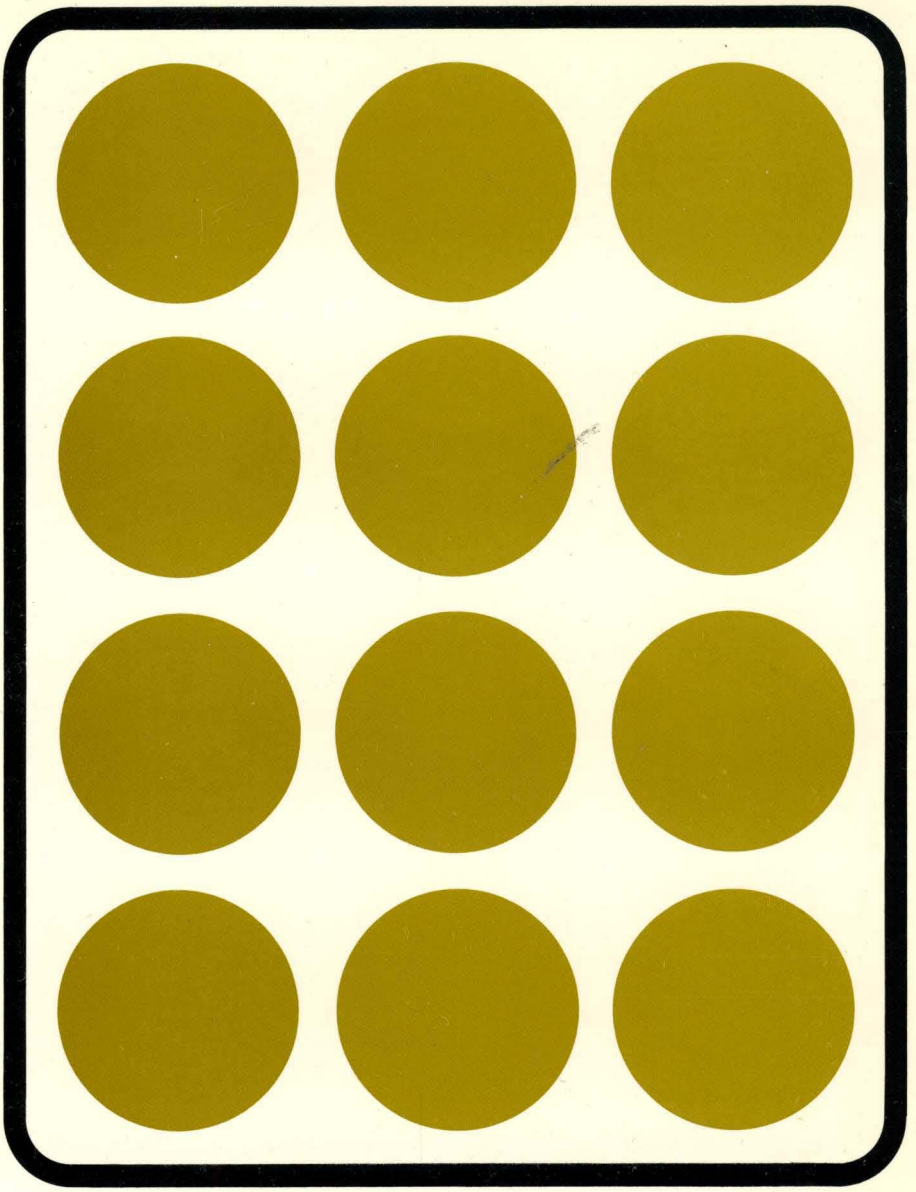
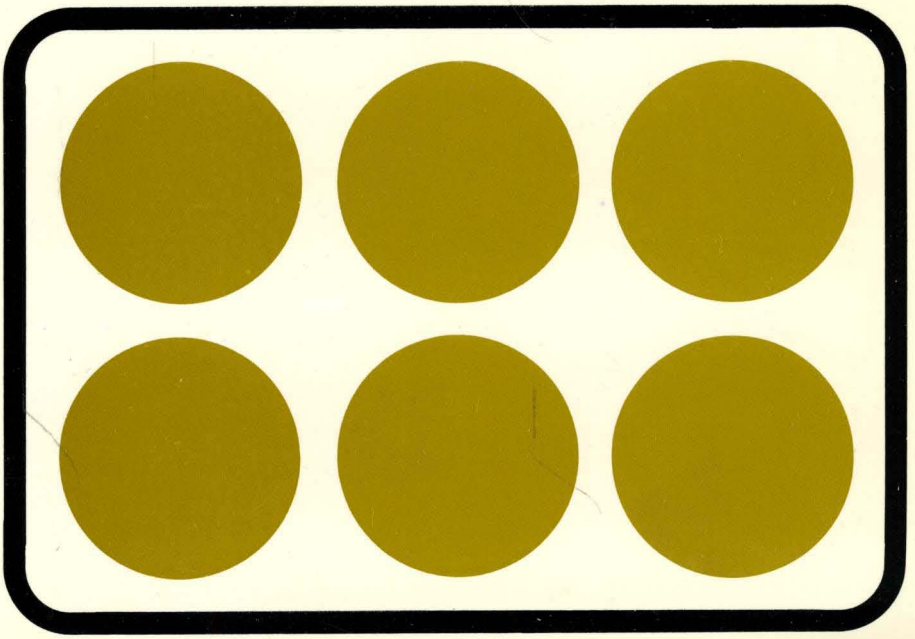


1993 DISK/TREND® REPORT



OPTICAL DISK DRIVES

1993 DISK/TREND® REPORT

OPTICAL DISK DRIVES

July, 1993

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FOREWORD

1993 is an interesting year for optical storage. First, the new double capacity 650 megabyte per side drives become available from multiple sources. We may even see Hitachi's triple capacity drive by year-end. It also seems likely that 230 megabyte 3.5" optical drives will be in the market by the end of 1993. 3.5" drive form factors are shrinking, and the prices are coming down. CD-ROM drive sales are booming. As personal computer manufacturers and game manufacturers start including CD-ROM drives as standard equipment, manufacturers are hard put to find adequate production capacity and component supplies. WORM drives are having a reincarnation in the form of CD-WORM. While expensive, CD-WORM prices are coming down and the large number of installed CD-ROM drives helps to create applications for the WORM drives. By late 1996, these will be the only small WORMs left wiggling.

The four 'P' problems: Performance, package, price, and profitability still nag the industry, but they seem a little closer to resolution than at this time last year. While optical drives don't meet current magnetic drive performance, the best have achieved the levels of the rigid drives of a few years ago. But magnetic drives are approaching optical drive areal densities, so there is much improvement needed before optical drives can claim to be competitive with rigid drives.

The optical disk library business is doing quite well, especially the 1 to 39 cartridge segment. New products are being introduced and new competitors are appearing. However, the action is mostly in the 5.25" segment.

DISK/TREND ON DISK, statistical and specification tables on floppy disks, is again available to subscribers to the DISK/TREND Report. Instructions for using the disks are included at the end of this report.

We are always willing to help you at any time by providing additional information on the industry which we may have available. And, as always, we welcome and appreciate your suggestions for improvements in the DISK/TREND report.

James N. Porter

Robert H. Katzive

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INTRODUCTION

This is the eighth year for the DISK/TREND Report on optical disk drives, including coverage of optical disk libraries. The organization of this year's report is consistent with reports of previous years, but we have changed the name of the sections on read-only drives and libraries to reflect their total CD-ROM content. Disk diameter tables have been modified to reflect anticipated new product introductions. Here are a few useful reminders to help in interpreting the information presented.

* As with other DISK/TREND reports, this report concentrates upon disk drives and optical libraries used with computers, rather than upon media, controllers, or other related topics. Optical video disk drives and libraries for entertainment, optical tape drives, and optical card drives are not covered.

* Unit totals are given in spindles for drives and in units with positioning mechanisms for libraries. All current optical disk drives have one spindle.

* Market share tables, usually included in DISK/TREND reports, are omitted for some product groups of this report, because the 1992 market was too small or too concentrated for market share figures to be meaningful.

* This year's report divides optical disk drives into three groups and libraries into four groups:

  * CD-ROM optical disk drives
  * Read/write optical disk drives less than 1 gigabyte
  * Read/write optical disk drives more than 1 gigabyte

  * CD-ROM optical libraries
  * Read/write optical libraries, 1 - 39 cartridges
  * Read/write optical libraries, 40 - 69 cartridges
  * Read/write optical libraries, more than 70 cartridges

* The read/write groups include all equipment with the capability to both read and write data on an optical disk, regardless of whether drives are write-once or erasable (rewritable)/multifunction types. Forecasts for drives and libraries using both types of technology are given in each optical disk drive product group section as appropriate.

* Data contained in the tables of DISK/TREND reports is again being offered on floppy disks as an option to report subscribers. Instructions are included in the last section of the report.

* Forecasts assume a 'normal' economy without economic cyclic effects.

SUMMARY: OPTICAL DISK DRIVES AND LIBRARIES

Industry size

Despite worldwide economic difficulties, optical disk drive revenues grew 11.1% in 1992, to over $1.3 billion. As in 1991, the 1992 growth leadership came from the CD-ROM segment.

Growth was moderate for read/write drives under 1 gigabyte and negative for the second year in a row for drives over 1 gigabyte. Sales of 3.5" magneto-optic drives, disappointing in 1991, improved significantly in 1992, though sales to large OEMs remain weak. In 1992, over 2.9 million optical disk drives were shipped, up 75.6% over 1991, but again most of the gain was in CD-ROM drives. Shipments of drives over 1 gigabyte contracted, but the growth rate for optical drives under one gigabyte actually edged out the growth rate for CD-ROM drives, reaching 76.9%, on the strength of a better than expected year for 3.5" drives.

Optical library shipments grew to 24,622 units in 1992, up 78.2%, of which 46.6% were CD-ROM libraries. Optical library revenues jumped 51.4% to $249.3 million, the second straight year of strong growth. (The library revenues do not include the revenues of associated drives, to avoid double counting.)

U.S. manufacturers' revenue share rose to almost 11.7% of worldwide optical disk drive revenues, reflecting declining CD-ROM drive prices and declining 3.5" drive prices from non-U.S. producers, while shipment growth and new product mix favored U.S. supplier revenues. U.S. companies improved their share of library revenues, capturing 59.4% in 1992. The U.S. share of drive unit shipments rose slightly to 1.9%, but it is expected to decline as a result of very large CD-ROM drive shipments from non-U.S. firms, the result of U.S. nonparticipation in the CD-ROM market. U.S. firms' share of library unit shipments grew sharply to 40.7% in 1992, because of a large increase in 1-39 cartridge library shipments by U.S. suppliers, and is forecasted to expand to 50.1% in 1996.

