

TUNGSTEN

By Earle B. Amey

Tungsten's unique high-temperature properties can be utilized advantageously in the production of numerous end-use items. The high melting point, high density, good corrosion resistance, and good thermal and electrical conductivity properties of tungsten and its alloys and the excellent cutting and wear-resistant properties of its carbide continue to provide important items for consumption in the domestic and military sectors.

Total reported domestic consumption of tungsten in primary end-use categories increased by about 7% in 1994 compared with that of 1993. Demand generally increased in the cemented carbide end-use sectors that included the combined cutting tool, mining tool, oil drilling equipment, and wear-resistant component industries. Demand for tungsten chemicals and directly reusable tungsten scrap also increased in 1994. Counter to these increases was a decrease in the use of ferrotungsten in steels, which included the tool, alloy, and stainless steel sectors as well as a decrease in the demand for mill products made from metal powder. A gradual strengthening of the U.S. economy influenced the overall increase in demand for tungsten products during 1994.

The average Metal Bulletin (London) combined price for wolframite and scheelite concentrates, instituted in April 1992, increased about 23% in 1994 compared with that of 1993. The concentrate price increased to an average of \$42.35 per metric ton unit (mtu) tungsten oxide from an average of \$34.56 per mtu in 1993. This trend for 1994 reversed the downward trend that existed since 1992.

Prices for ammonium paratungstate (APT) on the world market increased during 1994, consistent with the increasing prices for concentrates. According to quotations in Metal Bulletin (London), the average price for APT on the U.S. market, duty-paid and delivered to processing plants, increased by 67% from an average of \$48.50 per mtu in January to an average of \$81.00 per mtu by yearend. Similarly, quotations for Chinese No. 1 Grade APT in Hong Kong increased by 192% during the year from an average price of \$29.50 per mtu to an average of \$86.00 per mtu. The average price of APT on the European free market increased by 157%, from \$35 per mtu to \$90 per mtu, according to quotations published

in Metal Bulletin (London).

As a result of a stronger tungsten market, at least one additional tungsten mine operator (none in the United States) was opened. The pattern of imports of tungsten materials by U.S. processors during 1994 showed a shift towards tungsten concentrate, tungsten oxide, tungsten scrap, and sodium tungstate and away from the intermediates ammonium paratungstate. Competition is apparently coming from the Russians. However, China continued to be the dominant supplier of tungsten materials to the United States in 1994, providing about 33% of all imported tungsten materials.

A summary of the important U.S. and international statistics for 1994 and the previous 4 years are shown in table 1. (*See table 1.*)

Legislation and Government Programs

The Office of the United States Trade Representative (USTR) investigated, under the Trade Act of 1974, acts, policies, and practices of the Government of China concerning the enforcement of intellectual property rights and the provision of property protection. If these acts, policies, and practices are to be unreasonable and constitute a burden or restriction on U.S. commerce, USTR will propose raising tariffs on a list of Chinese import articles. The antidumping tariffs on imports of tungsten ore concentrates and products from China, initially imposed on October 28, 1991, were extended until March 1995. These import duties are currently 37% on tungsten concentrates, 35% on tungsten oxide and acid, and 33% on tungsten carbide and fused carbide. The extent to which the tariffs might affect the European market is uncertain, primarily because ammonium paratungstate (APT), the major tungsten material being processed in Europe, is not included under these tariffs.

Three Republics in the former U.S.S.R. were granted Generalized System of Preferences (GSP) trade status. Documents signed by the President provided GSP status to Kazakhstan, Romania, and Ukraine effective in March. These Republics will be permitted to have its imports enter the U.S. duty free rather than be assessed the duty that exists under Most-Favored-Nation trade status. Tungsten affected by the GSP status includes concentrates,

ferrotungsten, carbide powder blends, and certain forms of waste and scrap.

Strategic Considerations

Tungsten is an important strategic material necessary for defense purposes, including the industrial base. Currently, the heavy-metal alloys of tungsten, containing 3% to 10% nickel and small quantities of iron or copper, are used in several of the smaller diameter projectiles for penetrating armor plate. Cemented tungsten carbide parts, which exhibit excellent cutting and wear-resistant properties, are vital to the U.S. metalworking, machining, construction, transportation, mining, and oil and gas drilling industries. Tungsten mill products and powders are essential to the lamp and lighting industry as filaments and electrodes; to the electrical and electronic industries as wear-resistant, electrically conductive contact surfaces; and to the superalloy and steel industries as alloying components. The Department of Defense (DOD) relies heavily on the maintenance of a broad domestic production base to cover mobilization contingencies. The entire tungsten industry, from mined ore to manufactured products, thus represents an important component of the U.S. defense policy. The DOD continually assesses the U.S. ability to produce tungsten to ensure that this and other sources of supply are sufficient to meet current and projected levels of demand necessary to preserve the national defense.

Issues

During 1994, prices for tungsten concentrates strengthened reaching 1992 levels. Major liquidation of both Russian and Chinese stockpiles occurred as the supply of tungsten ore tightened and a large amount of tungsten ore was put into production. Because of the uncertainty of the tungsten market, however, Western mine operators continued to leave its mine on care-and-maintenance status, or to keep its mines closed.

China remained the principal supplier of tungsten products to the world market during 1994, and many observers believe that stocks of Chinese concentrate have nearly been depleted. On the other hand, the quantity of tungsten materials available from Russia and certain

other members of the Commonwealth of Independent States (C.I.S.) began to become competitive with China. However, uncertainties still remain regarding the extent to which the C.I.S. might become a source of tungsten supply to the world market as it makes the transition to a market economy. Given all of these tungsten market factors, by yearend 1994 industry analysts believed a more balanced supply-demand condition was in place, but the future is very much dependent upon the Chinese.

