finland	--	--	--	--	--	--	8,610	4,850	5,270	8,610	4,850	5,270
France	--	--	--	--	--	--	7	5	9	7	5	9
Germany	6,830	4,770	14,600	--	--	--	7	5	15	6,840	4,780	14,600

See footnotes at end of table.

TABLE 13--Continued
U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY 1/

Country	Low-carbon (not more than 3% carbon) (HTSUSA 2/ 7202.49.5000)			Medium-carbon (more than 3% carbon but not more than 4% carbon) (HTSUSA 2/ 7202.49.1000)			High-carbon (more than 4% carbon) (HTSUSA 2/ 7202.41.0000)			Total (all grades)		
	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)	Gross weight (metric tons)	Chromium content (metric tons)	Value (thou-sands)
1995--Continued:												
India	--	--	--	--	--	--	11,600	6,970	$10,300	11,600	6,970	$10,300
Japan	525	348	$1,350	--	--	--	269	169	309	793	517	1,660
Kazakstan	7,040	4,370	7,730	5,840	3,840	$5,750	34,300	22,800	28,000	47,200	31,000	41,500
Latvia	1,120	727	1,150	--	--	--	15,500	10,700	13,300	16,600	11,500	14,500
Netherlands	(3/)	(3/)	(3/)	--	--	--	--	--	--	(3/)	(3/)	(3/)
Norway	--	--	--	--	--	--	6,170	3,850	5,200	6,170	3,850	5,200
Philippines	--	--	--	--	--	--	2,580	1,530	2,390	2,580	1,530	2,390
Poland	--	--	--	--	--	--	1,410	801	1,020	1,410	801	1,020
Russia	28,100	19,500	37,200	--	--	--	68,300	45,800	57,800	96,400	65,300	95,000
Slovenia	--	--	--	--	--	--	1,250	750	1,140	1,250	750	1,140
South Africa	14,300	8,050	10,900	--	--	--	118,000	60,000	58,900	132,000	68,000	69,800
Sweden	--	--	--	--	--	--	38	26	49	38	26	49
Turkey	956	699	1,240	1,500	930	1,170	82,400	51,000	69,000	84,800	52,600	71,400
Ukraine	185	131	237	--	--	--	--	--	--	185	131	237
United Kingdom	61	46	132	--	--	--	162	107	201	224	153	332
Zimbabwe	1,340	716	1,320	--	--	--	29,000	18,400	24,000	30,300	19,100	25,300
Total	65,800	42,800	82,900	7,570	4,930	7,060	422,000	254,000	309,000	495,000	301,000	399,000
1996:												
Albania	--	--	--	--	--	--	8,170	4,730	5,170	8,170	4,730	5,170
China	8,180	5,370	12,600	--	--	--	9,860	6,280	6,540	18,000	11,600	19,100
Croatia	20	13	17	--	--	--	9,430	5,880	6,110	9,450	5,900	6,130
Estonia	--	--	--	--	--	--	8,310	5,400	5,360	8,310	5,400	5,360
Finland	--	--	--	--	--	--	9,020	4,790	4,820	9,020	4,790	4,820
Germany	9,200	6,410	21,100	--	--	--	19	14	38	9,220	6,430	21,100
India	1,360	933	2,220	--	--	--	6,150	3,810	3,860	7,500	4,750	6,080
Japan	533	345	1,380	--	--	--	18	12	25	551	357	1,400
Kazakstan	152	106	257	--	--	--	77,600	46,800	45,600	77,700	46,900	45,800
Philippines	--	--	--	36	23	47	--	--	--	36	23	47
Russia	18,000	11,900	27,200	--	--	--	21,600	11,300	16,200	39,700	23,100	43,400
South Africa	18,900	10,600	16,800	--	--	--	105,000	53,400	45,100	124,000	64,000	61,800
Turkey	902	652	1,890	--	--	--	43,800	27,100	27,400	44,700	27,800	29,200
United Kingdom	313	201	575	--	--	--	2,030	1,090	973	2,340	1,290	1,550
Zimbabwe	3,140	1,930	3,240	--	--	--	58,200	36,700	35,300	61,400	38,700	38,600
Total	60,700	38,400	87,200	36	23	47	359,000	207,000	202,000	420,000	246,000	290,000

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States of America code.
3/ Revised to zero.

