DIAMOND, INDUSTRIAL

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Diamond may well be the world's most versatile engineering material as well as its most famous gemstone. The superiority of diamond in so many diverse industrial applications is attributable to a unique combination of properties that cannot be matched by any other material. For example, diamond is the strongest and hardest known material and has the highest thermal conductivity of any material at room temperature (May 1995).

As the hardest substance known (more than twice as hard as its nearest competitors[1]), diamond has been used since biblical times[2] as a grinding, drilling, cutting, and polishing tool (Yoder, 1994, p. 3). Today, industrial-grade diamond (i.e., diamond that does not meet gem-quality standards for color, clarity, size, or shape) continues to be used principally as an abrasive in many applications despite its higher cost. Even though it is more expensive than competing abrasive materials, diamond has proven to be more cost effective in numerous industrial processes because it cuts faster and lasts longer than any rival (Boucher, 1997).

In addition to its utility as an abrasive, diamond has other exceptional properties (e.g., chemical, electrical, and optical characteristics) that make it ideal for many industrial uses—including wear- and corrosion-resistant coatings, special lenses, heat sinks in electrical circuits, and wire drawing—as well as for research and development in advanced technologies.

Both synthetic (i.e., manufactured) diamond and natural diamond have industrial uses. Synthetic industrial diamond, however, is superior to its natural diamond counterpart because it can be produced in unlimited quantities, and, in many cases, its properties can be tailored for specific applications (Boucher, 1996). Consequently, manufactured diamond accounts for more than 90% of the industrial diamond used in the United States.

Legislation and Government Programs

In 1998, the National Defense Stockpile (NDS), operated by the U.S. Department of Defense (DOD), contained the following categories of industrial diamond: industrial stone, bort, and diamond dies. At yearend, the NDS had an inventory of 3.1 million carats of industrial stone valued at $31 million; 62,300 carats of diamond bort valued at $331,000; and 25,500 pieces of diamond dies valued at $255,000 (Cook, 1999).

Congress has authorized the DOD to dispose of all NDS diamond dies and portions of the stockpiled stone and bort. During 1998, more than 411,000 carats of stockpiled diamond stone were sold for $23 million, one of the largest NDS disposals conducted during the year (Tom Meeker, Defense Logistics Agency, oral commun., 1999); no stockpiled diamond bort or diamond dies were sold. The DOD plans to conduct additional sales until all NDS diamond stocks are exhausted. Further information concerning NDS diamond is available in the "Prices" section of this report.

Production

The U.S. Geological Survey conducts an annual survey of domestic industrial diamond producers and U.S. firms that recover diamond wastes. Although most of these companies responded to the 1998 survey, a few significant firms withheld certain data that they deemed confidential. Thus, only estimates of U.S. primary and secondary output are provided below.

As one of the world's leading producers of synthetic industrial diamond, the United States accounted for an estimated output of 140 million carats in 1998. Only two U.S. companies produced synthetic industrial diamond during the year—Du Pont Industrial Diamond Division, Gibbstown, NJ, and GE Superabrasives, Worthington, OH. General Electric Co., Fairfield, CT, which owns GE Superabrasives and other diamond manufacturing plants abroad, is one of the world's largest producers of industrial diamond.

In 1998, nine firms also manufactured polycrystalline diamond (PCD) from synthetic diamond grit and powder. These companies were the Dennis Tool Co., Houston, TX; GE Superabrasives; Novatek Inc., Provo, UT; Phoenix Crystal, Ann Arbor, MI; Precorp Inc., Provo, UT; SII Megadiamond Industries Inc., Provo, UT; Tempo Technology Corp., Somerset, NJ; U.S. Synthetic Corp., Orem, UT; and Western Diamond Products, Salt Lake City, UT (Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1998).

An estimated 10 million carats of used industrial diamond were recycled in the United States during 1998. Most of this material was recovered by recycling firms from used drill bits, diamond tools, and other diamond-containing wastes. Additional diamond was recovered during the year from residues generated in the manufacture of PCD; most of this material was recovered for PCD from within their production operations (Wilson Born, National Research Company, oral commun., 1999).

The recovery and sale of industrial diamond was the principal business of four U.S. companies in 1998: Industrial

[1]Cubic boron nitride and silicon nitride are the hardest rivals (Ravi, 1994, p. 337).

[2]Diamond was used as a tool (for engraving) before 300 B.C.