Production

Domestic production data for tungsten are developed by the U.S. Bureau of Mines by means of two separate, voluntary surveys. These surveys are "Tungsten Ore and Concentrate" and "Tungsten Concentrate and Tungsten Products." Of the 15 mining and 14 processing operations to which survey requests were sent, response was received from 67% and 100%, respectively, of those operations surveyed. Production and stock totals for the survey respondents are shown in table 1.

Major processors of tungsten materials in 1994 were Buffalo Tungsten Inc., Depew, NY; General Electric Co., Euclid, OH; Osram Sylvania, Inc. (formerly GTE Products Corp.), Towanda, PA; Kennametal Inc., Latrobe, PA, and Fallon, NV; Teledyne Firth Sterling, LaVergne, TN; and Teledyne Advanced Materials (formerly Teledyne Wah Chang Huntsville), Huntsville, AL. Net production statistics for tungsten metal powders, carbides, and chemicals are shown in table 2. (See table 2.)

The already low tungsten mining activity in the United States further declined in 1994 as the uncertainties in the tungsten market continued. Only limited quantities of tungsten concentrate and ammonium paratungstate were produced by U.S. Tungsten Corp., a division of Strategic Minerals Corp., at its Pine Creek Mine and conversion facility in Bishop, CA.

General Electric Co. (GE) completely liquidated their Springer tungsten mine. The Winnemucca mine last operated in November 1982 and had been put on maintenance and care status.

Consumption

Total reported domestic consumption of tungsten in primary end-use categories (table 3) increased by about 7% in 1994 compared with that of 1993. Demand generally increased in the cemented carbide end-use sectors that included the combined cutting tool, mining tool, oil drilling equipment, and wear-resistant component industries. Demand for

ferrotungsten used in steels that included the tool, alloy, and stainless steel sectors, as well as demand for tungsten chemicals, also increased in 1994. Counter to these increases was a decrease in the demand for mill products made from powders and directly reusable tungsten scrap. (See table 3.)

Reported consumption of obsolete tungsten scrap, reprocessed either chemically or physically for reuse, decreased to 2,073 metric tons of contained tungsten in 1994 from 2,156 tons in 1993. Increased competition associated with the uncertainty in the market for primary and intermediate tungsten materials likely contributed to the decline in demand for this form of scrap.

Further strengthening of the U.S. economy influenced the overall increase in demand for tungsten products during 1994. A slow economic recovery in the major industrial sectors of auto, aerospace, and construction, where a significant quantity of tungsten is consumed as cemented carbide components, continued from 1993. Demand for cemented carbide components in the oil drilling industry fluctuated during 1994. The number of operating oil drilling rigs in the United States rapidly declined from a high of 813 in early January to a yearly low of 697 rigs in late May, then gradually increased to yearly high of 842 rigs by yearend 1994, according to figures reported by the International Association of Drilling Contractors and Baker Hughes Inc.

Foreign Trade

Comprehensive lists of U.S. export and import trade statistics by material quantity and value and by country of destination and origin are shown in tables 5 through 13. (See tables 5 through 13.)

The pattern of imports of tungsten materials by U.S. processors during 1994 showed a shift away from the intermediate ammonium paratungstate and toward tungsten concentrate and the intermediates tungsten oxide and sodium tungstate. The shift reversed a trend that began in 1991, subsequent to the imposition of the 151% antidumping tariff on imports of concentrate from China that effectively halted such imports. The concentrate prices increased during this period with an increase in demand and the appearance of a depletion of Chinese inventories. In 1994, concentrate represented a 44% share of the combined imports of concentrate and intermediates from all sources, compared with a 36% share in 1993, a 63% share in 1992, and an 87% share in 1990, prior to the antidumping tariff. The share of these combined imports of concentrate and intermediate materials provided

by China as intermediate materials was 37% in 1994 down from 51% in 1993.

Total U.S. imports of all tungsten materials increased by 43% in 1994 compared with those of 1993. China continued to be the dominant supplier, providing about 33% of all imported tungsten materials. China's share of the total quantity of tungsten materials imported by the United States was down about 11 percentage points compared with that of 1993. However, the total quantity of tungsten materials imported from China increased from 3,280 tons of contained tungsten in 1993 to 3,500 tons in 1994. Of the total tungsten imports from China in 1994, the percentage imported as intermediate products was 71%, about the same as 1993. Major suppliers of concentrates to the United States in 1994 included Russia (56%), Bolivia (18%), and Peru (10%).

World Review

Capacity.—Rated capacity for mines and mills as of December 31, 1994, was approximately 42,000 tons of contained tungsten. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on 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 both operating plants and plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure.

Mine capacity for tungsten is based on published reports, maximum production statistics, and estimates. The latter is utilized particularly for certain countries where capacity information is either incomplete or unavailable. Estimated annual mine production capacity declined by about 20% in 1994 compared with that of 1993. Some of this decline was attributed to an estimated lower capacity in the C.I.S., associated with the transition to a market economic system within the individual republics of the former U.S.S.R. Decline in mine capacity was attributed further to the apparent closure of additional smaller, inefficient mines in China, as well as to production declines at some larger mines, following the discontinuation of Government subsidies to tungsten mines during the last quarter of 1992.

Annual concentrate world production is shown by country in Table 14 and as a total in table 1; annual world concentrate consumption statistics are also shown in table 1. (See tables 1 and 14.)

Austria.—Metallgesellschaft (MG) put its shareholding in the Mittersill tungsten mine and the Wolfram Bergbau und Huttenengesellschaft conversion plant on the market. MG has a 67% shareholding, with Plansee Metall holding 26% and Teledyne 7%.

