

INDUSTRIAL DIAMOND

By Gordon T. Austin

Industrial diamond is natural diamond that does not meet the standards of gem diamond because of its color, size, or other imperfection. Also, it may be a synthetic diamond that is tailor-made for industrial applications.

Legislation and Government Programs

The National Defense Stockpile (NDS) for industrial diamonds, as of December 31, 1994, had a goal of zero and an inventory of 2.5 million carats for crushing bort. The goal for industrial stones was 3.0 million carats and the inventory was 5.54 million carats. There is currently legislative authority for disposal of 4.0 million carats of bort and 3.0 million carats of industrial stones. The inventory of small diamond dies was about 25,500 pieces compared with a goal of zero pieces; but no disposal authorization was issued.

Production

The United States was the largest producer of synthetic industrial diamond. This has made the United States independent of foreign sources for crushing bort or similar diamond except for grit sizes larger than about 20 mesh. Having no production of natural diamond, it was dependent on other countries for its natural diamond supply.

Three domestic firms produced synthetic industrial diamond in the United States: Du Pont Industrial Diamond Div., Gibbstown, NJ; General Electric Co., GE Superabrasives, Worthington, OH; and Suprahards, Inc. Cedar Knolls, NJ. Three firms, Megadiamond Industries Inc., a subsidiary of Smith International Inc., Provo, UT., U.S. Synthetics Corp., Orem, UT; and Temple Technology of New Jersey manufactured polycrystalline diamond from purchased synthetic diamond grit. The firms had the capability to manufacture synthetic industrial diamond grit, but chose not to for economic reasons. Publishing production data would disclose company proprietary data. Domestic production did increase significantly. The United States continued to be the largest single producer of synthetic industrial diamond, a role it has enjoyed since 1957.

U.S. secondary production of industrial diamond was from six firms. They were

Amplex Corp., Worcester, MA; American Boarts Crushing, Boca Raton, FL; Diamondsharp Corp., Keene, NH; Industrial Diamond Laboratory Inc., Bronx, NY; Industrial Diamond Powders Co., Pittsburgh, PA; International Diamond Services Inc., Houston, TX; and National Research Co., Fraser, MI. The firms reclaimed a total of about 16.1 million carats from used drill bits, diamond tools, and wet and dry diamond-containing waste.

Consumption

The United States continued to be the largest single consumer of industrial diamond. The U.S. Bureau of Mines estimate of apparent consumption of industrial diamond was approximately 154 million carats, a slight increase compared with 1993 consumption.

The principal uses of industrial diamond stones are in drilling bits and reaming shells, single- or multiple-point diamond tools, diamond saws, diamond wheels, abrasive and diamond wire-drawing dies. Miscellaneous uses include: engraving points, glass cutters, bearings, surgical instruments and special tools. Changes in technology and conventional wisdom have resulted in an increased use of synthetic industrial diamonds and polycrystalline diamond shapes (PDS) and compacts (PDC) for many of the uses listed above. There has been an increased use of PDS, PDC, and matrix set synthetic diamond grit in drilling bits and reaming shells in the last three years. Diamond saws, diamond wheels, and diamond abrasive grit and powder are almost exclusively made from synthetic diamond. PDS and PDC are used in the manufacture of single- and multiple-point tools and PCD is used in a majority of the diamond wire-drawing dies.

Mineral, oil, and gas exploration were the primary uses of drilling bits and shells. Foundation testing for dams, buildings, and other construction also used diamond bits and shells, as did masonry drilling in buildings for conduits and access and testing of concrete in various structures and other similar applications. The primary uses of diamond tools were for dressing and trueing grinding wheels and for cutting, machining, boring, and finishing. Beveling glass automobile windows

also was a use. Cutting dimension stone, ceramics, and concrete in highway reconditioning were the major uses of diamond saws. The forming of refractory shapes for furnace linings also uses diamond saws. Diamond wire dies were essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys.

Diamond grit, powders, and fragmented bort go into diamond grinding wheels, saws, impregnated bits and tools, and loose abrasives compounds for lapping and polishing.