Diamond Laboratory Inc., Bronx, NY; Industrial Diamond Powders Co., Pittsburgh, PA; International Diamond Services Inc., Houston, TX; and National Research Company, Fraser, MI. In addition to these companies, other domestic firms may recover industrial diamond in smaller secondary operations.

Consumption

In 1998, as in preceding years, the United States continued to be the world's largest market for industrial diamond. On the basis of economic indicators, such as production and trade data, estimated U.S. consumption of industrial diamond rose to a record high of at least 270 million carats during the year. This peak in growth primarily reflects expanded output in domestic industries where diamond is used. The following U.S. industry sectors were the principal consumers of industrial diamond in 1998: construction, computer chip production, machinery manufacturing, mining services (drilling, etc.), stone cutting/polishing, and transportation systems (infrastructure and vehicles[3]). Within these sectors, stone cutting and highway building/repair together accounted for the largest demand. Research and high technology uses included polishing silicon wafers and disks drives in the computer industry, heat sinks in electronic circuits, lenses for laser radiation equipment, and close-tolerance machining of ceramic parts for the aerospace industry (Bailey and Bex, 1995).

Diamond tools have a myriad of industrial functions. Diamond drilling bits and reaming shells are used principally for mineral, oil, and gas exploration. Additional applications for diamond bits and reaming shells include foundation testing, masonry drilling, and inspecting concrete in various structures. The primary uses of point diamond tools are for dressing and truing grinding wheels and for cutting, machining, boring, and finishing; beveling glass for automobile windows also is an application. Cutting dimension stone and cutting/grooving concrete in highway reconditioning are the major uses of diamond saws; other applications include the cutting of composites and the forming of refractory shapes for furnace linings. Very fine diamond saws are used to slice brittle metals and crystals into thin wafers for electronic and electric devices. Diamond wire dies are essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys. The primary uses of diamond grinding wheels include the sharpening and shaping of carbide machine tool tips, die grinding, plate glass edging, and optical grinding.

Two types of natural diamond are used by industry: diamond stone (generally larger than 60 mesh/800 microns) and diamond bort (smaller, fragmented material). Diamond stone is employed primarily in drilling bits and reaming shells used by mining companies; it also is incorporated in single- or multiple-point diamond tools, diamond saws, diamond wheels, and diamond wire dies. Diamond bort is utilized for drilling bits and as a loose grain abrasive for polishing. Other tools that incorporate natural diamond include: engraving points, glass cutters, bearings, and surgical instruments.

[3] One and a half carats of industrial diamond reportedly are consumed in the production of every automobile made in the United States.

Synthetic diamond grit and powder are used in diamond grinding wheels, saws, impregnated bits and tools, and as loose abrasive compounds for polishing. The diamond grinding wheels can be as much as 1 meter in diameter.

Loose powders and compounds made of synthetic diamond for polishing are used primarily to finish optical surfaces, jewel bearings, gemstones, wiredrawing dies, cutting tools, and silicon wafers for computer chips. Hundreds of other products made from metals, ceramics, plastics, and glass also are finished with diamond powders and compounds.

The use of polycrystalline diamond shapes (PDS) and compacts (PDC) continues to increase for many of the applications cited above, including some of those that employ natural diamond. In particular, the use of PDS, PDC, and matrix-set synthetic diamond grit for drilling bits and reaming shells has increased in recent years. Moreover, PDS and PDC are used in the manufacture of single- and multiple-point tools, and PDC is used in a majority of the diamond wire-drawing dies. In combination with uses in the silicon chip and computer industry, the manufacturing of PCD for PDS and PDC now accounts for much of the diamond powder consumed in the United States (Wilson Born, National Research Company, oral commun., 1998).

Prices

Natural and synthetic industrial diamonds differ significantly in price (Boucher, 1997). Natural industrial diamond, which normally has a more limited range of values, varies in price from approximately $0.30 per carat for bort-size material to about $7 to $25 per carat for most stone.

Synthetic industrial diamond has a much greater range of prices, which varies according to size, shape, crystallinity, and the absence or presence of metal coatings. In general, synthetic diamond for grinding and polishing generally varies from $0.30 per carat (as low as $0.10 per carat for low-quality material) to $1 per carat; strong and blocky material for sawing and drilling sells for $2 to $3 per carat. Prices are dropping in some markets because of low-cost imports from Russia and China (Fred Penna, Jr., Industrial Diamond Powders Co., oral commun., 1999). Large synthetic crystals with excellent structure for specific applications sell for several hundred dollars per carat.