China.—According to published reports, the availability of tungsten materials from China became more limited. Many Chinese tungsten mines have closed down since 1991 as a result of low ore prices. China National Minerals and Metals Import and Export Corp. (Minmetals) ceased offering tungsten products, including ore concentrates, and the intermediate materials ammonium paratungstate (APT) and tungsten oxides, in late April 1994. A spokesperson for Minmetals indicated the action was necessary due to domestic shortages of tungsten ore and concentrates. As a result, day-to-day sales of some of the Chinese products are much more selective. Russian tungsten materials appear to be slowly entering the world market as an alternative source for consumers.

Commonwealth of Independent States.—During 1994, there were increased efforts by the republics of the former U.S.S.R to market a variety of tungsten-containing materials and products. Metallurgical operations that were formerly staffed and funded to meet the defense and aerospace requirements, as well as the domestic needs for mining and metalworking, were continuing plans to provide quality tungsten merchandise to the market. The merchandise expected to be marketed included tungsten oxide, metal and carbide powders, as well as a number of wrought shapes, such as rod, wire, tube, strip and foil, and certain end-use products, consisting of cemented carbide cutting tools, drill bits, and wear parts.

India.—Development of tungsten mining resources in India could be affected by privatization efforts underway in that country. India informed its mining policy in March 1993 to allow up to 50% foreign equity investment effective January 1994. Although Indian tungsten resources have not been fully delineated, an excess of 10 million tons of ore have been estimated with a metal content of about 50 thousand tons of tungsten.

International Tungsten Industry Association (ITIA).—The International Tungsten Industry Association (ITIA) held its seventh International Tungsten Symposium in Huntsville, Alabama (USA), November 2-4, 1994. Speakers from six countries presented a wide range of papers covering subjects, focusing on tungsten supply, demand, production, and consumption, as well as technological papers detailing developments in

applications of high-purity tungsten and chemical vapor deposited tungsten, new developments in indexable metal cutting inserts, and a review of hardmetals and tungsten heavy alloys markets. One of the highlights was provided by the Chinese delegation's presentation on various aspects of production and consumption in China. The paper stated that, in an effort to play a positive role in the world's tungsten market, the Chinese government had imposed new taxes and a strict export quota and licensing system.

Korea, Republic of.—The government of the Republic of Korea, consistent with its ongoing privatization process, sold its majority ownership in Korea Tungsten Mining Co. Ltd. (KTMC). The new owner, Keopyeong Group, a Korean conglomerate, will continue to maintain KTMC's Sangdong Tungsten Mine on care and maintenance status.

Japan.—Japan reportedly closed its last tungsten mine in September 1993. The mine, in Yamaguchi prefecture and owned by Tanaka Kogyo, supplied a portion of Japan's demand for tungsten, but for most of 1993 it operated well below capacity. Falling market prices for the intermediate tungstates made it more economical and practical to import additional quantities of the intermediates, mainly from China, than to domestically produce and process the concentrate.

Peru.—Avocet Ventures Inc., B.C., Canada, parent company of Waller Metals Ltd., London, U.K., purchased an additional tungsten mining interest in Peru. Fermin Malaga Santolalla e Hijos Negociacion Minera S.A., Peruvian owner and operator of the Pasto Bueno Mine, sold 40% of the mine's shares to Avocet. The Pasto Bueno Mine, located in the Pampas District of the Pallasca Province in Ancash Department, near Lima, had been operated on a limited basis in recent years because of low tungsten prices. Fermin Malaga is, with the assistance of Avocet, developing plans to bring production and milling to its rated capacity of 1,200 tons of tungsten per year. Avocet also holds a 20% interest in Peru's Minera Regina, owner of the Palaca XI tungsten mine, with an option to increase the equity interest to 41%. The mine started production in January and has been increasing output of tungsten concentrates primarily to fulfill its long-term contract with Osram (USA).

Portugal.—Avocet Ventures Inc., B.C., Canada, parent company of Waller Metals Ltd., London, U.K., announced plans to reopen the Panasquiera tungsten mine near Fundao in January 1995. Minorco SA, Luxembourg, the company from whom Avocet purchased the mine in early 1994, had placed it on care and maintenance status at the end of 1993.

According to a spokesperson for the new ownership of the Panasquiera Mine, a strengthening of the tungsten market was foreseen.

Russia.—According to published reports, Russia, a former trade recipient of Chinese tungsten materials, shipped several tons of tungsten concentrates into China. China is reported to be converting the Russian concentrates into ammonium paratungstate for export as a means of circumventing Chinese import restrictions on tungsten concentrates.

Sandvik AB, Sandviken, Sweden, a leading manufacturer of cemented tungsten carbide products, acquired more than 50% interest in a major Russian carbide manufacturing company. The Russian company, Moskovoskji Kombinat Tverdih Splavov (MKTS), manufactures and markets cemented carbide components for use as machine tools, rock-drilling tips and wear parts. Sandvik has had a 20-year association with MKTS and began to acquire shares in the company when MKST initiated a move to privatize in 1993. According to a spokesperson for Sandvik, the acquisition was an important step towards creating a base for supplying the Russian industry with cemented carbide products as gains are made in the Russian economy.

United Nations Conference on Trade and Development (UNCTAD).—The third Meeting of the UNCTAD Intergovernmental Group of Experts on Tungsten (IGE) was held in Geneva, Switzerland, November 7-9, 1994. The Secretariat from the UNCTAD, as well as individual delegations, provided a positive outlook for the world tungsten industry, but also outlined several issues that confronted the international tungsten industry. Possibly significant is the emergence of The Russian Federation as a supplier of a broad range of tungsten products, Kazakhstan as a possible supplier of ore and concentrate, and the erratic relationship between ore and concentrate prices versus the prices for intermediate tungsten prices. Most importantly, however, was the lack of participation from China and their unsatisfactory quality and level of participation in reporting statistics to the Secretariat.