In 1992, optical disk drive sales in the United States accounted for 54.9% of worldwide revenue, an increase from 50.1% in 1991. The U.S. market accounted for 69.0% of library revenues, a significant gain from 1991. In 1996, the U.S. optical drive market is expected to be even larger, 61.4% of a $4.2 billion drive

market. The proportion of the library market in the U.S. is also expected to grow, reaching 69.2% of anticipated total revenues of $623.6 in 1996. Increasing usage of optical storage technology for records management continues to drive the U.S. optical library market.

IBM continues to expand its optical storage activities with new higher capacity 5.25" and 3.5" magneto-optic rewritable drives and an expanded number of models of the 3995 optical library. IBM also remains a purchaser of 5.25" and 12" write-once drives and libraries to integrate into its systems. IBM, Hewlett-Packard, Sony and other firms are involved in several initiatives to expand the capacity of 5.25" and 3.5" magneto-optic drives.

The U.S. optical library producers continue to do well, as a result of aggressive new product development and because of their strengths in system integration and software support. Because optical libraries are used mostly on multiuser systems, a technology well understood by many U.S. companies, U.S. library producers continue to do well in penetrating the domestic market. However, there are indications that non-U.S. producers will become more aggressive in the U.S. market, especially in the fast growing 1-39 cartridge segment.

The fact that non-U.S. companies have major strengths in optical drive component technology has contributed to the emergence of non-U.S. manufacturers as the major drive producers. U.S. firms will have difficulty in overcoming the Japanese lead in media, lasers, optical components, heads and mechanisms. Future improvements in drive capacity and performance will depend strongly upon improvements in laser technology.

The number of participants in the optical drive industry has grown by seven to 43, with one newcomer in the U.S. and the balance in Asia. Most of the newcomers are CD-ROM or 3.5" drive producers. The roster of optical library manufacturers grew by three to 29, including one new European competitor and two new Japanese competitors. All of the new entrants in this market are producers of 5.25" optical libraries.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992		Forecast							
	Revenues		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	44.9	81.0	65.5	120.3	84.8	155.0	98.8	173.1	112.9	199.6
PCM/Reseller	13.6	19.9	14.7	21.9	24.5	39.8	33.4	55.3	43.6	70.3
OEM/Integrator	34.7	54.6	51.1	80.7	60.5	100.0	70.7	118.7	83.6	142.4
TOTAL U.S. REVENUES	93.2	155.5	131.3	222.9	169.8	294.8	202.9	347.1	240.1	412.3
Non-U.S. Manufacturers										
Captive	36.4	194.3	51.4	256.6	60.5	298.7	69.9	347.3	79.5	388.0
PCM/Reseller	191.0	298.7	289.0	453.1	393.2	643.2	441.5	732.6	447.9	751.0
OEM/Integrator	399.3	662.7	753.4	1,159.3	1,233.7	1,832.2	1,554.1	2,306.1	1,804.3	2,635.3
TOTAL NON-U.S. REVENUES	626.7	1,155.7	1,093.8	1,869.0	1,687.4	2,774.1	2,065.5	3,386.0	2,331.7	3,774.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	719.9	1,311.2	1,225.1	2,091.9	1,857.2	3,068.9	2,268.4	3,733.1	2,571.8	4,186.6

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992		Forecast							
	Revenues		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	33.9	40.9	38.8	47.8	42.2	53.5	46.5	59.8	48.9	64.0
PCM/Reseller	18.8	28.0	43.6	60.6	63.3	85.8	78.2	106.4	89.7	122.0
OEM/Integrator	59.7	79.4	82.8	111.6	103.8	143.9	119.1	167.1	128.6	183.1
TOTAL U.S. REVENUES	112.4	148.3	165.2	220.0	209.3	283.2	243.8	333.3	267.2	369.1
Non-U.S. Manufacturers										
Captive	1.3	17.4	1.8	18.3	1.6	19.0	1.4	19.0	1.2	18.6
PCM/Reseller	10.5	14.3	12.9	19.0	17.4	24.2	19.6	27.4	21.5	30.2
OEM/Integrator	47.9	69.3	76.9	115.9	103.2	155.0	125.6	185.5	141.6	205.7
TOTAL NON-U.S. REVENUES	59.7	101.0	91.6	153.2	122.2	198.2	146.6	231.9	164.3	254.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	172.1	249.3	256.8	373.2	331.5	481.4	390.4	565.2	431.5	623.6

Figure 1

CHANGING PRODUCT MIX
Worldwide Optical Disk Drive Revenue

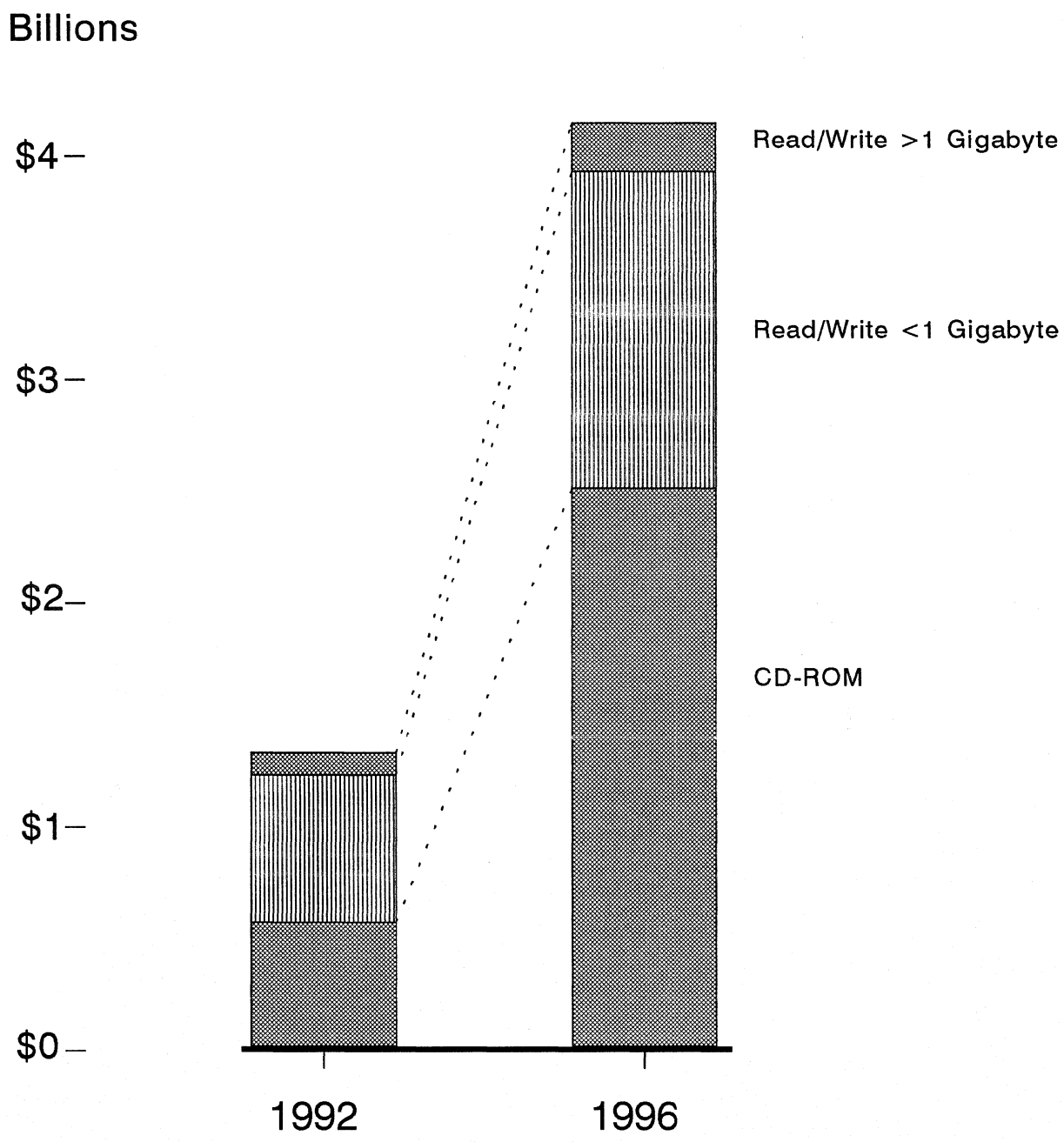
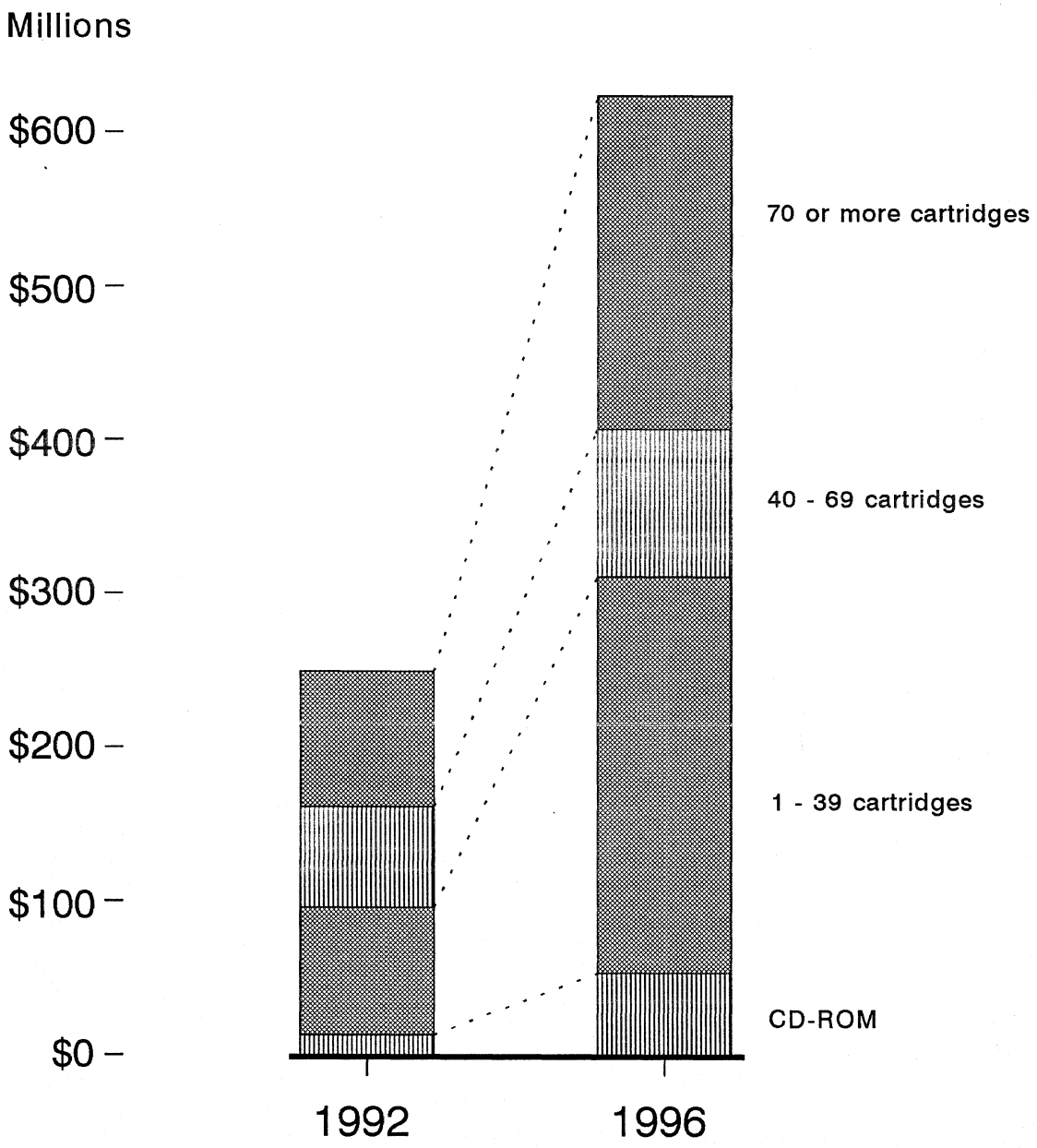