In 1998, the DOD appraised the average per-carat market value of diamond bort and industrial stone in the NDS at $5.35 and $10, respectively. In certain cases, however, significantly higher assessments of industrial diamond in the stockpile have been made by those who bid on diamonds offered for sale during the year by the DOD; for example, some bidders at the NDS disposal sale in May 1998 paid an average of more than $237 per carat for diamonds that they valued as gem-quality stones (Tom Meeker, Defense Logistics Agency, oral commun., 1999). Bids at a subsequent sale in early 1999 ranged from $1 to $122 per carat (Defense Logistics Agency, 1999).

Foreign Trade

In 1998, the United States continued to lead the world in industrial diamond trade; imports came from 41 countries (tables 1 and 2), and exports/reexports went to 40 countries (tables 3 and 4). Although the United States has been a major producer of synthetic diamond for decades, its growing domestic markets have become more reliant on foreign sources of industrial diamond in recent years. Moreover, U.S. markets for natural industrial diamond always have been dependent on imports and secondary recovery operations because domestic production of natural diamond was lacking.

During 1998, U.S. imports of diamond powder, dust, and grit reached 221 million carats valued at $96 million. Imports of industrial quality stones were 4.7 million carats valued at $18 million. China, Russia, and Ukraine are expected to become more important sources of synthetic diamond for U.S. markets. Some prices of diamond from China were as low as $0.18 per carat (Jean Etienne, Funik Ultrahard Materials Co., Ltd., written commun., 1998).

During 1998, the United States exported and reexported about 4.6 million carats of industrial diamond stone valued at $35 million (table 3). Additionally, the United States exported and reexported 108 million carats of industrial diamond powder, dust, and grit valued at $89 million (table 4). Reexports can account for a significant portion of total exports/reexports; therefore, exports and reexports are listed separately in tables 3 and 4 so that U.S. trade and consumption can be calculated more accurately.

World Review

Despite declines in the economies of several industrialized nations in 1998, total industrial diamond output worldwide during the year was estimated to be well above 500 million carats; various reports estimate that global output was at least 600 million carats valued between $600 and $800 million (Wilson Born, National Research Company, oral commun., 1998; Glenn Han, IMEC Company, oral commun., 1999; Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1999). World demand for industrial diamond in the 1990's had been growing at annual rates of more than 10% (Boucher, 1997). The decline of several important Asian markets, however, dampened demand for some products during 1997 and 1998 (Ellis, 1998; Union Minière, 1998).

More than 30 countries produced industrial diamond in 1998 (tables 5 and 6). In addition to the countries listed in table 6, Germany and the Republic of Korea produce synthetic diamond (Norman Rohr, Warren Diamond Powder Co., Inc., 1999), but specific data on their output could not be confirmed. China may produce much more than the output shown in the table (Wilson Born, National Research Company, oral commun., 1999; Norman Rohr, Warren Diamond Powder Co., Inc., oral commun., 1999).

Two-thirds of global industrial diamond output was focused in just four countries: the United States, Ireland,[4] Russia, and South Africa (Lombardero, 1998). Furthermore, at least 70% of world's synthetic output in 1998 was manufactured by only two companies: General Electric and De Beers Consolidated Mines Limited (Boucher, 1997; Lombardero, 1998). The dominance of synthetic diamond was even more pronounced, accounting for more than 90% of global production and consumption.

Outlook

The United States will continue to be the world's largest market for industrial diamond well into the 21st century and will remain a significant producer and exporter of industrial diamond as well. Strength of the Nation's demand for industrial diamond will depend on the vitality of the domestic industrial base that employs diamond and on how well the life cycle cost-effectiveness of diamond compares with competing materials that initially are less expensive.

The many advantages that diamond offers for precision machining and longer tool life, which compensate for increases in other production line costs, seem certain to spur demand for diamond tools. In fact, even the use of wear-resistant diamond coatings to increase the life of materials that compete with diamond promises to be a rapidly growing application (May 1999). Increased tool life not only leads to lower costs per unit of output, but also means fewer tool changes and longer unattended production runs (Advanced Materials & Processes, 1998). In view of the many advantages that cascade from increased tool life, and reports that diamond film surfaces can increase durability by a factor of 50 (Advanced Materials & Processes, 1998), much wider use of diamond as an engineering material is expected.