The Secretariat requested to continue statistical data collection and dissemination, as well as review of the tungsten market, an essential ingredient for continued market transparency. This objective has eluded IGE because significant market participants, such as China, do not participate in data collection. As a result, IGE decided to remit to the fourth session of the Standing Committee on Commodities the determination of a date for the fourth session of the IGE on tungsten.

The Director of Marketing for the Metal

Powder Industry Federation in Princeton, New Jersey, an industry advisor to the U.S. delegation, presented a paper entitled, "U.S. Tungsten Demand Grows in Face of Shrinking Raw Materials Base". He stated that U.S. producers are enjoying good business, but are concerned regarding the availability of ore, concentrates, and intermediate products for the near and longterm.

Current Research and Technology

GE Lighting, a division of General Electric Co., Fairfield, Conn., introduced in Europe a new energy-saving lamp without a tungsten filament that instead uses a high-frequency magnetic field to produce light. The lamp will be introduced first to industrial consumers. It consumes only 23 watts to produce light similar to a 100-watt incandescent reflector lamp and still fits into existing sockets. In addition, the new "induction" reflector light bulb lasts about 10 times longer. Each year about 384,000 pounds of tungsten are sold in the United States to make filaments for light bulbs.¹

Tungsten, rhenium, and molybdenum wires have reportedly been laminated between sheets of niobium by means of explosive welding processes developed by Northwest Technical Industries in order to produce composites with high strength at high temperatures. The time duration required for explosive welding is so short that the heat-affected zone between the constituent materials is microscopic. Therefore, the initial physical and mechanical properties of the alloys are not degraded. These composites are being developed for the next generation of gas turbine and rocket engines.²

A new technique, which can create new metallurgical powder combinations, can also plate materials less expensively. This technique, called Self-Propagated High-temperature Synthesis (SPHTS), does not require as high a temperature nor the special equipment as previous methods. The technique can be used commercially to coat cutting tools or milling machines, and can be used to create incredible metallurgical powder combinations that have up to 20 times better adhesion. In addition, SPHTS can increase the hardness, as well as, life and usefulness of the hard alloy and ceramic tools.³

Tungsten carbide is being used in a punch to push out fibers in metal, ceramic, and polymer matrix composites. This fiber push-out apparatus can, at the same time, measure the fiber-matrix bond strength and sliding stress. These critical parameters can influence a composite's strength, fatigue, crack growth, and creep behavior. As a result, the apparatus has been used to examine failure modes in

composite fibers with multiple coating layers, to study the effects of variables in hot isostatic pressing, and to investigate the effects of fiber distribution on interfacial properties.⁴

Military researchers are focusing on replacing depleted uranium (DU) in penetrators, piercing tanks, and armor with heavy tungsten alloys. DU retains some radioactivity and is difficult to clean up. Currently, a DU penetrator makes a narrower hole and deeper penetration than would its tungsten-bearing counterpart. Researchers are working on these property differences and expect that the most likely replacement would be alloys containing combinations of tungsten, nickel, iron, and cobalt.⁵

Outlook

Based on the first quarter reported consumption of all tungsten products, the total annual demand for tungsten materials in the United States in 1995 was estimated to be about 9,000 tons of contained tungsten. This would represent an increase in consumption of approximately 10% compared with the 8,112 tons reported for 1994. The economic recovery rate in 1995 is expected to exceed slightly the modest gains the economy experienced in 1994. As a result, overall demand for cutting and wear-resistant components integrally associated with the metalworking, machining, construction, transportation, mining, and oil and gas drilling industries is expected to increase moderately in 1995. In particular, the consumption of cemented carbide tool bit inserts is expected to increase as the automobile market grows and the requirement for machined automobile parts correspondingly rises. In the short term, demand for tungsten in the lighting, electrical, and electronic sectors is expected to continue to increase slowly, although there could be a significant erosion of this demand should the recent breakthroughs in the development of tungsten-free light bulbs begin to capture a significant portion of the lighting market. The general rate of growth in tungsten demand will continue to be dampened by the effects of substitution in the cutting and wear-resistant component industries as well as by technological improvements within the industry that result in a more efficient use of tungsten.

The sources of future supplies of tungsten concentrate and intermediate materials for U.S. consumption became less certain by the end of 1994 as observers indicated that some clearing of inventories by traders had taken place. Specifically, the future supply of ammonium paratungstate from China, the predominate world provider, remained questionable in view of the continued low mine production that was

limiting the quantity of concentrate production. In addition, China was believed to have exhausted its supply of concentrate stocks. Consequently, a more balanced tungsten supply-demand condition began to emerge at the end of 1994. In the short term, the tungsten market was expected to correct the transition from an oversupply of tungsten to one that more closely balances its supply and demand, effectively allowing for the entrance of more producers into the market.

¹Wall Street Journal. GE Lighting Unit To Unveil in Europe Energy-Saving Lamp. V. 223, No. 77, Apr. 20, 1994, p. B6.

²Butler, D. Refractory Metal Composites Laminated by Explosive Bonding. Advanced Materials & Processing. V. 146, No. 4, Oct. 1994, p. 7.

³American Metal Market. Powder Technology Applied to Plating. V. 102, No. 101, June 1994, p. 5.

⁴Touchstone Research Laboratory. Fiber-Matrix Bond Strength and Sliding Stress Measured. Advanced Materials & Processes. V. 145, No. 2, Feb. 1994, p. 14.

⁵American Metal Market. Tungsten Understudy for Armor-Piercing Role. V. 102, No. 208, Oct. 1994, p. 5.