Three major types of grinding wheels were made--resinoid, metal, and vitrified bonds--in many shapes and sizes designed for specific applications. The sizes range up to 1 meter in diameter for very large industrial wheels. Sharpening and shaping of carbide machine tool tips, grinding of dies, edging of plate glass, and optical grinding were among the primary applications of diamond grinding wheels. The cutting of concrete, stone, ceramics, and composite materials were uses of saws made with diamond grit. Very fine saws sliced wafers from brittle metals and crystals for use in electronic and electric devices.

Finishing optical surfaces, jewel bearings, gem stones, wiredrawing dies, cutting tools, and metallographic specimens were the primary uses of polishing and lapping powder and compounds. Hundreds of other important items made from metals, ceramics, plastics, and glass also were finished with diamond compounds.

Prices

The Bureau does not collect price data on industrial diamonds. The Bureau did track the average import value of various classifications of industrial diamonds. The average value of U.S. imports of natural grit and powder, synthetic grit and powder, and industrial stones was \$0.87 per carat, \$0.49 per carat, and \$9.41, respectively.

Foreign Trade

The United States was the largest exporter of industrial diamond grit and powder in the world. The United States exported and reexported a record 153 million carats of natural and synthetic grit and powder, an increase of 43% over the record set in 1993. The material

was worth a record \$143 million. Additionally, the U.S. exported and reexported approximately 4.4 million carats of industrial stones, valued at \$89.6 million. Imports of dust, grit, and powder in 1994 were a record high 174 million carats, about 31% more than those in 1993. The 1994 imports of diamond stones were 2.8 million carats, about 46% less than 1993 imports. (See tables 1 and 2.)

Outlook

Synthetic industrial diamond production is significantly larger than the production of natural industrial diamonds. The countries that have synthetic diamond production, in declining order are; the United States, Ireland, Russia, South Africa, China, Germany, Japan, Sweden, Republic of Korea, Czechoslovakia, Romania, France, and Greece.

Diamond grit and powder should experience substantial increases in domestic demand for every end use during the next 5 years. The increases for synthetic grit and powder are expected to be greater than for natural. The constant-dollar prices of these materials, especially the synthetic diamond products, should continue to decrease or at least remain constant. This is because planned production increases will make them more cost-effective. The contract construction industry is an area in which the greatest increases will occur. This is because large quantities of saw-grade diamond will be required for highway and bridge repair and replacement. Large increases also are expected in the dimension stone industry as a cutting and polishing media. The stone, clay, and glass industries will increase their uses in cutting, shaping, and polishing media. Additionally, polycrystalline synthetic diamond compacts and shapes will continue to displace natural diamond stone and tungsten carbide drill bits in the mineral services sector. The probable average annual growth rate in U.S. production is about 10%, based on estimates by the U.S. producers. U.S. production of synthetic material is sufficient to supply U.S. diamond grit and powder demand. The United States will continue to be a major exporter.

The major domestic end use for industrial stones in the next 5 years will continue to be in the oil, gas, and mineral industries. These stones are natural and cannot yet be manufactured commercially. Polycrystalline synthetic diamond compacts and shapes have had a major negative impact on the natural industrial diamond stone markets. This will limit the growth of U.S. demand for stone during the next 5 years. U.S. consumption should average between 6 and 7 million carats per year for the next 5 years. Approximately

50% of the potential natural stone applications will be replaced by the synthetic compacts and shapes by the year 2000. (See table 3.)

Other Sources

U.S. Bureau of Mines Publications
Diamonds (Industrial) Ch. Mineral Commodity Summaries, 1995
Abrasive Materials Annual Report, 1993
Mineral Facts and Problems, 1985

TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY 1/

(Thousand carats and thousand dollars)

Country	National industrial diamond stones (including glazers' and engraver's diamond unset) (7102.21.3000 and .4000)				Miners' diamond, natural and synthetic (7102.21.1010 and .1020)			
	1993		1994		1993		1994	
	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/
Belgium	96	420	84	683	528	6,710	453	3,830
China	39	34	2	2	--	--	(3/)	3
Ghana	236	3,300	101	1,990	6	300		
India	76	58	9	19	22	5	--	--
Ireland	169	536	90	120	94	269	30	194
Japan	9	82	(3/)	3	2	118	1	36
Netherlands	47	2,190	2	1,810	203	2,290	118	1,270
South Africa, Republic of	23	81	37	118	(3/)	38	--	--
Switzerland	(3/)	5	(3/)	2	256	947	272	885
United Kingdom	1,560	7,120	843	6,780	422	3,860	291	3,620
Zaire	960	3,780	80	838	115	2,380	238	3,410
Other	62	682	68	310	276	467	86	480
Total	3,280	18,300	1,320	12,700	1,920	17,400	1,490	13,700

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/ Customs value.