Source: Bureau of the Census.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE 1/

HTSUSA 2/	Type	1995 Quantity (metric tons)	1995 Value (thousands)	1996 Quantity (metric tons)	1996 Value (thousands)	Principal sources, 1996
	Metals and alloys:					
	Chromium metal:					
8112.20.3000	Waste and scrap, gross weight	109	$542	67	$312	Russia (30%); China (26%); Sweden (23%); Canada (20%).
8112.20.6000	Other than waste and scrap, gross weight	6,930	44,900	8,670	60,900	Russia (42%); China (18%); France (18%); United Kingdom (15%).
7202.50.0000	Ferrochromium-silicon, gross weight	49,600	32,500	49,400	33,200	Russia (36%); Kazakstan (32%); Zimbabwe (15%); China (12%).
7202.50.0000	Ferrochromium-silicon, contained weight	17,300	32,500	21,100	33,200	
	Chemicals: (gross weight)					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	4,060	7,270	3,800	7,060	Kazakstan (56%); Germany (22%); Netherlands (11%).
2819.90.0000	Other	5,030	14,500	4,350	13,100	Canada (33%); Germany (28%); Japan (23%); China (10%).
2833.23.0000	Sulfates of chromium	170	127	192	159	Mexico (58%); South Africa (21%); Germany (11%); United Kingdom (10%).
	Salts of oxometallic or peroxometallic acids:					
2471.20.0000	Chromates of lead and zinc	396	925	114	260	Norway (37%); France (19%); Philippines (14%); United Kingdom (14%); Poland (13%).
2841.30.0000	Sodium dichromate	7,000	4,660	5,100	4,040	United Kingdom (85%); Argentina (7%).
2841.40.0000	Potassium dichromate	377	661	381	718	United Kingdom (64%); Russia (32%); Mexico (3%).
2841.50.0000	Other chromates and dichromates; peroxochromates	919	2,040	573	1,260	United Kingdom (93%); France (3%); Austria (2%); Canada (2%).
2849.90.2000	Chromium carbide	200	1,970	190	2,270	Japan (50%); United Kingdom (30%); Germany (19%).
	Pigments and preparations based on chromium: (gross weight)					
3206.20.0010	Chrome yellow	4,700	10,400	7,020	17,600	Canada (74%); Mexico (17%); Hungary (4%); Philippines (3%).
3206.20.0020	Molybdenum orange	673	2,250	1,840	5,670	Canada (97%); Japan (3%).
3206.20.0030	Zinc yellow	136	314	127	283	Norway (100%).
3206.20.0050	Other	805	3,060	929	3,530	France (51%); Germany (11%); Mexico (8%); Poland (7%); Canada (6%).

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Harmonized Tariff Schedule of the United States of America code.

Source: Bureau of the Census.