⁶New Coatings and Surfaces. Deposition of Tungsten Films With Controlled Structure. Nov. 1993, p. 2.

OTHER SOURCES OF INFORMATION

Bureau of Mines Publications

Tungsten. Reported monthly in Mineral Industry Surveys.

Tungsten Chapter in Mineral Commodity Summaries.

Other Sources

American Metal Market (daily paper).

Federal Register.

ITIA Newsletters.

Metal Bulletin (London).

Platt's Metals Week.

Private correspondence.

UNCTAD Reports. Meeting of Intergovernmental Group of Experts on Tungsten. November 1994.

TABLE 1
SALIENT TUNGSTEN STATISTICS 1/

(Metric tons of tungsten content unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Concentrate:					
Mine production	W	W	W	W	W
Mine shipments	W	W	W	W	W
Value thousands	W	W	W	W	W
Consumption	5,880 2/	5,310 2/	4,310	2,870 3/	3,630 3/
Shipments from Government stocks	--	--	--	--	--
Exports	139	21	38	63	44
Imports for consumption	6,420	7,840	2,480	1,720	2,960
Stocks, Dec. 31:					
Producer	16	26	44	44	44
Consumer	1,080	1,780	702	592	756
Ammonium paratungstate:					
Production	6,330 2/	5,860 2/	5,760	4,730 2/	536 4/
Consumption	8,790	8,900 5/	7,010	6,970	7,080
Stocks, Dec. 31: Producer and consumer	896	578	333	420	82
Primary products:					
Net production	4,680 6/	8,980	8,450	9,410	7,410
Consumption	8,500	7,980	6,910	7,580	8,110
Stocks, Dec. 31:					
Producer	1,460 7/	1,670 7/	1,510 7/	1,480 7/	1,160 7/
Consumer	793	796	601	716	849
World:					
Concentrate:					
Production	51,900 r/	48,200 r/	40,400 r/	32,000 r/	25,500 e/
Consumption 8/	45,300	41,900 r/	38,500 r/	31,800 r/	29,800 e/

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

2/ Excludes 2 months of "Withheld" data.

3/ Excludes 3 months of "Withheld" data.

4/ Excludes 11 months of "Withheld" data.

5/ Excludes 1 month of "Withheld" data.

6/ Includes only hydrogen-reduced metal powder and chemicals.

7/ Excludes tungsten carbide-cast and crystalline.

8/ Based on data received from United Nations Conference on Trade and Development, Apr. 1995.

TABLE 2
NET PRODUCTION 1/ AND STOCKS OF TUNGSTEN PRODUCTS IN THE UNITED STATES 2/

(Metric tons of tungsten content)

	Hydrogen reduced metal powder	Tungsten carbide powder		Chemicals	Total
		Made from metal powder	Cast and crystalline		
Net production 1994	3,190	4,220	W	W	7,410
Net production 1993	4,660	4,750	W	W	9,410
Producer stocks, Dec. 31, 1994	648	390	W	120	1,160
Producer stocks, Dec. 31, 1993	816	519	W	147	1,480

W Withheld to avoid disclosing company proprietary data.

1/ Gross production less quantity used to make other products in table.

2/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits.

TABLE 3
 REPORTED CONSUMPTION AND STOCKS OF TUNGSTEN PRODUCTS
 IN THE UNITED STATES IN 1994, BY END USE 1/

(Metric tons of tungsten content)

End Use	Ferro- tungsten 2/	Tungsten metal powder	Tungsten carbide powder	Tungsten scrap 3/	Other tungsten materials 4/	Total
Steel:						
Stainless and heat-resisting Alloy	30	--	--	5	--	20
Tool	18	--	--	--	--	19
Superalloys	529	--	--	W	W	529
Alloys (excludes steels and superalloys):	W	W	33	199	W	300
Cutting and wear-resistant materials	--	97	5,640	W	W	5,920
Other alloys 5/	W	W	--	W	--	W
Mill products made from metal powder	--	1,200	--	--	--	1,200
Chemical and ceramic uses	--	W	(6/)	--	105	108
Miscellaneous and unspecified	--	--	--	--	W	W
Total	582	1,330	5,670 7/	388	141	8,110
Consumer stocks, Dec. 31, 1994	20	22	767 7/	40	(8/)	849

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

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes scheelite, natural and synthetic.

3/ Does not include that used in making primary tungsten products.

4/ Includes tungsten chemicals and others.

5/ Includes welding and hard-facing rods and materials and nonferrous alloys.

6/ Included in "Tungsten carbide powder: Cutting and wear-resistant materials."

7/ Based on reported consumption plus information from secondary sources on companies not canvassed; includes estimates.

8/ Included in "Tungsten scrap."

TABLE 4
 MONTHLY PRICE QUOTATIONS OF TUNGSTEN CONCENTRATE IN 1994

Month	Metal Bulletin (London), European market, 65% WO3 basis, c.i.f. 1/				Metals Week, U.S. spot quotations, 65% WO3 basis, c.i.f. U.S. ports, including duty 2/			
	Dollars per metric ton unit			Dollars per short ton unit	Dollars per short ton unit			Dollars per metric ton unit
	Low	High	Average	Average	Low	High	Average	Average
January	27.00	39.00	33.00	29.94	28.00	40.00	34.00	37.48
February	27.00	39.00	33.00	29.94	28.00	45.00	37.00	40.79
March	28.00	43.00	36.06	37.71	35.00	45.00	40.00	44.10
April	33.00	45.00	39.00	35.38	35.00	45.00	40.00	44.10
May	33.00	45.00	39.00	35.38	35.00	45.00	40.00	44.10
June	35.00	47.00	40.89	37.09	35.00	47.00	40.40	44.53
July	37.00	47.00	42.00	38.10	37.00	48.00	43.50	47.95
August	37.00	47.00	42.00	38.10	40.00	48.00	44.00	48.50
September	37.00	53.00	46.33	42.03	40.00	48.00	44.00	48.50
October	45.00	55.00	50.00	45.36	40.00	48.00	44.00	48.50
November	45.00	60.00	52.50	47.63	40.00	48.00	44.00	48.50
December	47.00	60.00	54.63	49.56	40.00	48.00	44.00	48.50

1/ Combined wolframite and scheelite quotations. Low and high prices are reported semiweekly. Monthly averages are arithmetic averages of semiweekly low and high prices. The average annual price per metric ton unit of WO3, of all semiweekly low and high prices was \$42.35 for 1994. The average equivalent price per short ton unit of WO3 was \$38.42 for 1994.