Figure 2

CHANGING PRODUCT MIX
Worldwide Optical Library Revenue



Marketing channels

Marketing channels used by optical drive and library manufacturers are defined in this report as Captive, PCM/Reseller, and OEM/integrator. Captive drives and libraries are sold as part of systems that are manufactured by the same company. The PCM/Reseller channel includes drives and libraries used in add-on subsystems for use with computer systems of all types and sizes, plus aftermarket distribution through wholesalers, dealers and other resellers. The PCM/Reseller channel also includes drive or library sales directly from the manufacturer to government or large end user "house accounts". The OEM/Integrator channel includes drives and libraries sold to system manufacturers to be used as part of computer systems. Also included are sales to system integrators and value-added resellers which assemble complete systems.

In 1992, OEM/Integrator optical disk drive revenues rose to 54.7% of worldwide total revenues of $1.3 billion, followed by PCM/Reseller revenues at 24.3%. Anticipated 1996 revenues of almost $4.2 billion will show the OEM/Integrator share rising to 66.4%, while PCM/Reseller revenue is projected to shrink to 19.6%, and the captive share is forecasted to decline to 14% of 1996 revenues.

$249.3 million of optical library revenues were split 59.6% from OEM/Integrators, 23.4% from captive sales, and 17% from the PCM/Reseller channel. 1996 library expected revenues of $623.6 million will be shared among OEM/Integrators with 62.4%, captive sales with 13.2%, and 24.4% through PCM/Resellers. Because of the complex system integration and support requirements of libraries, only the simplest types will be offered through the reseller channel, and some of the resellers handling libraries are beginning to acquire the characteristics of small OEMs as they increase their value-added content and perform increasing amounts of system integration.

Revenues in this report are based on the price of the drive or library the first time it is sold to an unaffiliated buyer, at captive end user, PCM/Reseller or OEM/Integrator levels. Drive prices are based on disk drives alone, without controllers or other accessories, and leased drives are valued at the price they would command if actually sold. Library prices are for the library only and do not include the disk drives or external controllers.

Industry participation

Industry participants are classified as U.S., Asian or European depending upon the geographical composition of their majority ownership. For instance, LMSI, a Philips subsidiary, is counted as a European company.

11 U.S. companies, 29 Asian firms and 3 European manufacturers currently compete in the optical disk drive market. The number of U.S. firms has increased by one (CD-ROM, Inc,). Cherokee Data Systems was renamed as MountainGate Data Systems. Asian producers increased their presence, as GoldStar, Samsung and Kyocera announced CD-ROM drives, while Seiko Epson and Laserbyte announced 3.5" drives. Asaca entered the market with a 5.25" drive. The roster of European drive producers did not change.

As of mid-1993, 19 companies offer read-only drives, all but one of which are non-U.S. firms and 14 of which are Japanese organizations. 32 manufacturers are making read/write drives under 1 gigabyte, up from 29 in 1992: 25 of these have rewritable or multifunction drives, an increase from 21 manufacturers last year.

11 U.S. firms, 12 Asian manufacturers and 6 European suppliers offer optical libraries. Of the 29 companies, 5 make read-only libraries: 3 of these do not participate in other product groups. 12 firms make only 5.25" libraries, while 6 make only larger diameter libraries. 8 firms make library models in two or more disk drive diameters.

The U.S. count of library manufacturers has remained constant, but the Asian manufacturer count for libraries has increased by two due to the market entry of Asaca and Nikkyo. Nikkyo previously manufactured optical libraries only under contract for other firms. The number of European library manufacturers has risen to 6 this year with the addition of Amber Technology in the U.K.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1992 Revenues $M	1992 Revenues %	1993 $M	1993 %	1994 $M	1994 %	1995 $M	1995 %	1996 $M	1996 %
U.S. Manufacturers										
Captive	81.0	6.1%	120.3	5.7%	155.0	5.0%	173.1	4.6%	199.6	4.7%
	+382.1%		+48.5%		+28.8%		+11.7%		+15.3%	
PCM/Reseller	19.9	1.5%	21.9	1.0%	39.8	1.2%	55.3	1.4%	70.3	1.6%
	-29.7%		+10.1%		+81.7%		+38.9%		+27.1%	
OEM/Integrator	54.6	4.1%	80.7	3.8%	100.0	3.2%	118.7	3.1%	142.4	3.4%
	+166.3%		+47.8%		+23.9%		+18.7%		+20.0%	
Total U.S. Manufacturers	155.5	11.7%	222.9	10.5%	294.8	9.4%	347.1	9.1%	412.3	9.7%
	+112.1%		+43.3%		+32.3%		+17.7%		+18.8%	
Non-U.S. Manufacturers										
Captive	194.3	14.8%	256.6	12.2%	298.7	9.7%	347.3	9.3%	388.0	9.2%
	-51.2%		+32.1%		+16.4%		+16.3%		+11.7%	
PCM/Reseller	298.7	22.7%	453.1	21.6%	643.2	20.9%	732.6	19.6%	751.0	17.9%
	+65.2%		+51.7%		+42.0%		+13.9%		+2.5%	
OEM/Integrator	662.7	50.8%	1,159.3	55.7%	1,832.2	60.0%	2,306.1	62.0%	2,635.3	63.2%
	+25.5%		+74.9%		+58.0%		+25.9%		+14.3%	
Total Non-U.S. Manufacturers	1,155.7	88.3%	1,869.0	89.5%	2,774.1	90.6%	3,386.0	90.9%	3,774.3	90.3%
	+4.4%		+61.7%		+48.4%		+22.1%		+11.5%	
Worldwide Recap										
Captive	275.3	21.0%	376.9	18.0%	453.7	14.8%	520.4	13.9%	587.6	14.0%
	-34.8%		+36.9%		+20.4%		+14.7%		+12.9%	
PCM/Reseller	318.6	24.3%	475.0	22.7%	683.0	22.3%	787.9	21.1%	821.3	19.6%
	+52.4%		+49.1%		+43.8%		+15.4%		+4.2%	
OEM/Integrator	717.3	54.7%	1,240.0	59.3%	1,932.2	62.9%	2,424.8	65.0%	2,777.7	66.4%
	+30.8%		+72.9%		+55.8%		+25.5%		+14.6%	
Total All Manufacturers	1,311.2	100.0%	2,091.9	100.0%	3,068.9	100.0%	3,733.1	100.0%	4,186.6	100.0%
	+11.1%		+59.5%		+46.7%		+21.6%		+12.1%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 4

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL LIBRARIES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1992 Revenues $M	1992 Revenues %	Forecast 1993 $M	Forecast 1993 %	Forecast 1994 $M	Forecast 1994 %	Forecast 1995 $M	Forecast 1995 %	Forecast 1996 $M	Forecast 1996 %
U.S. Manufacturers										
Captive	40.9 -4.0%	16.4%	47.8 +16.9%	12.8%	53.5 +11.9%	11.1%	59.8 +11.8%	10.5%	64.0 +7.0%	10.2%
PCM/Reseller	28.0 --	11.2%	60.6 +116.4%	16.2%	85.8 +41.6%	17.8%	106.4 +24.0%	18.8%	122.0 +14.7%	19.5%
OEM/Integrator	79.4 +106.2%	31.8%	111.6 +40.6%	29.9%	143.9 +28.9%	29.8%	167.1 +16.1%	29.5%	183.1 +9.6%	29.3%
Total U.S. Manufacturers	148.3 +77.8%	59.4%	220.0 +48.3%	58.9%	283.2 +28.7%	58.7%	333.3 +17.7%	58.8%	369.1 +10.7%	59.0%
Non-U.S. Manufacturers										
Captive	17.4 -59.0%	6.9%	18.3 +5.2%	4.9%	19.0 +3.8%	3.9%	19.0 --	3.3%	18.6 -2.1%	2.9%
PCM/Reseller	14.3 +110.3%	5.7%	19.0 +32.9%	5.0%	24.2 +27.4%	5.0%	27.4 +13.2%	4.8%	30.2 +10.2%	4.8%
OEM/Integrator	69.3 +115.9%	28.0%	115.9 +67.2%	31.2%	155.0 +33.7%	32.4%	185.5 +19.7%	33.1%	205.7 +10.9%	33.3%
Total Non-U.S. Manufacturers	101.0 +24.2%	40.6%	153.2 +51.7%	41.1%	198.2 +29.4%	41.3%	231.9 +17.0%	41.2%	254.5 +9.7%	41.0%
Worldwide Recap										
Captive	58.3 -31.4%	23.4%	66.1 +13.4%	17.7%	72.5 +9.7%	15.1%	78.8 +8.7%	13.9%	82.6 +4.8%	13.2%
PCM/Reseller	42.3 +364.8%	17.0%	79.6 +88.2%	21.3%	110.0 +38.2%	22.9%	133.8 +21.6%	23.7%	152.2 +13.8%	24.4%
OEM/Integrator	148.7 +110.6%	59.6%	227.5 +53.0%	61.0%	298.9 +31.4%	62.0%	352.6 +18.0%	62.4%	388.8 +10.3%	62.4%
Total All Manufacturers	249.3 +51.4%	100.0%	373.2 +49.7%	100.0%	481.4 +29.0%	100.0%	565.2 +17.4%	100.0%	623.6 +10.3%	100.0%

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Product mix

While the shipments of optical disk drives grew substantially in 1992, there was not much change in the mix between product groups. The share of CD-ROM drives edged up .2% to 86.8% of optical disk drives shipped in 1992. Similarly, the share of read/write drives under 1 gigabyte also edged up to 13% from 12.9%. The share of read/write drives over 1 gigabyte declined to .2% of shipments due to declining captive sales in 1992 as well as the increasing shipments of the CD-ROM and small writable drives. However, within the under 1 gigabyte product group, there was a significant mix change strongly favoring 3.5" drives, which rose from 9.9% of the rewritable drives shipped in that group in 1991 to 47.8% in 1992. The change is due to a larger number of 3.5" drive vendors and higher 3.5" drive production rates.