TABLE 15
PRINCIPAL WORLD CHROMITE PRODUCERS, 1996

Country 1/	Company
Albania	Albchrome (Government owned).
Brazil	Bayer AG (Germany).
	Coitezeiro Mineração S.A.
	Cia. de Ferro-Ligas da Bahia S.A.
	Cia. de Mineração Serra de Jacobina S.A.
	Mineração Vale do Jacurici S.A.
	Indústria e Comércio de Minérios S.A.
	Invituruí Mineração S.A.
	Magnesita S.A.
	Piunhiense Mineração Ltda.
	Rada Mineração Ltda.
Finland	Outokumpu Oy.
	Outokumpu Steel Oy.
	Outokumpu Chrome Oy.
India	Ferro Alloys Corp. Ltd.
	Mysore Mineral Ltd.
	Orissa Mining Corp. Ltd. (Government owned).
	Tata Iron and Steel Co. Ltd.
Indonesia	PT. Palabim Mining-PT. Bituminuse
Japan	Japan Chrome Industry Co. Ltd.
Kazakstan	Donskoy Ore Dressing Complex.
Philippines	Acoje Mining Co. Inc.
	Benguet Corp.
	Philchrome Mining Corp.
	Velore Mining Corp.
Russia	Saranov Complex.
South Africa 2/	African Mining and Trust Co. Ltd.
	Rustenburg Minerals Development Co. (Pty.) Ltd.
	Zeerust Chrome Mine Ltd.
	Bayer AG (Germany).
	Bayer (Pty.) Ltd.
	Canadian Gold S.A. (Pty.) Ltd.
	Goudini Chrome (Pty.) Ltd.
	Chromecorp Holdings (Pty.) Ltd.
	Chrome Resources (Pty.) Ltd.
	Consolidated Metallurgical Industries Ltd.
	Hernic Chrome
	Hernic Mining (Pty.) Ltd.
	Lebowa Development Corp. Ltd.
	Dilokong Chrome Mine (Pty.) Ltd.
	Pilanesberg Chrome (Pty.) Ltd.
	Rooderand Chrome Mine (Pty.) Ltd.
	Samancor Ltd.
	Batlhako Mining Ltd.
	Eastern Chrome Mines.
	Doornbosch Mines.
	Lannex Joint Venture.
	Montrose Mine.
	Groothoek Section.
	Jagdlust Section.
	Montrose Section.
	Mooihoek Mine.
	Steelpoort Mine.
	Tweefontein Mine.
	Western Chrome Mines.
	Buffelsfontein Section.
	Elandsdrift Section.
	Henery Gould Section.
	Millsell Section.
	Mooinooi Section.
	Waterloof Section.
	Vereeniging Refractories Ltd.
	Bophuthatswana Chrome Co. (Pty.) Ltd.
	Marico Chrome Corp. Ltd.
Sudan	Advanced Mining Works Ltd.
	Blue Nile Mines Co. Ltd.

See footnotes at end of table.

TABLE 15--Continued
PRINCIPAL WORLD CHROMITE PRODUCERS, 1996

Country 1/	Company
Turkey	Aycan Madencilik Ltd. Sti.
	Bilfer Madencilik A.S.
	Birlik Madencilik Sanayi ve Ticaret A.S.
	Cevher Madencilik ve Ticaret A.S.
	Dedeman Madencilik Turzim Sanayi ve Ticaret A.S.
	Ege Metal Endüstri A.S.
	Etibank General Management (Government owned).
	Hayri Ögelman Madencilik Ltd. Sti.
	Tekfen Dis. Ticaret A.S.
	Tevfik Refik Bayoglu Madencilik.
	Tut. Gen. Ticaret Ltd. Sti.
	Turk Maadin Sti. A.S.
Zimbabwe	Zimbabwe Alloys Ltd.
	Zimasco (Pvt.) Ltd.

1/ Other chromite-producing countries included Burma, China, Cuba, Egypt, Iran, Macedonia, Madagascar, Morocco, Oman, and Pakistan.

2/ Includes Bophuthatswana.