2/ Low and high prices are reported weekly. Monthly averages are arithmetic averages of weekly low and high prices. The average annual price per short ton unit of WO3, of all weekly low and high prices was \$41.22 for 1994. The average equivalent price per metric ton unit of WO3 was \$45.43 for 1994.

TABLE 5
U.S. EXPORTS OF TUNGSTEN ORE AND CONCENTRATE, BY COUNTRY

Country	1993		1994	
	Tungsten content 1/ (metric tons)	Value (thou- sands)	Tungsten content 2/ (metric tons)	Value (thou- sands)
Canada	3	\$14	--	--
France	1	3	--	--
India	1	6	--	--
Japan	--	--	41	\$195
Korea, Republic of	1	3	--	--
Mexico	2	8	3	14
Netherlands	55	269	--	--
South Africa, Republic of	1	4	--	--
Taiwan	1	3	--	--
Total	63	309	44	209

1/ Calculated based upon an estimated value of \$39 per metric ton unit WO₃.

2/ Calculated based upon an estimated value of \$38 per metric ton unit WO₃.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF AMMONIUM PARATUNGSTATE, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou- sands)	Tungsten content (metric tons)	Value (thou- sands)
Belgium	--	--	54	\$1,110
Germany	2	\$28	91	303
Japan	164	2,180	35	175
Netherlands	--	--	70	614
Total	166	2,210	250	2,200

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. EXPORTS OF TUNGSTEN CARBIDE POWDER, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Argentina	2	\$45	(2/)	\$22
Australia	8	435	7	229
Austria	27	366	55	920
Belgium	11	227	3	132
Brazil	8	168	16	197
Canada	373	7,870	411	9,550
Chile	--	--	(2/)	22
China	--	--	6	38
Denmark	169	1,120	65	442
Finland	1	81	2	48
France	14	208	92	1,250
Germany	226	3,270	135	2,570
India	(2/)	4	(2/)	13
Ireland	4	191	--	--
Israel	4	389	10	673
Italy	58	1,910	89	2,930
Japan	83	1,120	42	973
Korea, Republic of	1	54	2	235
Luxembourg	3	54	3	102
Mexico	2	124	1	112
Netherlands	52	716	99	1,340
Portugal	--	--	5	44
Singapore	5	192	3	185
South Africa, Republic of	14	162	13	212
Spain	--	--	1	16
Sweden	84	1,200	106	2,120
Switzerland	12	742	22	853
Taiwan	4	181	18	496
United Kingdom	78	1,500	108	1,690
Venezuela	3	100	4	131
Other	2	59	1	95
Total	1,250	22,500	1,320	27,600

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 8
U.S. EXPORTS OF TUNGSTEN AND TUNGSTEN ALLOY POWDER, BY COUNTRY 1/

Country	1993			1994		
	Gross weight (metric tons)	Tungsten content 2/ (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content 2/ (metric tons)	Value (thousands)
Australia	7	6	\$63	4	3	\$66
Austria	5	4	73	1	1	29
Belgium	1	1	24	3	2	93
Brazil	17	14	17	7	6	222
Canada	36	29	792	43	34	930
Finland	1	1	28	2	2	54
France	1	1	66	11	9	344
Germany	104	83	2,460	207	166	5,910
Hong Kong	2	2	36	1	1	30
Israel	121	97	807	152	122	1,380
Italy	6	5	252	3	2	111
Japan	9	7	198	4	3	122
Korea, Republic of	1	1	29	1	1	64
Mexico	5	4	115	18	14	216
Netherlands	81	65	661	2	2	38
Singapore	32	26	455	53	42	806
South Africa, Republic of	1	1	18	2	2	56
Spain	(3/)	(3/)	7	--	--	--
Sweden	23	18	23	21	17	314
Switzerland	5	4	123	17	14	271
Taiwan	23	18	653	15	12	389
Turkey	1	1	16	(3/)	(3/)	4
United Kingdom	34	27	926	25	20	1,010
Other	1	1	21	2	2	87
Total	516	416	7,860	595	477	12,500