Erasable or multifunction read/write drives less than 1 gigabyte represented 91.1% of shipments in that group in 1992, and are expected to increase share to 94.8% in 1996. 4.72" write-once drives that prepare disks in the CD-ROM format will become an increasingly important part of the product mix, and are expected to be the dominant type of write-once drive in 1996. This is partly due to expected demand for the 4.72" models and partly due to decline in shipments of 5.25" write-once drives, as they are displaced by multifunction drives over the next several years.

In 1992, read/write drives less than 1 gigabyte captured 50.1% of optical disk drive revenues, followed by CD-ROM drives with 42.3%, a slight gain over 1991 for each category. The revenue share of read/write drives over 1 gigabyte declined to 7.6% in 1992, and is expected to continue to decline until 1995, when sales of 5.25" drives with capacities over 1 gigabyte will help this product group start to increase revenue market share. High capacity read/write drives over 1 gigabyte will hold only a .1% share of 1996 unit shipments, with 34,500 units shipped, but will generate 6.5% of total revenue, due to high prices relative to other drives.

CD-ROM drive shipments are forecasted to exceed the 18.4 million unit mark in 1996, spurred by growth in both professional and consumer markets. Shipments of 3.15" drives are expected to be a small portion of the total, not exceeding .6% in 1996. The performance requirements of multimedia capable systems will shift demand toward high performance 4.72" drives, 77.2% of 1992 ship-

ments, which are expected to hold 88.3% of the 1996 market and 89.7% of its revenues. The very high volumes anticipated for the high performance drives should allow pricing close to that of low performance drives, making them advantageous choices for most systems.

CD-ROM optical libraries were again the largest segment for libraries in 1992, accounting for a 46.6% share of an 24,622 unit market. The next largest segment was the 1 to 39 disk cartridge library which grew strongly to capture a 37.3% share. The 40 to 69 cartridge libraries kept about the same position, capturing a 10.8% share in 1992. Libraries with 70 or more cartridges increased share slightly to 5.3% share. A major factor in the changes from 1991 is the popularity of 5 and 10 cartridge libraries in the 1 to 39 disk cartridge product group.

In 1996, the shipment share of CD-ROM libraries is expected to decline to 38.5% while the 1 to 39 cartridge group will continue its strong growth to capture 47.6%. The 40 to 69 cartridge libraries will decrease their share slightly to 7.8%, and libraries with 70 or more cartridges will drop to a 6.1% share. The rapidly expanding market for low-end libraries for use with personal computers and small workstations will swamp the classical library market in terms of unit shipments, although not in revenues.

Optical libraries with 70 or more cartridges held the largest 1992 revenue share with 35.3%, followed closely by the 1 to 39 cartridge group with 33.3%. CD-ROM libraries accounted for only 5.4% of revenues. While unit shipment statistics favor the bottom of the line, 50% of 1996 revenues will be generated from the two top of the line categories. 41.4% of revenues will be generated by the 1 to 39 cartridge category, while only 8.5% will be generated by CD-ROM libraries. The 1 to 39 cartridge product group will have the largest revenue and shipment share in 1996.

TABLE 5

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1992		Forecast							
ALL MANUFACTURERS	Revenues		1993		1994		1995		1996	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM	555.0	42.3%	1,091.7	52.2%	1,804.0	58.8%	2,237.7	59.9%	2,494.8	59.6%
ALL CAPACITIES	+20.9%		+96.7%		+65.2%		+24.0%		+11.5%	
READ/WRITE	656.4	50.1%	874.1	41.8%	1,110.7	36.2%	1,296.0	34.7%	1,419.1	33.9%
LESS THAN 1 GIGABYTE	+12.1%		+33.2%		+27.1%		+16.7%		+9.5%	
READ/WRITE	99.8	7.6%	126.1	6.0%	154.2	5.0%	199.4	5.3%	272.7	6.5%
MORE THAN 1 GIGABYTE	-26.4%		+26.4%		+22.3%		+29.3%		+36.8%	
Total Worldwide Revenue	1,311.2	100.0%	2,091.9	100.0%	3,068.9	100.0%	3,733.1	100.0%	4,186.6	100.0%
	+11.1%		+59.5%		+46.7%		+21.6%		+12.1%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 6

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1992		Forecast							
ALL MANUFACTURERS	Revenues		1993		1994		1995		1996	
	$M	%	$M	%	$M	%	$M	%	$M	%
OPTICAL LIBRARIES	13.4	5.4%	26.1	7.0%	40.5	8.4%	47.5	8.4%	53.3	8.5%
CD-ROM	+83.6%		+94.8%		+55.2%		+17.3%		+12.2%	
OPTICAL LIBRARIES	82.9	33.3%	147.1	39.4%	196.0	40.7%	234.4	41.5%	258.2	41.4%
1-39 CARTRIDGES	+88.8%		+77.4%		+33.2%		+19.6%		+10.2%	
OPTICAL LIBRARIES	64.7	26.0%	74.9	20.1%	86.3	17.9%	93.1	16.5%	95.6	15.3%
40-69 CARTRIDGES	+1.1%		+15.8%		+15.2%		+7.9%		+2.7%	
OPTICAL LIBRARIES	88.3	35.3%	125.1	33.5%	158.6	32.9%	190.2	33.6%	216.5	34.7%
70 OR MORE CARTRIDGES	+78.4%		+41.7%		+26.8%		+19.9%		+13.8%	
Total Worldwide Revenue	249.3	100.0%	373.2	100.0%	481.4	100.0%	565.2	100.0%	623.6	100.0%
	+51.4%		+49.7%		+29.0%		+17.4%		+10.3%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 7

CONSOLIDATED WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS	1992		Forecast							
IN THOUSANDS	Shipments		1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM	2,527.1	86.8%	6,298.1	91.8%	11,013.2	92.9%	14,645.2	92.7%	18,478.3	92.3%
ALL CAPACITIES	+76.1%		+149.2%		+74.9%		+33.0%		+26.2%	
READ/WRITE	379.4	13.0%	558.5	8.1%	836.9	7.1%	1,156.4	7.3%	1,521.9	7.6%
LESS THAN 1 GIGABYTE	+76.9%		+47.2%		+49.8%		+38.2%		+31.6%	
READ/WRITE	7.1	.2%	9.0	.1%	11.5	--	17.3	--	34.5	.1%
MORE THAN 1 GIGABYTE	-27.6%		+26.8%		+27.8%		+50.4%		+99.4%	
Total Worldwide Shipments	2,913.6	100.0%	6,865.6	100.0%	11,861.6	100.0%	15,818.9	100.0%	20,034.7	100.0%
	+75.6%		+135.6%		+72.8%		+33.4%		+26.7%	
% U.S. Manufacturers	1.9%		1.2%		1.0%		1.0%		1.0%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 8

CONSOLIDATED WORLDWIDE SHIPMENTS
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1992 Shipments Units	1992 Shipments %	1993 Forecast Units	1993 Forecast %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %
OPTICAL LIBRARIES	11,473	46.6%	15,666	41.9%	19,949	39.7%	24,533	38.9%	29,035	38.5%
CD-ROM	+48.7%		+36.5%		+27.3%		+23.0%		+18.4%	
OPTICAL LIBRARIES	9,180	37.3%	16,202	43.3%	23,119	46.0%	29,743	47.1%	35,878	47.6%
1-39 CARTRIDGES	+185.5%		+76.5%		+42.7%		+28.7%		+20.6%	
OPTICAL LIBRARIES	2,651	10.8%	3,451	9.2%	4,297	8.6%	5,150	8.2%	5,913	7.8%
40-69 CARTRIDGES	+13.2%		+30.2%		+24.5%		+19.9%		+14.8%	
OPTICAL LIBRARIES	1,318	5.3%	2,081	5.6%	2,859	5.7%	3,708	5.8%	4,591	6.1%
70 OR MORE CARTRIDGES	+141.4%		+57.9%		+37.4%		+29.7%		+23.8%	
Total Worldwide Shipments	24,622	100.0%	37,400	100.0%	50,224	100.0%	63,134	100.0%	75,417	100.0%
	+78.2%		+51.9%		+34.3%		+25.7%		+19.5%	
% U.S. Manufacturers	40.7%		45.6%		48.3%		49.5%		50.1%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Figure 3