TABLE 16
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 1996

Country 1/	Company
Albania	Albchrome Ltd. (Government owned).
Brazil	Cia. de Ferro-Ligas da Bahia S.A.
China	Chongqing Ferroalloy Works (Government owned).
	Emei Ferroalloy Works (Government owned).
	Hanzhong Ferroalloy Works (Government owned).
	Hengshan Iron and Steel Works (Government owned).
	Hunan Ferroalloy Works Government owned).
	Jiangyin Ferroalloy Factory (Government owned).
	Jilin Ferroalloy Works (Government owned).
	Jinzhou Ferroalloy Works (Government owned).
	Liaoyang Ferroalloy Works (Government owned).
	Nanjing Ferroalloy Plant (Government owned).
	Shanghai Ferroalloy Works (Government owned).
	Xibei Ferroalloy Works (Government owned).
Croatia	Dalmacija Ferro-Alloys Works.
Finland	Outokumpu Oy.
	Outokumpu Steel Oy.
	Outokumpu Chrome Oy.
Germany	Elektrowerk Weisweiler GmbH.
India	Deepak Ferro-Alloys Ltd.
	Eastern Metals & Ferro-Alloys Ltd.
	Ferro Alloys Corp. Ltd.
	Charge Chrome Works.
	Ferroalloys Works.
	GMR Vasavi Industries Ltd.
	Hi-Tech Electrothermics (Pvt.) Ltd.
	Indian Metals & Ferro Alloys Ltd.
	Indian Charge Chrome Ltd.
	Industrial Development Corp.
	Ispat Alloys Ltd.
	Jindal Ferro Alloys Ltd.
	Mandsaur Ferro Alloys Ltd.
	Monnet Industries Ltd.
	Nav Chrome Ltd.
	Nava Bharat Ferro Alloys Ltd.
	Standard Chrome Ltd.
	Tata Iron and Steel Co. Ltd.
	Bamnipal Plant.
	Joda Plant.
	VBC Ferro-Alloys Ltd.
	Visvesvaraya Iron & Steel Ltd. (State owned).
	V.K. Ferroalloys (Pvt.) Ltd.

See footnotes at end of table.

TABLE 16--Continued
PRINCIPAL WORLD FERROCHROMIUM PRODUCERS, 1996

Country 1/	Company
Italy	Acciaierie e Ferriere Lombarde Falck SpA.
	Darfo s.r.l.
	Ferroleghe SpA.
Japan	Japan Metals and Chemicals Co. Ltd.
	Nippon Denko Co. Ltd.
	NKK Corp.
	Pacific Metals Co. Ltd.
	Showa Denko K.K.
Kazakstan	Aktubinsk Ferroalloy Works.
	Aksu (formerly Yermakovsky) Ferroalloy Plant.
Norway	Elkem A/S.
Philippines	Ferrochrome Philippines Inc.
	Integrated Chrome Corp.
	Philippine Mineral & Alloy Corp.
Poland	Huta "Laziska" Ferroalloy Plant.
Romania	S.C. Ferom S.A.
Russia	Chelyabinsk Electrometallurgical Works.
	Klutchevsk Ferroalloy Plant.
	Serovsk Ferroalloy Works.
Slovakia	Oravske Ferozliatinarske Zavody.
Slovenia	Tovarna Dusika Ruse-Metalurgija d.o.o.
South Africa	Assoc. Manganese Mines of South Africa Ltd.
	Feralloys Ltd.
	Chromecorp Holdings Ltd.
	Chrome Resources (Pty.) Ltd.
	Ferrochrome Division.
	Johannesburg Consolidated Investment Co. Ltd.
	Consolidated Metallurgical Industries Ltd.
	Lydenburg Works.
	Rustenburg Works.
	Purity Ferrochrome (Pty.) Ltd.
	Samancor Ltd.
	Batlhako Ferrochrome Ltd.
	Ferrometals Division.
	Middelburg Ferrochrome Division.
	Palmiet Ferrochrome Division.
	Tubatse Ferrochrome Division.
Sweden	Vargön Alloy AB.
Turkey	Etibank General Management (Government owned).
United States	Elkem Metals Co.
	Macalloy Corp.
Zimbabwe	Zimbabwe Alloys Ltd.
	Zimasco (Pvt.) Ltd.

1/ Other ferrochromium-producing countries include Chile, Mexico, Spain and Taiwan.