3/ Less than 1/2 unit.

Source: Bureau of the Census.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF DIAMOND POWDER, DUST AND GRIT, BY COUNTRY 1/

(Thousand carats and thousand dollars)

Country	Diamond powder and dust, synthetic (7105.10.0020; 0030 and .0050)				Diamond powder and dust, natural (7105.1011 and .0015)			
	1993		1994		1993		1994	
	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/	Quantity	Value 2/
Belgium	383	652	1,050	1,920	1,250	2,730	772	1,860
China	5,140	1,710	4,920	735	43	35	1,630	272
Germany	11,900	9,690	22,200	4,630	101	157	522	574
Hong Kong	48	22	3,390	1,080	302	53	60	13
India	--	--	38	19	34	31	18	8
Ireland	76,400	45,800	95,400	60,000	4,090	5,890	3,310	4,100
Japan	3,730	2,660	3,170	2,220	132	189	2	4
Korea, Republic of	2,920	1,020	5,290	3,940	15	35	841	270
Russia	10,600	1,760	17,700	2,010	90	67	217	227
South Africa, Republic of	389	111	56	31	3	2	--	--
Switzerland	2,540	2,340	509	282	368	113	450	155
Ukraine	6,840	988	5,370	468	2	2	--	--
United Kingdom	2,650	2,270	3,190	1,370	836	1,450	1,760	943
Zaire	--	--	30	22	359	234	997	551
Other	1,340	714	1,090	1,070	332	281	400	521
Total	125,000	69,800	163,000	79,800	7,950	11,300	11,000	9,510

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/ Customs value.

Source: Bureau of the Census.

TABLE 3
NATURAL DIAMOND: WORLD PRODUCTION, BY TYPE AND COUNTRY 1/ 2/

(Thousand carats)

Country	1990			1991		
	Gem 3/	Industrial	Total	Gem 3/	Industrial	Total
Angola 4/	1,060	73	1,130	899	62	961
Australia	17,300	17,300	34,700	18,000	18,000	36,000
Botswana	12,200	5,200	17,400	11,600	4,950	16,500
Brazil	600	900	1,500	600	900	1,500 e/
Central African Republic	303	78	381	296	82	378 r/
China e/	200	800	1,000	200	800	1,000
Gabon e/	400	100	500	400	100	500
Ghana	520	130	650	560	140	700
Namibia	750	15	763	1,170	20	1,190
Russia e/	XX	XX	XX	XX	XX	XX
Sierra Leone 5/	66	12	78	160	83	243
South Africa, Republic of	3,900 r/	4,800 r/	8,710	3,800 r/	4,600 r/	8,430
U.S.S.R. e/ 6/	12,000	12,000	24,000	10,000	10,000	20,000
Venezuela	85	248	333	102	112	214
Zaire	2,910	16,500	19,400	3,000	14,800	17,800
Total	48,400	53,400	102,000	47,000	50,000	97,000
Other	4,200	5,000	9,000	4,000	4,800	9,000
Grand total	52,600 r/	58,400 r/	111,000 r/	51,000 r/	54,800	106,000 r/