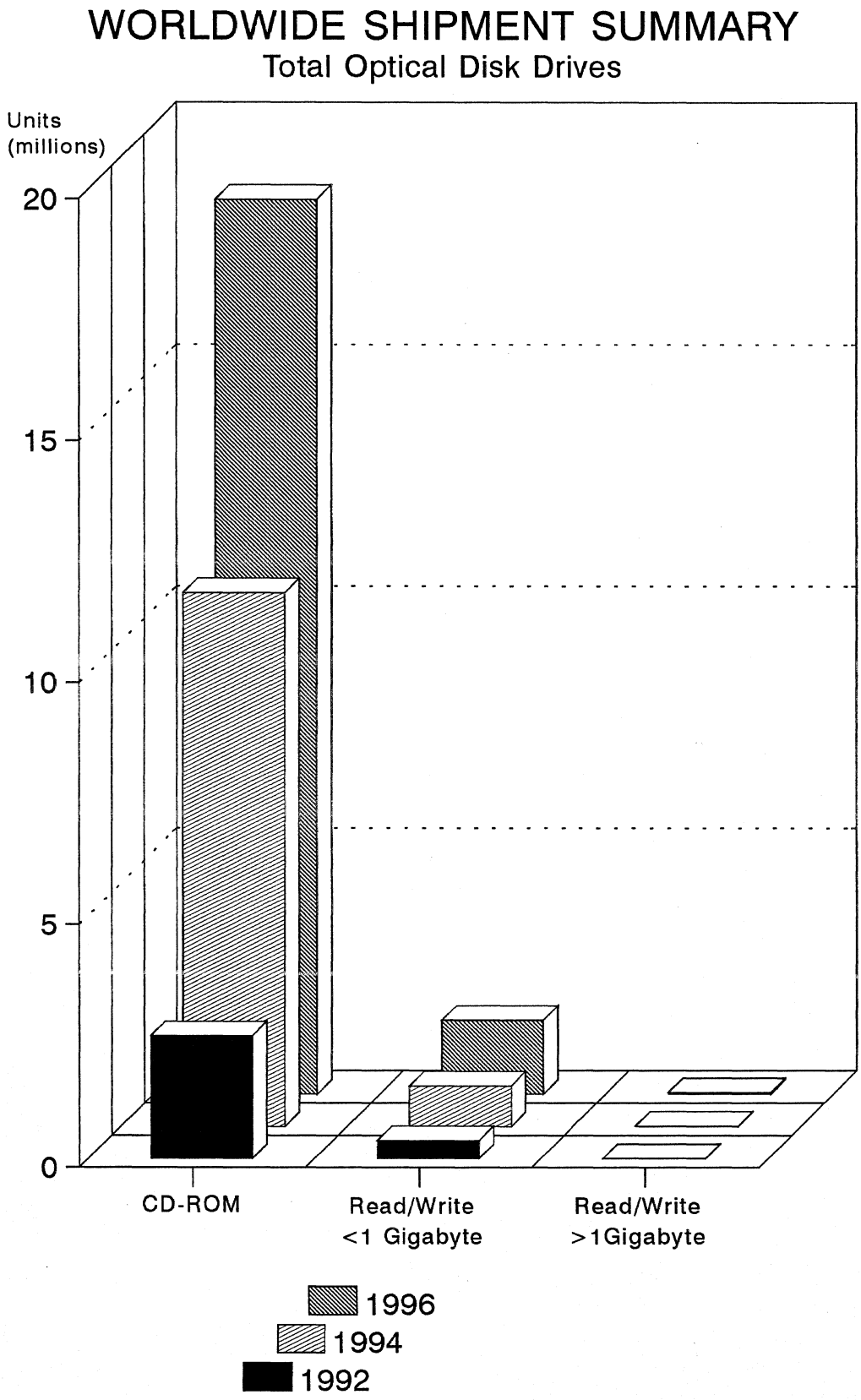
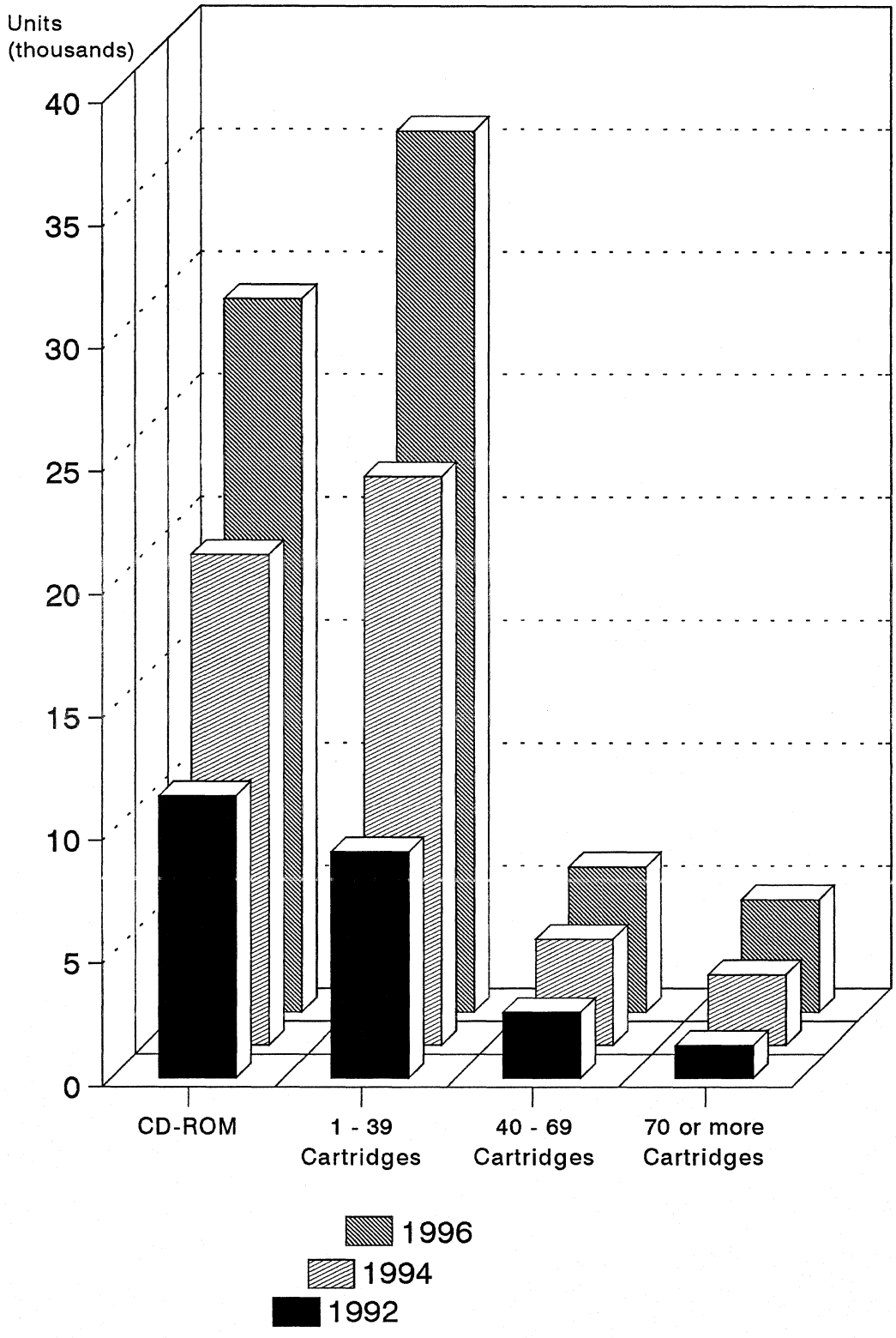

WORLDWIDE SHIPMENT SUMMARY
Total Optical Disk Drives
Units
(millions)
20
15
10
5
0
CD-ROM
Read/Write
<1 Gigabyte
Read/Write
>1Gigabyte
1996
1994
1992

Figure 4

WORLDWIDE SHIPMENT SUMMARY

Total Optical Libraries



Noncaptive market

CD-ROM drives slightly increased their share of unit shipments in the noncaptive market (OEM/Integrator and PCM/Reseller distribution channels)in 1992, capturing 87.2% of the worldwide market. Read/write drives less than 1 gigabyte held second place with 12.7%, the same as 1991, while the share for read/write drives over 1 gigabyte shrank to .1%. CD-ROM drives are expected to continue to gain share of unit shipments until leveling off at the end of the forecast period.

CD-ROM drives and read/write drives less than a gigabyte virtually tied for revenue share, holding 46.4% and 46.5% respectively. The relatively high prices for the drives over 1 gigabyte enabled them to obtain a 7.1% share, down from 12.1% in 1991. For CD-ROM drives, strong growth in unit shipments again exceeded the effects of price declines, resulting in a slight share gain over 1991 results. The share of noncaptive revenue held by CD-ROM drives is expected to increase to 65.3% by the end of the forecast period due to very strong anticipated shipment growth.

In 1992, the major OEM/Integrator drive revenue producers were Sony, Matsushita Electric, Toshiba and Hitachi, in that order. The top four companies accounted for 60.7% of total OEM/Integrator market value. Sony led with 24.6% of the OEM/Integrator total, down substantially from 1991. The share held by the top four is down about 7 points from 1991, reflecting a broadening of the supplier base. Sony, NEC, Matsushita Electric, and Ricoh were the leading PCM/Reseller channel suppliers, together holding 59.4% share, slightly less than in 1991. The top two U.S. producers captured only 6.1% of 1992 OEM/Integrator revenues, but a significant improvement over 1991, due mostly to IBM gains. U.S. firms also did poorly in the reseller channel, taking only a 6.2% share.

The very strong growth of the CD-ROM drive market will drive an expansion of the noncaptive market share through 1996, overcoming the effect of anticipated growing captive sales by IBM, Hewlett-Packard and others as well as the generally higher price levels for products sold on a captive basis.

CD-ROM libraries generated 48.6% of the noncaptive optical library unit shipments in 1992, followed by the 1 to 39 disk product group with 37.1%. The low-end segments of the optical library market will remain strong through 1996, with the CD-ROM library product group still holding 39.6% share in 1996 and the

1 to 39 cartridge libraries increasing share to 47.3%. The share of the 40 to 69 cartridge group is slowly decaying. This group's 1992 share of 9.9% is expected to see a slow decline to 7.6% in 1996. U.S. manufacturers accounted for 39.8% of noncaptive 1992 shipments, and their share is expected to grow to 49.4% in 1996.

As might be expected from their generally higher prices, high-end libraries capture OEM/Integrator revenue shares that exceed unit shipment shares. In 1992, the 40 to 69 cartridge and more than 70 cartridge segments together captured 56.5% of 1992 noncaptive revenue. However, in 1992, the 1 to 39 disk product group was the largest single revenue producing segment with a 36.5% share. This product group will remain the strongest revenue producer throughout the forecast period, and is expected to hold a 43.7% share in 1996. The 70 or more disk product group will hold a 31.2% share in 1996. The 1996 CD-ROM segment share is only 9.9% because of the much lower pricing levels for most of the optical libraries in this segment.