TABLE 17
CHROMITE: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons, gross weight)

Country 3/	1992	1993	1994	1995	1996
Albania	322,000	282,000	222,879	245,813 r/	235,816
Brazil 4/	448,980	307,577	359,788	447,963 r/	450,000 e/
Burma e/	6,200	1,000	1,000	1,000 r/	1,000
China e/	25,000	54,000	62,000	94,000 r/	80,000
Cuba e/	50,000	50,000	50,000	50,000	50,000
Egypt e/	600	600	600	600	600
Finland	499,000	511,000	572,747	597,605 r/	582,174
Greece e/ 5/	4,000	2,500	--	--	--
India	1,082,069 r/	1,069,603 r/	909,076 r/	1,536,386 r/	1,363,205
Indonesia e/	2,000	2,500	2,500	10,000 r/	13,300
Iran 6/	130,265	114,780 r/	129,000	129,000 e/	129,000 e/
Japan e/	8,000	7,000	7,000	7,000	7,000
Kazakstan	3,500,000 e/	2,900,000 e/	2,020,000	2,871,000 r/	1,190,000
Macedonia e/	6,000	5,000	5,000	5,000	6,000
Madagascar	160,700	144,200	90,200	102,859 r/	137,210 p/
Morocco 7/	302 r/	-- r/	-- r/	-- r/	--
New Caledonia	8,169	--	--	--	--
Oman	1,764	10,236 r/	6,166	5,300	15,000
Pakistan	22,852	22,154	6,240	17,000 e/	27,987
Philippines	65,721 r/	61,732 r/	76,003 r/	111,035 r/	78,345
Russia	121,400	120,800	143,000	151,400	96,700
South Africa 8/	3,363,481	2,838,000 r/	3,599,000 r/	5,085,000 r/	5,017,550
Sudan e/	10,000	11,500	25,000	44,988 r/ 9/	12,000
Turkey 10/	758,732 r/	767,313 r/	1,270,431 r/	2,080,043 r/	2,000,000 e/
United Arab Emirates	1,000 e/	20,000 e/	55,000 r/	37,000 r/	56,000
Zimbabwe	522,013	252,033	516,801	707,433 r/	697,311
Total	11,100,000 r/	9,560,000 r/	10,100,000 r/	14,300,000 r/	12,200,000

e/ Estimated. p/ Preliminary. r/ Revised.

1/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through June 25, 1997.

3/ Figures for all countries represent marketable output unless otherwise noted.

4/ Average Cr_2O_3 content was as follows: 1992--44.1%; 1993--41.0%; 1994--41.3%; 1995--42.2% (revised); and 1996--42.2%.

5/ Direct-shipping ore plus concentrate.

6/ Concentrate.

7/ Chromite production from Compagnie de Tifnout Tiranimine (CTT) discontinued.

8/ Includes production by Bophuthatswana.

9/ Reported figure.

10/ Salable product: direct-shipping lump ore plus concentrate.