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Tungsten content estimated by multiplying gross weight by 0.80.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 9
U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Tungsten and tungsten alloy wire:				
Argentina	1	\$6	--	--
Belgium	--	--	1	\$59
Brazil	4	247	(2/)	60
Canada	5	368	4	201
China	1	102	4	518
France	(2/)	51	(2/)	54
Germany	3	189	(2/)	70
Hong Kong	1	99	2	158
India	17	1,030	10	626
Italy	1	166	(2/)	26
Japan	7	898	3	421
Korea, Republic of	3	170	1	67
Mexico	4	230	4	330
Netherlands	(2/)	17	(2/)	28
Poland	(2/)	11	(2/)	3
Switzerland	(2/)	6	(2/)	3
Taiwan	8	440	5	395
United Kingdom	1	150	2	197
Other	9	642	4	316
Total	65	4,830	40	3,530
Unwrought tungsten and alloy in crude form, waste and scrap:				
Australia	32	284	106	527
Belgium	(2/)	4	--	--
Canada	11	189	70	546
Chile	4	61	1	6
France	--	--	2	11
Germany	144	1,270	256	1,170
Israel	3	39	1	10
Italy	--	--	23	182
Japan	--	--	7	37
Mexico	17	365	63	354
Spain	10	62	15	83
Sweden	5	42	12	100
Taiwan	2	732	3	42
United Kingdom	28	150	25	154
Other	7	63	49	252
Total	263	3,260	633	3,470
Other tungsten metal:				
Australia	2	165	1	61
Belgium	(2/)	7	(2/)	68
Brazil	2	251	2	238
Canada	9	437	4	256
Colombia	1	221	(2/)	31
France	1	314	2	330
Germany	6	445	2	213
Hong Kong	4	699	4	783
India	2	119	2	92
Ireland	1	69	(2/)	103
Italy	2	134	1	645
Japan	6	1,950	8	1,360
Korea, Republic of	2	139	3	258
Mexico	8	818	4	455
Netherlands	(2/)	124	(2/)	192
Singapore	2	432	2	601
South Africa, Republic of	1	81	1	102
Sweden	(2/)	12	(2/)	39
Switzerland	(2/)	120	(2/)	98
Taiwan	9	784	3	236
Thailand	1	65	(2/)	31
United Kingdom	10	722	14	859
Venezuela	(2/)	56	(2/)	61
Other	3	350	4	833
Total	70	8,510	55	7,950

See footnotes at end of table.

TABLE 9-Continued
U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Ferrotungsten and ferrosilicon tungsten:				
Canada	1	\$8	1	\$13
Germany	--	--	31	50
Mexico	--	--	7	8
Total	1	8	39	71
Wrought tungsten:				
Canada	40	1,260	58	1,820
France	6	379	9	693
Germany	5	181	24	680
India	8	424	11	569
Israel	10	147	1	124
Italy	4	283	8	566
Japan	12	1,110	8	977
Korea, Republic of	7	598	18	881
Mexico	1	78	4	181
Netherlands	(2/)	39	(2/)	136
Saudi Arabia	19	1,490	--	--
Singapore	2	67	1	50
Spain	6	220	7	319
Taiwan	1	223	3	382
United Kingdom	6	391	3	328
Venezuela	1	21	--	--
Other	3	299	6	531
Total	131	7,220	161	8,230
Other tungsten compounds: 3/				
Argentina	--	--	(2/)	7
Brazil	11	152	37	292
Canada	6	22	3	9
Colombia	(2/)	3	1	8
Japan	--	--	17	56
Netherlands	--	--	49	236
Sweden	--	--	36	100
United Kingdom	3	36	6	54
Other	--	--	1	43
Total	20	213	150	804

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Includes only other tungstates.

Source: Bureau of the Census.

TABLE 10
U.S. IMPORTS FOR CONSUMPTION OF TUNGSTEN ORE AND
CONCENTRATE, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou- sands)	Tungsten content (metric tons)	Value (thou- sands)
Australia	--	--	74	\$507
Bolivia	762	\$3,390	542	2,090
Brazil	--	--	76	342
Burma	55	245	11	64
Chile	--	--	27	107
Japan	31	142	--	--
Korea, Republic of	--	--	14	68
Mexico	48	137	58	269
Netherlands	47	161	--	--
Peru	299	1,450	306	1,280
Portugal	240	1,550	--	--
Russia	1	4	1,660	3,600
Rwanda	132	399	--	--
Thailand	34	168	126	587
Uganda	73	195	57	130
Vietnam	--	--	11	63
Total	1,720	7,840	2,960	9,110

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM
PARATUNGSTATE, BY COUNTRY 1/

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou- sands)	Tungsten content (metric tons)	Value (thou- sands)
China	934	\$5,080	625	\$3,240
Germany	109	1,000	160	1,590
Hong Kong	115	346	45	249
Japan	(2/)	12	--	--
Russia	--	--	18	140
Sweden	17	39	--	--
Total	1,180	6,480	848	5,220

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

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

Country	1993		1994	
	Tungsten content (metric tons)	Value (thou- sands)	Tungsten content (metric tons)	Value (thou- sands)
Austria	27	\$152	--	--
China	516	2,220	484	\$1,720
France	1	3	--	--
Germany	(2/)	5	--	--
Hong Kong	78	285	--	--
Mexico	31	161	31	161
Total	652	2,830	515	1,880

1/Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS
TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Waste and scrap:				
Australia	1	\$2	--	--
Austria	19	90	--	--
Belgium	4	30	115	\$511
Brazil	31	154	18	75
Canada	6	28	20	80
China	74	408	159	1,000
France	23	89	102	367
Germany	241	1,090	531	2,580
Ireland	46	276	32	168
Israel	85	254	80	211
Italy	41	161	129	401
Japan	197	1,110	401	1,600
Korea, Republic of	8	48	20	47
Mexico	1	5	5	22
Netherlands	36	250	31	220
Pakistan	75	132	18	34
Portugal	13	66	6	28
Russia	10	60	132	858
Singapore	41	133	36	142
South Africa, Republic of	61	277	76	334
United Kingdom	235	889	561	1,910
Other	1	6	127	474
Total	1,250	5,560	2,600	11,100
Unwrought tungsten, except alloys, in lumps, grains, and powders:				
Belgium	2	104	3	110
Canada	12	369	11	389
China	-	--	61	691
Germany	17	745	24	871
Hungary	10	55	--	--
Japan	14	1,170	12	1,280
Russia	4	17	--	--
South Africa, Republic of	1	23	27	108
Uganda	--	--	13	20
United Kingdom	30	322	34	207
Other	5	131	14	142
Total	95	2,930	199	3,820
Unwrought tungsten, ingots, shot, alloy, and other:				
Austria	(2/)	19	2	164
China	(2/)	2	--	--
Germany	6	234	--	--
South Africa, Republic of	120	61	10	15
Other	4	5	(2/)	12
Total	130	320	12	190
Wrought tungsten-wire, plate, sheet, strip, foil, and other: 3/				
Austria	15	1,700	(2/)	52
Belgium	1	397	1	156
Canada	--	--	5	379
China	10	581	6	369
France	(2/)	122	(2/)	106
Germany	6	905	4	680
Israel	27	1,410	14	671
Japan	76	10,700	54	7,370
Mexico	6	1,190	(2/)	236
Netherlands	5	593	(2/)	375
Russia	(2/)	10	(2/)	4
United Kingdom	3	322	5	466
Other	8	570	14	1,210
Total	158	18,500	104	12,100