Country	1992			1993		
	Gem 3/	Industrial	Total	Gem 3/	Industrial	Total
Angola 4/	1,100	80	1,180	130 r/	15 r/	145 r/
Australia	18,100 r/	22,100 r/	40,200 r/	18,800 r/	23,000 r/	41,900 r/
Botswana	11,200	4,790	15,900	10,300 r/	4,420 r/	14,700 r/
Brazil	653	665	1,320	600	900	1,500 e/
Central African Republic	307	107	414	370 r/	125 r/	495 r/
China e/	200	800	1,000	230	850	1,080
Gabon e/	400	100	500	400	100	500
Ghana	570	140	710	570 r/	140 r/	710 r/ e/
Namibia	1,520 r/	30 r/	1,550	1,120 r/	20 r/	1,140
Russia e/	9,000	9,000	18,000	8,000	8,000	16,000
Sierra Leone 5/	180 r/	116 r/	296	90	68	158
South Africa, Republic of	4,600 r/	5,600 r/	10,200 r/	4,600 r/	5,700 r/	10,300
U.S.S.R. e/ 6/	XX	XX	XX	XX	XX	XX
Venezuela	302	176	478	145 r/	155 r/	301 r/
Zaire	8,930	4,570	13,500	2,010 r/	13,600 r/	15,600 r/
Total	52,500	42,700	95,000	42,800	51,400	94,200
Other	4,800	5,800	11,000	4,900	5,900	10,800
Grand total	57,300 r/	48,500 r/	106,000 r/	47,700 r/	57,300 r/	105,000 r/

See footnotes at the end of table.

TABLE 3--Continued
 NATURAL DIAMOND: WORLD PRODUCTION, BY TYPE AND COUNTRY 1/

(Thousand carats)

Country	1994 e/		
	Gem 3/	Industrial	Total
Angola 4/	270	30	300
Australia	19,500	23,800	43,300
Botswana	11,000	5,000	16,000
Brazil e/	600	900	1,500
Central African Republic	370	125	495
China e/	230	850	1,080
Gabon e/	400	100	500
Ghana	580	145	725
Namibia	1,280	30	1,310 7/
Russia e/	8,500	8,500	17,000
Sierra Leone 5/	155	100	255
South Africa, Republic of	5,000	5,800	10,600 7/
U.S.S.R. e/ 6/	XX	XX	XX
Venezuela	220	175	395
Zaire	4,000	13,000	17,000
Total	47,100	52,800	99,900
Other	5,200	5,900	11,100
Grand total	52,300	58,700	111,000

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

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

2/ Table includes data available through May 30, 1995. Total natural diamond output (gem plus industrial) for each country actually is reported, except where indicated by a footnote to be estimated. In contrast, the detailed separate production data for gem diamond and industrial diamond are U.S. Bureau of Mines estimates except Brazil (1990) and Central African Republic (1990-93), for which source publications give details on grade as well as totals. The estimated distribution of total output between gem and industrial diamond is conjectural, and for most countries, is based on the best available data at time of publication.

3/ Includes near-gem and cheap-gem qualities.

4/ Figures do not include smuggled artisanal production.

5/ Figures are estimates based on reported exports and do not include smuggled diamonds.

6/ Dissolved in Dec. 1991.

7/ Reported figure.

TABLE 4
SYNTHETIC DIAMOND: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand carats)

Country	1990	1991	1992	1993	1994 e/
Belarus e/	XX	XX	30,000	30,000	25,000
China e/	15,000	15,000	15,000	15,500	15,500
Czech Republic	XX	XX	XX	5,000 e/	5,000
Czechoslovakia e/ 3/	10,000	10,000	10,000	XX	XX
France e/	5,000	4,000	3,500	3,500	3,500
Greece e/	1,000	1,000	750	1,000	1,000
Ireland e/	60,000	60,000	60,000	66,000	65,000
Japan e/	25,000	30,000	30,000	32,000	32,000
Romania e/	3,000	3,000	5,000 r/	5,000 r/	5,000
Russia e/	XX	XX	80,000	80,000	80,000
Serbia and Montenegro	XX	XX	5,000	5,000	5,000
Slovakia	XX	XX	XX	5,000	5,000
South Africa, Republic of e/	60,000	60,000	60,000	60,000 r/	60,000
Sweden e/	25,000	25,000	25,000	25,000	25,000
U.S.S.R. e/ 4/	120,000	120,000	XX	XX	XX
Ukraine e/	XX	XX	10,000	10,000	8,000
United States	W	90,000	90,000	103,000	104,000
Yugoslavia e/ 5/	5,000	5,000	XX	XX	XX
Total	329,000 r/	423,000	424,000 r/	446,000 r/	439,000

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data. 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 May 30, 1995.

3/ Dissolved Dec. 31, 1992.

4/ Dissolved in Dec. 1991.

5/ Dissolved in Apr. 1992.