TABLE 18
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	1992	1993	1994	1995	1996 e/
Albania	21,650 r/	35,600 r/	33,764 r/	42,986	31,189 3/
Brazil 4/	91,100	83,892	77,163	95,840	72,609 3/
Chile	2,110	680	1,579	2,730	2,700
China e/	410,000	372,000	370,000	400,000	450,000
Croatia	56,456	27,336	31,704 r/	26,081 r/	10,559 3/
Czechoslovakia 4/ 5/	52,500	XX	XX	XX	XX
Finland	187,100	218,370	253,501 r/	246,805 r/	236,000
France	6,694	--	--	--	--
Germany	26,520	16,400	17,283	18,000 r/	16,000
India 6/	192,674 r/	234,500	251,459	300,000 e/	300,000
Iran 7/	--	--	7,150 r/	11,900 r/	15,000
Italy	60,315	53,504	22,650	51,017	29,915 3/
Japan 4/	275,615	211,102	204,181	221,425	200,365 3/
Kazakstan	400,000 e/	327,896	200,000 e/	486,000 r/	352,000
Macedonia	3,958	4,376	3,164	3,765	3,780 3/
Mexico	70 e/	--	--	--	-- 3/
Norway	102,000	80,000	120,000	148,000	108,800 3/
Philippines	27,400	11,908	16,186	50,450	--
Poland	35,322	38,449	7,353 r/	18,334	18,000
Romania	6,971 r/	3,907	3,885	15,053	9,650 3/
Russia	400,000 e/	255,900	265,525	200,000 e/	50,000
Slovakia 4/ 5/	XX	50,600	48,555	65,260	65,000
Slovenia	17,104	9,000	12,592	18,876	19,000
South Africa 8/	770,600	833,600	1,103,612	1,386,400 r/	1,400,000
Spain	--	2,390	2,300	1,320	805 3/
Sweden	133,300	127,543	134,076	130,170	138,110 3/
Turkey	85,755	90,030	97,585	94,251 r/	101,450 3/
United States 9/	60,900	63,000	67,400	72,500	36,800 3/
Zimbabwe 4/	190,994	124,000	182,852	254,142	261,918 3/
Total	3,620,000 r/	3,280,000	3,540,000 r/	4,360,000 r/	3,930,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ World totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through June 25, 1997.

3/ Reported figure.

4/ Includes high- and low-carbon ferrochromium.

5/ Czechoslovakia was dissolved on Dec. 31, 1992. All production for Czechoslovakia in 1992 came from Slovakia.

6/ Includes ferrochrome and charge chrome.

7/ Production began in 1994.

8/ Includes high- and low-carbon ferrochromium and ferrochromium-silicon.

9/ Includes high- and low-carbon ferrochromium, ferrochromium-silicon, chromium metal, and other chromium materials.

TABLE 19
WORLD CHROMIUM ANNUAL PRODUCTION CAPACITY OF CHROMITE ORE,
FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL IN 1996 1/

(Thousand metric tons, contained chromium)

	Ore	Ferro-chromium	Metal	Chemicals	Stainless steel
Albania	150	32	--	--	--
Argentina	--	--	--	6	--
Austria	--	--	--	--	12
Bangladesh	--	--	--	--	3
Belgium	--	--	--	--	107
Brazil	135	89	(2/)	12	37
Burma	(2/)	--	--	--	--
Canada	--	--	--	--	32
Chile	--	2	--	--	--
China	13	293	4	21	68
Croatia	--	42	--	--	--
Cuba	14	--	--	--	7
Egypt	1	--	--	--	--
Finland	211	131	--	--	89
France	--	--	5	--	163
Germany	--	28	(2/)	24	255
Greece	21	--	--	--	--
India	309	195	(2/)	8	100
Indonesia	20	--	--	--	--
Iran	34	83	--	2	--
Italy	--	64	--	--	182
Japan	3	146	1	20	660
Kazakstan	1,100	330	--	42	--
Korea, North	--	32	--	--	--
Korea, Republic of	--	--	--	--	150
Macedonia	3	7	--	5	--
Madagascar	21	--	--	--	--
Mexico	--	2	--	5	--
Norway	--	88	--	--	--
Oman	6	--	--	--	--
Pakistan	10	--	--	3	--
Philippines	60	60	--	--	--
Poland	--	16	--	3	--
Romania	--	26	--	9	--
Russia	40	233	14	60	330
Slovakia	--	39	--	--	--
Slovenia	--	11	--	--	--
South Africa	1,700	1,250	--	--	95
Spain	--	--	--	--	140
Sudan	2	--	--	--	--
Sweden	--	97	--	--	105
Taiwan	--	1	--	--	83
Thailand	(2/)	--	--	--	--
Turkey	580	103	--	10	54
Ukraine	--	--	--	--	33
United Arab Emirates	8	--	--	--	--
United Kingdom	--	--	4	52	92
United States	--	83	3	53	390
Zimbabwe	170	169	--	--	--
Total	4,610	3,650	32	336	3,190

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.