See footnotes at end of table.

TABLE 13-Continued
 U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS
 TUNGSTEN-BEARING MATERIALS 1/

Product and country	1993		1994	
	Tungsten content (metric tons)	Value (thousands)	Tungsten content (metric tons)	Value (thousands)
Calcium tungstate:				
Bolivia	--	--	10	\$45
China	158	\$531	254	927
Germany	3	176	2	106
Japan	(2/)	17	(2/)	28
Total	161	723	267	1,110
Tungsten oxides:				
Austria	--	--	59	338
China	1,090 4/	5,060	890	4,470
Germany	234 4/	737	2	43
Hong Kong	44 4/	188	52	368
Russia	38 4/	315	929	5,140
Switzerland	--	--	43	164
United Kingdom	(2/) 4/	61	5	34
Other	(2/)	5	1	6
Total	1,400	6,370	1,980	10,600
Other metal-bearing materials in chief value of tungsten:				
China	4	101	--	--
Germany	--	--	(2/)	5
Total	4	101	(2/)	5
Chlorides of tungsten:				
China	41 4/	192	--	--
Other	(2/)	12	--	--
Total	41	204	--	--
Sodium tungstate:				
Bolivia	--	--	3	12
China	405	1,590	991	4,330
Germany	24	105	(2/)	39
Hong Kong	--	--	--	--
Japan	(2/)	29	(2/)	14
Zambia	(2/)	2	--	--
Total	429	1,730	994	4,390
Tungsten carbide:				
Austria	57	761	(2/)	12
Canada	31	833	10	369
China	53	1,050	30	919
France	3	63	24	349
Germany	99	1,690	159	2,790
Hong Kong	3	41	5	73
Israel	--	--	8	107
Japan	1	303	2	91
Korea, Republic of	17	318	17	252
Mexico	9	344	--	--
Sweden	13	364	--	--
United Kingdom	3	60	(2/)	2
Other	3	65	4	119
Total	291	5,890	258	5,080

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Less than 1/2 unit.

3/ Quantity estimated from reported gross weight.

4/ All or part of these data have been referred to the Bureau of the Census for verification.

Source: Bureau of the Census.

TABLE 14
TUNGSTEN: WORLD CONCENTRATE PRODUCTION, BY COUNTRY^{1/ 2/}

(Metric tons of tungsten content)

Country	1990	1991	1992	1993	1994e/
Argentina	6	5 r/	-- r/	-- r/	--
Australia	1,090	237	159 r/	23 r/	11
Austria	1,380	1,310	1,490 r/	104 r/	--
Bolivia	1,010	1,070	851	262 r/	450
Brazil	316	223	205	245 r/	250
Burma ^{3/}	443 r/	356 r/	531 r/	524 r/	580
China e/ ^{4/}	32,000	31,800	25,000	21,600 r/	16,500
Czechoslovakia e/ ^{5/}	84	13	XX	XX	XX
India	10 e/	11	11	1 r/	1
Japan	260	279	347	66 r/	-- ^{6/}
Kazakhstan e/	XX	XX	200 r/	150 r/	100
Korea, North e/	1,000	1,000	1,000	1,000	900
Korea, Republic of	1,360	780	247	200	--
Malaysia	--	2	3	2	-- ^{6/}
Mexico	183	194	162	160 e/	150
Mongolia e/	500	300	260	250	250
Peru	1,540	1,230	802	398 r/	800
Portugal e/	1,410 r/	971 r/	1,870 r/	1,280 r/ e/	1,000
Russia e/	XX	XX	6,500 r/	5,000 r/	4,000
Rwanda e/	156 ^{7/}	175	175	175	30
Spain	10	--	--	--	--
Tajikistan e/	XX	XX	200	150	100
Thailand	290	230	70	18 r/ e/	20
Uganda e/	4	4	66 ^{6/}	60	60
U.S.S.R. e/ ^{8/}	8,800	8,000	XX	XX	XX
United Kingdom	42	9	-- r/	-- r/	--
United States	W	W	W	W	W
Uzbekistan e/	XX	XX	300	300	300
Zaire	17	15 e/	--	--	--
Zimbabwe e/	1	1	--	--	--
Total	51,900 r/	48,200 r/	40,400 r/	32,000 r/	25,500

e/ Estimated. r/ Revised. W Witheld to avoid disclosing company proprietary data; not included in "Total." XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through July 5, 1995.

3/ Includes content of tin-tungsten concentrate.

4/ Based upon data published in the Yearbook of Nonferrous Metals Industry of China, 1992 and 1993.

5/ Dissolved Dec. 31, 1992.

6/ Reported figure.

7/ Estimate based on reported gross weight with a content of 54% W and 68% WO₃.

8/ Dissolved in Dec. 1991.