U.S. library manufacturers captured 53.4% of the OEM/Integrator revenues and 66.2% of the PCM/Reseller revenues in 1992. Hewlett-Packard, Matsushita Electric and Sony were the leading OEM/Integrator channel suppliers with 52% of the revenues between them. The three top OEM/Integrator suppliers share was about the same as in 1991. In the PCM/Reseller channel, IDE, Hewlett-Packard and Pioneer were the leaders with a combined total of 75.7% of revenues. Noncaptive library revenues will rise from a 76.6% share of the worldwide total in 1992 to a 86.8% share in 1996, with the strongest growth coming from sales of low-end libraries.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1992		Forecast							
ALL MANUFACTURERS	Revenues		1993		1994		1995		1996	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM	480.1	46.4%	997.2	58.2%	1,691.7	64.8%	2,104.7	65.6%	2,346.7	65.3%
ALL CAPACITIES	+40.9%		+107.7%		+69.6%		+24.4%		+11.5%	
READ/WRITE	481.4	46.5%	618.2	36.1%	795.8	30.4%	940.5	29.3%	1,023.4	28.4%
LESS THAN 1 GIGABYTE	+48.4%		+28.4%		+28.7%		+18.2%		+8.8%	
READ/WRITE	74.4	7.1%	99.6	5.7%	127.7	4.8%	167.5	5.1%	228.9	6.3%
MORE THAN 1 GIGABYTE	-19.6%		+33.9%		+28.2%		+31.2%		+36.7%	
Total Worldwide Revenues	1,035.9	100.0%	1,715.0	100.0%	2,615.2	100.0%	3,212.7	100.0%	3,599.0	100.0%
	+36.7%		+65.6%		+52.5%		+22.8%		+12.0%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 10

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1992		Forecast							
ALL MANUFACTURERS	Revenues		1993		1994		1995		1996	
	$M	%	$M	%	$M	%	$M	%	$M	%
OPTICAL LIBRARIES	13.4	7.0%	26.1	8.5%	40.5	9.9%	47.5	9.8%	53.3	9.9%
CD-ROM	+106.2%		+94.8%		+55.2%		+17.3%		+12.2%	
OPTICAL LIBRARIES	69.5	36.5%	132.1	43.1%	178.6	43.8%	214.4	44.1%	236.0	43.7%
1-39 CARTRIDGES	+260.1%		+90.1%		+35.2%		+20.0%		+10.1%	
OPTICAL LIBRARIES	52.3	27.4%	61.6	20.1%	72.5	17.7%	79.5	16.4%	82.6	15.2%
40-69 CARTRIDGES	+60.9%		+17.8%		+17.7%		+9.7%		+3.9%	
OPTICAL LIBRARIES	55.8	29.1%	87.3	28.3%	117.3	28.6%	145.0	29.7%	169.1	31.2%
70 OR MORE CARTRIDGES	+160.7%		+56.5%		+34.4%		+23.6%		+16.6%	
Total Worldwide Revenues	191.0	100.0%	307.1	100.0%	408.9	100.0%	486.4	100.0%	541.0	100.0%
	+139.6%		+60.8%		+33.1%		+19.0%		+11.2%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS	1992		Forecast							
IN THOUSANDS	Shipments		1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM	2,301.1	87.2%	5,985.1	92.4%	10,610.2	93.5%	14,163.2	93.2%	17,939.3	92.8%
ALL CAPACITIES	+103.3%		+160.1%		+77.3%		+33.5%		+26.7%	
READ/WRITE	336.4	12.7%	489.4	7.6%	744.6	6.5%	1,038.8	6.8%	1,377.8	7.1%
LESS THAN 1 GIGABYTE	+102.9%		+45.5%		+52.1%		+39.5%		+32.6%	
READ/WRITE	5.9	.1%	7.8	--	10.4	--	15.2	--	29.2	.1%
MORE THAN 1 GIGABYTE	-18.1%		+32.2%		+33.3%		+46.2%		+92.1%	
Total Worldwide Shipments	2,643.4	100.0%	6,482.3	100.0%	11,365.2	100.0%	15,217.2	100.0%	19,346.3	100.0%
	+102.6%		+145.2%		+75.3%		+33.9%		+27.1%	
% U.S. Manufacturers	1.3%		.8%		.6%		.7%		.7%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 12

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1992 Shipments Units	1992 Shipments %	1993 Units	1993 %	1994 Units	1994 %	1995 Units	1995 %	1996 Units	1996 %
					Forecast					
OPTICAL LIBRARIES	11,473	48.6%	15,666	43.3%	19,949	40.9%	24,533	40.0%	29,035	39.6%
CD-ROM	+49.7%		+36.5%		+27.3%		+23.0%		+18.4%	
OPTICAL LIBRARIES	8,757	37.1%	15,638	43.2%	22,398	45.9%	28,846	46.9%	34,815	47.3%
1-39 CARTRIDGES	+252.1%		+78.6%		+43.2%		+28.8%		+20.7%	
OPTICAL LIBRARIES	2,348	9.9%	3,141	8.7%	3,982	8.2%	4,833	7.8%	5,595	7.6%
40-69 CARTRIDGES	+83.0%		+33.8%		+26.8%		+21.4%		+15.8%	
OPTICAL LIBRARIES	1,068	4.4%	1,778	4.8%	2,507	5.0%	3,305	5.3%	4,140	5.5%
70 OR MORE CARTRIDGES	+184.0%		+66.5%		+41.0%		+31.8%		+25.3%	
Total Worldwide Shipments	23,646	100.0%	36,223	100.0%	48,836	100.0%	61,517	100.0%	73,585	100.0%
	+100.2%		+53.2%		+34.8%		+26.0%		+19.6%	
% U.S. Manufacturers	39.8%		44.8%		47.6%		48.8%		49.4%	

Note: Percentage figures with plus/minus signs refer to year-to-year growth rates.

Figure 5

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Disk Drives

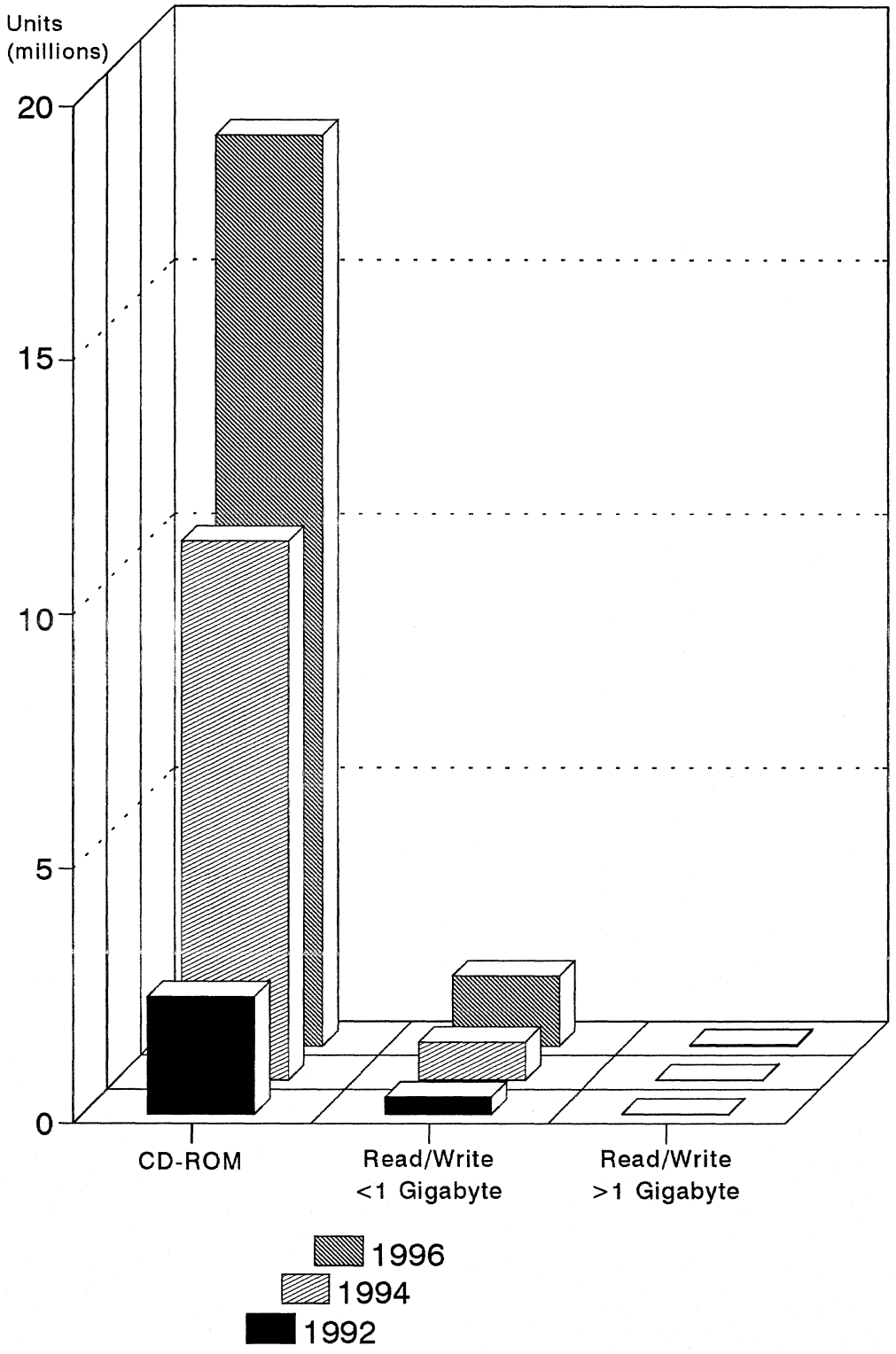
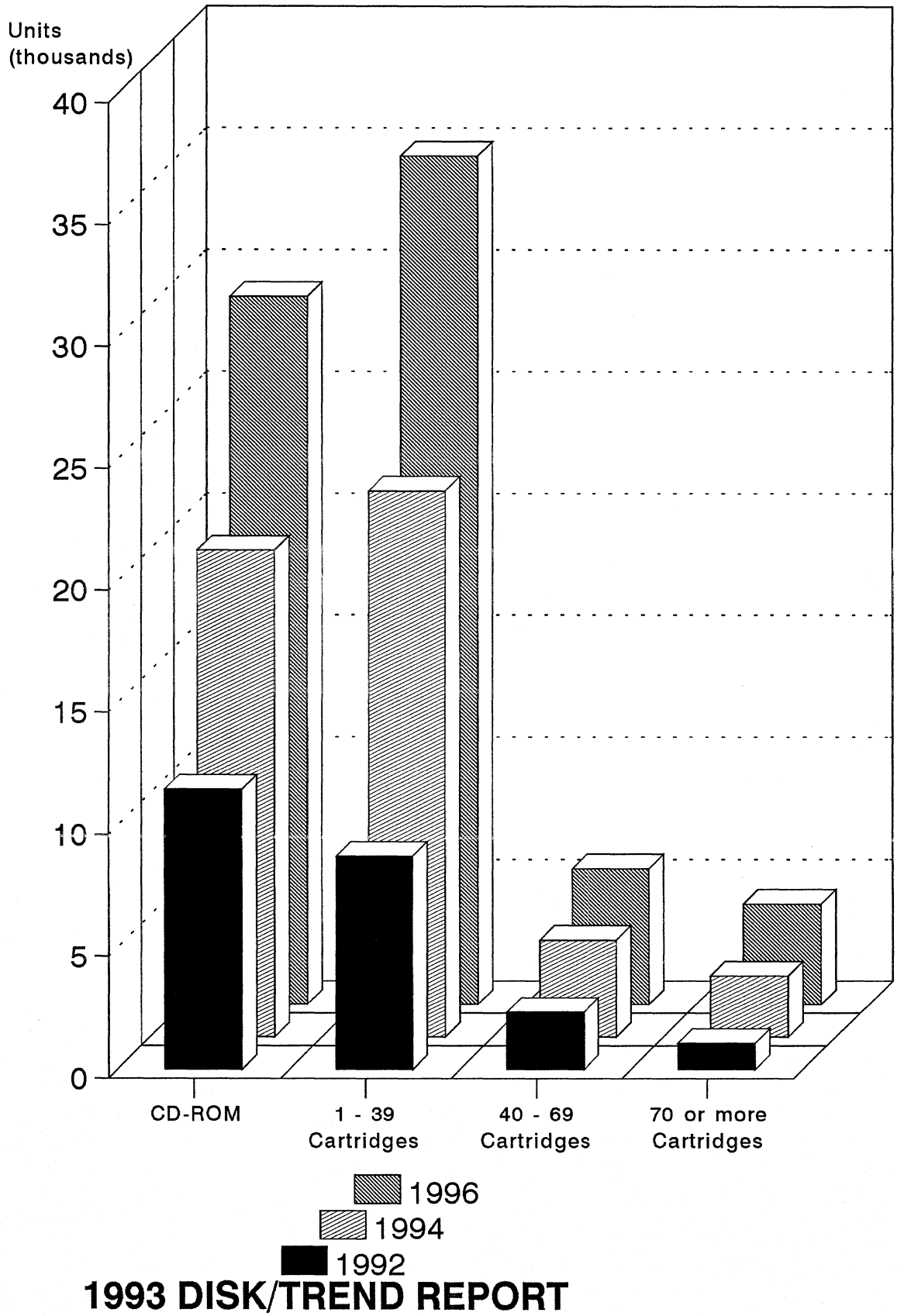