The most dramatic increase in U.S. demand for industrial diamond is likely to occur in the construction sector as the $200 billion Federal Transportation Equity Act legislation of 1998[5] is implemented to increase funding for improvements in the Nation's highway system. Demand for saw-grade diamond alone is expected to increase by more than $1 billion to fulfill goals mandated by the Act for the repair and replacement of roads, bridges, and other components in the transportation infrastructure of the country (Wilson Born, National Research Company, oral commun., 1999).

Domestic high-tech industries also will drive U.S. demand for industrial diamond. The most rapid rate of growth may be exhibited in the electronics sector, where diamond tools are used to slice high-purity silicon wafers into micro transistor chips and to polish CD's and computer disk drives.

Outside the United States, world demand for industrial diamond will continue to increase, but probably at a slower rate during the next few years as the industrialized economies in Asia begin to recover from the recession of 1997-98. Constant-dollar prices of synthetic diamond products, including chemical vapor deposition diamond films, will decline as production technologies become more cost effective and competition from low-cost producers in China and Russia increases. Nevertheless, competing demand for diamond among certain

[4]Some reports estimate that Ireland rather than the United States may be the world's largest producer.

[5]The legislation (P.O. 105-178; enacted June 9, 1998) is titled, Transportation Equity Act for the 21st Century, and will fund road building and repair through 2003.

consuming industries could induce short-term price increases for some products (Wilson Born, National Research Company, oral commun., 1998). Moreover, concentration of production among a limited number of major industrial diamond manufacturers could tend to limit price reductions.

According to industry sources, PCD for abrasive tools and wear parts will continue to replace competing materials in many industrial applications by providing closer tolerances, as well as extending tool life. For example, PDC and PDS will continue to displace natural diamond stone and tungsten carbide products used in the drilling and tooling industries (Wison Born, National Research Company, written commun., 1998).

Truing and dressing applications will remain a major domestic end-use for natural industrial diamond stone. The stone cannot be manufactured commercially. No shortage of the stone is anticipated, however, because new mines and more producers selling in the rough diamond market will maintain ample supplies. More competition introduced by the additional sources also may temper price increases.

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

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

(Thousand carats and thousand dollars)

	Natural industrial diamond stones (including glazers' and engravers' diamond unset; HTS 7102.21.3000 and .4000) 2/				Miners' diamond, natural and synthetic (HTS 7102.21.1010 and .1020) 2/			
	1997		1998		1997		1998	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Belgium	238	1,320	175	978	308	3,700	63	427
China	12	15	30	38	--	--	365	52
Congo (Kinshasa) 4/	19	287	15	188	20	1,180	3	182
Ghana	252	1,910	252	1,540	130	682	41	416
India	46	47	23	55	(5/)	7	2	201
Ireland	326	503	685	2,130	120	18	35	209
Japan	6	136	1	38	--	--	--	--
South Africa	6	165	2	4	2	243	(5/)	744
Switzerland	2	20	(5/)	34	357	840	575	1,240
United Kingdom	139	549	445	1,090	225	6,190	200	4,330
Other	551	3,200	942	3,310	28	443	862	1,250
Total	1,600	8,150	2,570	9,410	1,190	13,300	2,150	9,050

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Source: Harmonized Tariff Schedule of the United States.
3/ Customs value.
4/ Formerly Zaire.
5/ 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)

	Synthetic (HTS 7105.10.0020; .0030 and .0050) 2/				Natural (HTS 7105.10.0011 and .0015) 2/			
	1997		1998		1997		1998	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Belgium	3,910	4,900	4,600	5,120	2,520	2,320	2,700	2,340
China	39,000	7,250	38,700	6,480	9,270	1,510	350	173
France	1,320	810	223	205	347	157	27	23
Germany	1,920	393	8	16	30	35	75	59
Ghana	269	203	95	65	296	197	192	198
Hong Kong	1,180	297	807	562	1,170	145	--	--
India	526	181	2,050	711	135	61	1,070	375
Ireland	108,000	63,200	100,000	57,300	2,450	1,400	1,770	865
Japan	5,620	2,790	5,760	3,080	12	13	5	15
Korea, Republic of	14,800	8,950	8,990	6,310	764	473	1,360	723
Russia	46,900	6,730	6,540	2,140	399	100	18	23
Switzerland	5,870	2,090	3,510	1,830	380	467	1,370	874
United Kingdom	2,810	2,590	4,540	1,790	766	391	1,190	538
Other	2,110	618	34,600	4,430	771	773	625	232
Total	235,000	101,000	210,000	90,000	19,300	8,040	10,700	6,430

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Source: Harmonized Tariff Schedule of the United States.
3/ Customs value.

Source: Bureau of the Census.

TABLE 3
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND STONES, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Industrial unworked diamonds (HTS 7102.21.0000) 2/			
	1997		1998	
Country	Quantity	Value 3/	Quantity	Value 3/
Exports:				
Belgium	34	240	46	218
Canada	218	649	187	484
Germany	62	432	206	930
Hong Kong	8	55	2	24
Ireland	12	121	27	235
Israel	3	41	4	54
Italy	13	71	4	39
Japan	84	833	179	1,810
Korea, Republic of	5	43	32	319
Netherlands	16	85	7	70
Switzerland	14	131	3	30
United Kingdom	17	155	109	176
Other	76	590	43	380
Total	561	3,450	849	4,760
Reexports:				
Belgium	1,800	15,000	3,010	23,000
Canada	214	616	79	366
Germany	21	223	17	140
Hong Kong	85	691	56	559
Ireland	8	79	10	85
Israel	132	1,780	189	1,890
Japan	645	6,520	291	2,810
Korea, Republic of	93	788	67	675
Netherlands	1	3	--	--
Switzerland	9	88	7	69
United Kingdom	17	185	27	282
Other	7	67	6	74
Total	3,030	26,100	3,760	30,000
Grand total	3,590	29,500	4,610	34,700

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Source: Harmonized Tariff Schedule of the United States.
3/ Customs value.

Source: Bureau of the Census.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND POWDER, DUST AND GRIT, BY COUNTRY 1/

(Thousand carats and thousand dollars)

	Synthetic (HTS 7105.10.0025) 2/				Natural (HTS 7105.10.0010) 2/			
	1997		1998		1997		1998	
Country	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/	Quantity	Value 3/
Exports:								
Australia	679	1,290	469	952	10	25	6	13
Austria	1,380	821	2,630	1,250	112	126	214	221
Belgium	4,460	5,260	4,370	4,350	400	330	994	497
Brazil	1,660	1,140	814	396	--	--	18	93
Canada	3,370	6,000	1,610	1,740	115	272	82	185
China	1,590	1,190	1,580	1,700	--	--	24	6
France	126	78	185	109	11	28	22	41
Germany	4,960	3,520	4,460	2,780	155	140	157	104
Hong Kong	4,040	3,250	2,280	2,250	348	92	8	15
India	9,490	3,790	5,800	1,930	28	30	413	308
Ireland	26,600	29,800	33,500	38,000	124	262	55	100
Israel	230	89	610	175	974	222	--	--
Italy	1,540	688	1,900	902	108	70	113	76
Japan	25,700	20,500	19,100	13,700	747	631	368	485
Korea, Republic of	10,800	7,680	9,030	5,320	77	34	219	302
Luxembourg	259	195	91	41	62	68	--	--
Macao	1,660	406	--	--	309	165	141	129
Malaysia	849	497	356	154	2	4	47	22
Mexico	277	222	682	539	194	138	43	46
Singapore	6,550	3,190	1,930	801	97	65	189	91
Switzerland	3,090	1,620	2,760	1,820	344	186	682	366
Taiwan	6,460	3,910	2,020	2,270	11	3	16	9
Thailand	524	325	359	294	117	80	128	95
United Kingdom	2,650	725	1,850	598	1,360	699	1,160	1,020
Other	1,250	1,310	768	501	98	177	223	122
Total	120,000	97,500	99,100	82,600	5,810	3,850	5,320	4,340
Reexports:								
Australia	--	--	--	--	1	3	--	--
Belgium	1,020	225	--	--	--	--	--	--
Brazil	193	104	704	313	5	3	4	3
Canada	544	1,190	426	797	10	34	23	31
China	--	--	1,500	240	--	--	--	--
Germany	--	--	17	13	--	--	--	--
Hong Kong	86	33	44	12	--	--	27	7
India	12	21	--	--	--	--	--	--
Ireland	72	105	387	278	16	32	--	--
Israel	10	4	--	--	--	--	--	--
Japan	128	60	55	20	--	--	26	30
Korea, Republic of	142	173	24	10	--	--	--	--
Macao	--	--	53	67	--	--	--	--
Malaysia	133	28	52	12	--	--	--	--
Mexico	17	37	29	29	--	--	--	--
Netherlands Antilles	--	--	27	34	--	--	--	--
Singapore	--	--	23	10	--	--	--	--
Switzerland	15	40	--	--	15	46	--	--
Thailand	8	10	2	6	10	23	2	4
United Kingdom	167	48	77	18	11	8	--	--
Total	2,550	2,080	3,420	1,860	68	149	83	74
Grand total	123,000	99,500	103,000	84,500	5,880	4,000	5,410	4,420

1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Source: Harmonized Tariff Schedule of the United States.
3/ Customs value.