Figure 6

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Libraries



1993 DISK/TREND REPORT

TABLE 13

1992 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK DRIVES
(Value of non-U.S. currencies estimated at average 1992 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
IBM	66.8	24.3	--	--	30.5	4.3	97.3	7.4
Maxoptix	--	--	14.7	4.6	13.2	1.8	27.9	2.1
Other U.S.	14.2	5.2	5.2	1.6	10.9	1.5	30.3	2.3
U.S. Total	81.0	29.4	19.9	6.2	54.6	7.6	155.5	11.9
NON-U.S. MANUFACTURERS								
Canon	43.5	15.8	--	--	--	--	43.5	3.3
Hitachi	23.2	8.4	24.2	7.6	58.0	8.1	105.4	8.0
Laser Magnetic Storage Int'l.	--	--	15.8	5.0	34.3	4.8	50.1	3.8
Matsushita Electric Industrial	27.9	10.1	39.6	12.4	125.7	17.5	193.2	14.7
Mitsumi Electric	--	--	29.0	9.1	24.8	3.5	53.8	4.1
NEC	39.5	14.3	43.6	13.7	16.3	2.3	99.4	7.6
Olympus Optical	--	--	5.3	1.7	33.3	4.6	38.6	2.9
Philips	1.3	.5	2.0	.6	19.6	2.7	22.9	1.7
Ricoh	13.8	5.0	29.1	9.1	18.6	2.6	61.5	4.7
Sony	40.4	14.7	77.2	24.2	176.8	24.6	294.4	22.5
Toshiba	--	--	7.6	2.4	75.5	10.5	83.1	6.3
Other Non-U.S.	4.7	1.7	25.3	7.9	79.8	11.1	109.8	8.4
Non-U.S. Total	194.3	70.6	298.7	93.8	662.7	92.4	1,155.7	88.1
WORLDWIDE TOTAL	275.3	100.0	318.6	100.0	717.3	100.0	1,311.2	100.0

Note: 1. Drives sold in the PCM/Reseller market by other than the original manufacturer are valued at PCM/Reseller prices above, to avoid distortion of total market value

2. The DISK/TREND estimates of revenue for each disk drive manufacturer include net sales of disk drives only and do not represent total revenues for individual companies

TABLE 14

1992 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL LIBRARIES
(Value of non-U.S. currencies estimated at average 1992 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Cygnet Systems	--	--	--	--	11.3	7.6	11.3	4.5
Eastman Kodak	14.0	24.0	--	--	6.8	4.6	20.8	8.3
Filenet	10.4	17.8	--	--	2.4	1.6	12.8	5.1
Hewlett-Packard	16.3	28.0	12.5	29.6	43.7	29.4	72.5	29.1
International Data Engineering	--	--	15.4	36.4	11.4	7.7	26.8	10.8
Other U.S.	.2	.3	.1	.2	3.8	2.6	4.1	1.6
U.S. Total	40.9	70.2	28.0	66.2	79.4	53.4	148.3	59.5
NON-U.S. MANUFACTURERS								
Hitachi	12.0	20.6	--	--	4.0	2.7	16.0	6.4
Laser Magnetic Storage Int'l.	--	--	1.9	4.5	9.4	6.3	11.3	4.5
Matsushita Electric Industrial	4.2	7.2	3.0	7.1	17.8	12.0	25.0	10.0
NKK	--	--	3.2	7.6	13.7	9.2	16.9	6.8
Pioneer	--	--	4.1	9.7	5.0	3.4	9.1	3.7
Sony	--	--	--	--	15.8	10.6	15.8	6.3
Other Non-U.S.	1.2	2.1	2.1	5.0	3.6	2.4	6.9	2.8
Non-U.S. Total	17.4	29.8	14.3	33.8	69.3	46.6	101.0	40.5
WORLDWIDE TOTAL	58.3	100.0	42.3	100.0	148.7	100.0	249.3	100.0

Note: 1. Drives sold in the PCM/Reseller market by other than the original manufacturer are valued at PCM/Reseller prices above, to avoid distortion of total market value

2. The DISK/TREND estimates of revenue for each disk drive manufacturer include net sales of disk drives only and do not represent total revenues for individual companies

TABLE 15

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL DISK DRIVES

Codes: C = Captive
O = OEM/Integrator
P = PCM/Reseller
E = Erasable

DISK/TREND PRODUCT GROUP:		10 CD-ROM Optical Drives	11 Read/Write Optical Drives <1 GB	12 Read/Write Optical Drives >1 GB
U.S. Manufacturers (11)	Type			
CD-ROM, Inc.	P	4.72		
Eastman Kodak	C,O			14
Hewlett-Packard	C,O,P		5.25 E	
Honeywell	O		5.25	
IBM	C,O		3.5 E, 5.25 E	
Literal	O,P		5.25, 5.25 E	
Maximum Storage	O		5.25	
Maxoptix	O,P		5.25 E	
MountainGate Data Systems	O		5.25, 5.25 E	
Mountain Optech	O		3.5 E, 5.25, 5.25 E	
Pinnacle Micro	O,P		5.25 E	
Asian Manufacturers (29)				
Asaca	O		5.25 E	
Canon	C,O		5.25 E	
Chinon	O,P	3.15, 4.72	3.5 E	
Fujitsu	C,O		3.5 E, 5.25 E	8 E
GoldStar Co., Inc.	O,P	4.72		
Hitachi	C,O,P	4.72	5.25, 5.25 E	12
JVC	O		4.72	
Kawasaki Steel	O		5.25	
Kyocera	O,P	4.72		
Laserbyte	O,P		3.5 E	
Matsushita Electric Ind.	C,O,P	3.15, 4.72	3.5 E, 5.25, 5.25 E	
Matsushita Electronic Comp.	O	4.72		
Mitsubishi Electric	O		5.25, 5.25 E	
Mitsumi Electric	O	4.72		
MOST	O,P		3.5 E	
NEC	C,O,P	4.72	3.5 E, 5.25, 5.25 E	12
Nikon	O			12 E
Olympus	O		3.5 E	
Pioneer Electronic	O,P	4.72	5.25, 5.25 E	
Ricoh	C,O,P		3.5 E, 4.72, 5.25, 5.25 E	
Samsung Electronics	O	4.72		
Sanyo	O,P	4.72		
Seiko Epson	O		3.5 E	
Sharp	O,P	3.15	5.25 E	
Sony	C,O,P	3.15, 4.72	3.5 E, 4.72, 5.25 E	12
Teac	O	4.72	3.5 E	
Texel (Shinano Kenshi)	O	4.72		
Toshiba	O	3.15, 4.72	3.5 E	
Yamaha	C		4.72	
European Manufacturers (3)				
ATG Gigadisc	O			12
Laser Magnetic Storage Inter.	C,O,P	4.72	5.25	12
Philips Consumer Electronics	C,O,P	4.72	4.72	

Numbers in table are diameters in inches.

TABLE 16

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL LIBRARIES

Codes: C = Captive
O = OEM/Integrator
P = PCM/Reseller

DISK/TREND PRODUCT GROUP:		50	51	52	53
U.S. Manufacturers (11)	Type	CD-ROM Optical Libraries	Read/Write Optical Libraries 1-39 Disks	Read/Write Optical Libraries 40-69 Disks	Read/Write Optical Libraries 70+ Disks
Access	C		12		
Borett Automation Tech.	O	4.72			5.25, 12
Cygnet Systems	O		12		12
Document Imaging Systems	O				5.25
Docupoint	C,O				5.25
Eastman Kodak	C,O,P			5.25	14
Filenet	C,O				12
Hewlett-Packard	C,O,P		5.25		5.25
IBM	C,O		3.5, 5.25		5.25
International Data Engin.	O,P		3.5, 5.25		
Kubik Enterprises	O	4.72			
Asian Manufacturers (12)					
Aisin Seiki	O		5.25		
Asaca	O				5.25
Fujitsu	C,O				5.25, 12
Hitachi	C,O		5.25, 12	5.25, 12	
Matsushita Electric Indus.	C,O			5.25	
Mitsubishi Electric	C,O		5.25	5.25	5.25
NEC	C		5.25, 12	5.25	
Nikkyo	O		5.25	5.25	
NKK	O,P		5.25	5.25	5.25
Pioneer	O,P	4.72			
Ricoh	C,O		5.25	5.25	
Sony	O		12	12	12
European Manufacturers (6)					
Amber Technology	O,P			5.25	
ATG Gigadisc	O		12		
DSM	O,C	4.72	5.25, 12	12	5.25, 12
K+S	O,P		5.25		
Laser Magnetic Storage Inter.	O,P		12		
NSM	O	4.72			

Numbers in table are diameters in inches.

TECHNICAL REVIEW

1993 is a year in which recent improvements in optical disk drive technology are appearing in products actually being shipped by multiple manufacturers. These include rewritable drives with over 650 megabytes per side capacity (from IBM, Sony, Hewlett-Packard, NEC and Maxoptix) and CD-ROM drives with doubled data transfer rates (from NEC, Hitachi, Toshiba, Sony and others). CD-Recordable drives are also being shipped by several manufacturers. By year end, it is likely that these products will be joined by 230 megabyte magneto-optic 3.5 inch optical drives and a 975 megabyte per side magneto-optic drive from Hitachi.