Source: Bureau of the Census.

TABLE 5

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

(Thousand carats)

Country	1994	1995	1996	1997	1998
Gemstones: 3/					
Angola	270	2,600	2,250	1,110	2,400
Australia	19,500	18,300	18,897 4/	18,100	18,400
Botswana	10,550 4/	11,500	12,400 r/	15,100 r/	13,500
Brazil	300	676 4/	200	300	300
Canada	--	--	--	--	278
Central African Republic	401	400	350	400	330
China	230	230	230	230	230
Congo (Kinshasa) 5/	4,000	4,000	3,600	3,300 r/	2,000
Cote d' Ivoire	80	53	202	207	207
Ghana	118 4/	126	142	664 r/	640
Guinea	306	274	165	165 r/	165
Liberia	40	60	60	60	60
Namibia	1,312 4/	1,382 4/	1,400 r/	1,420 r/	1,600
Russia	10,000 r/	10,500 r/	10,500 r/	10,500 r/	10,500
Sierra Leone	155	113	162 4/	64 r/	50
South Africa	5,050	5,070	4,280	4,380	4,100
Venezuela	380	125	99 r/	158 r/	100
Zimbabwe	104	114	300	321 r/	40
Other	99 r/	119 r/	165 r/	121 r/	126
Total	52,900 r/	55,700 r/	55,400 r/	56,600 r/	55,000
Industrial:					
Angola	30	300	250	124	364
Australia	23,800	22,400	23,096 4/	22,100	22,500
Botswana	5,000	5,300	5,000	5,000	5,000
Brazil	600	600	600	600	600
Central African Republic	131	130	120	100	200
China	850	900	900	900	900
Congo (Kinshasa) 5/	13,000	13,000	17,000	18,900 r/	13,000
Cote d' Ivoire	4	22	100	100	100
Ghana	473 4/	505	573	166 r/	160
Guinea	75	91	40	40	40
Liberia	60	90	90	90	90
Russia	10,000 r/	10,500 r/	10,500 r/	10,500 r/	10,500
Sierra Leone	100	101	108	40 r/	30
South Africa	5,800	5,880	5,670	5,790	6,200
Venezuela	203	66	73 r/	90 r/	150
Zimbabwe	69	90	137	100	30
Other	92 r/	101 r/	120 r/	105 r/	106
Total	60,300 r/	60,100 r/	64,400 r/	64,700 r/	59,900
Grand total	113,000 r/	116,000 r/	120,000 r/	121,000 r/	115,000

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 May 27, 1999.

3/ Includes near- and cheap-gem qualities.

4/ Reported figure.

5/ Formerly Zaire.

TABLE 6
SYNTHETIC DIAMOND: ESTIMATED WORLD PRODUCTION, BY COUNTRY 1/ 2/ 3/

(Thousand carats)

Country	1994	1995	1996	1997	1998
Belarus	25,000 4/	25,000 4/	25,000	25,000	25,000
China	15,500	15,500	15,500	16,000	16,500
Czech Republic	5,000	5,000	5,000	5,000	5,000
France	3,500	3,000	3,000	3,500	3,000
Greece	1,000	1,000	750	750	750
Ireland	65,000	60,000	60,000	60,000	60,000
Japan	32,000	32,000	32,000	32,000	32,000
Poland	271 4/	256 4/	250 4/	260 r/	210
Romania	5,000	5,000	5,000	5,000	3,000
Russia	80,000	80,000	80,000	80,000	80,000
Slovakia	5,000	5,000	5,000	5,000	5,000
South Africa	60,000 4/	60,000	60,000	60,000	60,000
Sweden	25,000	25,000	25,000	25,000	25,000
Ukraine	8,000 4/	8,000	8,000	8,000	8,000
United States	104,000	115,000	114,000	125,000	140,000
Total	434,000	440,000	439,000	451,000	463,000

r/ Revised.
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 May 27, 1999.
3/ In addition to the countries listed, the Republic of Korea also produced significant amounts of synthetic diamond, but output was not officially reported, and available information is inadequate to formulate reliable estimates of output levels.
4/ Reported figure.