Despite the progress, there are areas in which further improvements remain to be made. Some of the more significant are:

* Higher power, higher frequency lasers needed for higher areal densities.
* Improved high function integrated chips to do specialized coding, compression, or other signal processing functions.
* High drive and media prices.
* Incompatible physical and recording standards, preventing media interchange between systems.
* Low mass head design for improved performance and cost.
* Susceptibility to hostile environments, especially dust.
* Need for higher data transfer rates to support large files and motion video.
* Need for direct overwrite for magneto-optic drives and media.
* Incompatibilities between optical drives and optical libraries.
* Repackaging of drives into smaller industry standard form factors.
* Lower power drives for use in portable equipment.

Although improvement in optical disk drive and library capabilities is continuing, optical storage is still only one of several technologies to be considered as a potential solution in a given application. A significant cause of slow growth in the optical storage industry is the prior availability of proven solutions offering less

risk and, often, better performance at lower cost. At present, not even optimistic observers expect optical drive performance and cost to equal that of the rapidly improving magnetic rigid disk drive until the end of the current decade. The advantages of optical recording, such as greater head to disk spacing that reduces the likelihood of head crashes, is not sufficient to overcome the optical drive and media economic and performance deficiencies.

Optical disk technology and applications

Three types of optical disk drives used as computer peripheral devices are discussed in the following sections.

* Read-only optical disks: The read-only optical disk group is dominated by 4.72" CD-ROM drives, which have typical capacities of 550 to 680 megabytes. A 3.15" proprietary format CD-ROM made its appearance in 1990 in the Sony "Data Discman", a portable data retrieval system initially sold only in Japan and now being sold in the U.S. A few manufacturers market an ISO format 3.15" CD-ROM drive using media capable of storing 180 to 200 megabytes of data. In the booming market for standard 4.72" CD-ROMs, some CD-ROM titles now require more than one disk to hold all of the data, and pressure is building to create a double capacity, backward compatible CD-ROM format. However, a new format is probably at least two years away. NEC has discussed a quadruple capacity design (about 2 gigabytes) for disk and drive using a green laser and narrower track pitch as a possible future product.

  CD-ROM technology borrows heavily from the designs of 4.72" CD audio players now in volume production, so while drive costs are relatively low, performance is slow. Inexpensive plastic lenses and low power lasers are commonly used. However, recently announced CD-ROM drives from NEC, Philips, Sony and others have doubled the RPM and the data transfer rate in order to support full motion video output. Pioneer announced a quadrupling of RPM and data transfer rate in early 1992. Despite these improvements, average access time is still typically between 200 and 300 milliseconds, and is in the range of a second for the least expensive drives, typically used for games.

  Except for CD-ROM, (and laser videodisks, not covered in this report) optical read-only (OROM) solutions have not met with success. Read-only memory formats include OROM capability on 3.5" and 5.25" and 12" media, but of these only the 3.5" format is getting serious consideration as a vehicle for software distribution and multimedia presentations. An alternate technology based upon the capacitive playback scheme developed by RCA for its videodisk system has been proposed, but has not been commercialized.

Most CD-ROM drives are used with small systems to provide personal access to large amounts of information, though some are attached to file servers as well. CD-ROM is now an accepted medium for distributing system documentation and software as well as application packages. CD-ROM acceptance benefits from industry agreement on the CD and CD-ROM standards developed jointly by Sony and Philips and also upon the recording format standard for computer data formalized as ISO standard 9660. This ISO standard has received extensions to cover the use of CD-ROM drives capable of reading data from multiple recording sessions, thus making it possible to use disks written on CD-WO drives.

In read-only recording, the disk is normally mass produced using a stamping process to impress the data upon the surface of the disk. The stamping master is produced using techniques analogous to those for making semiconductor masks. The sputtered aluminum surface onto which the master is impressed will vary its reflectivity in accordance with the data pattern. When scanned by a laser beam, the reflected rays carry a signal pattern which is processed within the drive to obtain the data content of the signal. Processing includes error correction and may include decompression if audio or video data is present.

Because mass production of read-only optical disks is done by a mastering and mass replication process, rather than by recording directly on the disk, the cost per disk can be low, usually under a dollar per disk. However, mastering costs and replication turnaround time can make production of single disks or very short runs economically unattractive. CD-WO drives appear poised to address this need.

* Nonreversible optical disks: The first optical disk recording systems to enter the market were "nonreversible" or "write-once" systems. A few systems with optical drives were sold in Japan in 1984, but it wasn't until 1986, after many years of costly development programs undertaken by manufacturers, that such devices began to move into production status.

  With track densities typically in the range of 16,000 to 20,000 tracks per inch and bit densities in the range of 25,000 to 35,000 bits per inch, write-once drives (and rewritable drives) are capable of higher areal densities than magnetic recording drives now in use. However, unless improvements in optical recording technology accelerate, magnetic drives might catch up by 1996. 12" and 14" drives can provide up to 10 gigabytes on a single removable disk. CD-WO drives, still costing over $4,000, have the potential to eventually provide inexpensive write-once disks with 500 to 600 megabytes of storage. There is some possibility that rewritable phase change media will become available to give CD-WO drives a rewritable capability.

  Writing techniques involve changing the reflectivity of an area of the disk, either by making a small hole or causing a surface reflectance change.

Recording systems are available which alter the writing layer from an amorphous to a crystalline state, and others deform the surface of the media to cause a reflectance change at the point where a bit is written. In 1990, a group of drive and media producers proposed a type of write-once capability (known as Continuous Composite WORM, or CCW, or MO-WORM) achieved using magneto-optic media, which is normally re-writable, prestamped with information indicating that it is to be used only in a write-once mode.

Writing power required at the surface of the disk is in the range of 10 milli-watts for writing at useful rotation rates of the media. Losses in the optical subsystem of the head require a laser with emitted power in the 20 to 30 milliwatt range. Read power is typically in the 1.5 to 2 milliwatt range, but must be carefully controlled to avoid an inadvertent write, due to the cumulative effects of successive read operations. To achieve media inter-change, drives must be able to sense the media formulation in use and adjust power levels as required.

Write-once drives require more complex logic to operate with computer operating systems which expect a disk drive to be rewritable, adding to system complexity and cost. Write-once storage also requires more user management than rewritable storage as the disks become completely written. Long latency, slow head positioning, read verification cycles and slow data transfer rates also make write-once storage an ineffective per-formance competitor to magnetic disk drives. However, high performance rewritable drives using CCW media can provide some improvement in write-once performance.

Although not yet demonstrated in field use, extensive accelerated testing indicates that write-once disks should provide archival lives which equal or exceed those of magnetic media, with 10 years being the minimum speci-fication for archival life of the media. Some media suppliers specify a 30 year lifetime and claims of lifetimes exceeding 50 years have been made. The lifetime is limited by the gradual appearance of defects on the record-ing layer, typically an alloy of tellurium, due to the corrosive effects of water and oxygen on the metal films used in the recording layers of the media. The termination point of media lifetime occurs when the error correction capability of the drive can no longer cope with the gradually increasing media defect density. Some media based on dye or dye/polymer designs have no metallic films and are expected to be more corrosion resistant than the original generation of metallic films. Other optical media using platinum or tin alloys as recording layers offer corro-sion resistance, but may trade off write sensitivity for the improved longevi-ty obtained.

The largest application for write-once recording technology is the archival storage of documents. The document is typically stored as a document image, rather than as character data. The write-once systems now avail-

able offer capacities per disk in the range of 300 megabytes to over 10 gigabytes. Smaller capacity 5.25" products are marketed as OEM drives for use in small systems and optical libraries; larger capacity drives are typically used in captive systems and in optical libraries by a few system manufacturers. Later write-once systems have offered a higher degree of sophistication, such as LMSI's dual head 12" drive which offers 5.6 gigabytes of disk capacity on-line and has two heads, allowing simultaneous access to both sides of the disk.

Obviously, the market for write-once optical disk systems will be limited to niche markets which can tolerate or desire nonreversibility. In some applications, the ability of write-once storage systems to maintain an audit trail or indicate whether or not stored data has been modified is a significant benefit.

The 5.25" multifunction drives that have entered the market are expected to gradually displace dedicated write-once 5.25" drives since the user will be able to determine drive functionality simply by choice of media.

* Rewritable optical disks: Magneto-optic (M-O) recording is the most commonly used rewritable technology, but rewritable phase change is also in use. Dye-polymer materials can also exhibit rewritability, but no such material has yet been developed to the point where it can compete with M-O or phase change recording.

  Magneto-optical recording, whose roots go back over thirty years, has competition from rewritable "phase change" optical recording, starting with the introduction of a drive and media by Matsushita Electric in 1990. Rewritable optical recording based upon dye/polymer technology developed by Optical Data, Inc., and related drives from Tandy initially received much attention but did not prove workable. ODI ceased operations and licensed the technology to Teijin, but little evidence of further development has been seen.

  Very high capacity rewritable drives require the availability of larger diameter rewritable media, which is difficult to fabricate with adequate yields within the current state of the art. The first 12" rewritable drive, with 2 gigabytes per side, was announced by Nikon in late 1991. However, improvements are being made in 5.25" drives and media as well. Sony, IBM, NEC, Maxoptix and Hewlett-Packard have already announced 5.25" drives with 650 megabytes per side capacity for shipment in 1993, and some companies, including Hewlett-Packard and Hitachi have expressed interest in producing drives with nearly 1 gigabyte per side capacity. Proposals for drives and media with 1.3 gigabytes per side are being considered by various standards bodies. Drives are expected to be available in 1995.

  Current magneto-optic drive designs use a low power laser to change the magnetic state of the active layer on a disk. The laser raises the tempera-

ture of the active layer into the range of the Curie point while a magnetic field is present, causing individual magnetic domains on the disk to align with the direction of the external magnetic field. Changes in magnetic orientation are detected during reading, as the affected spot on the disk causes a small rotation in the polarized light reflected from the surface or transmitted through the disk. Because the polarization shift is small, it is harder to get adequate signal to noise ratios with M-O media than it is with other types of media.

Magneto-optic media require less laser power for writing than write-once media because there is no need to physically deform the writing layer or cause it to melt, permitting the disk to rotate faster for a given available laser power. The faster rotation (Hewlett-Packard and Ricoh are up to 3,600 RPM and Fujitsu has announced a 5,400 RPM model) improves latency and data transfer rate. However, production magneto-optical disks have not yet shown the ability to overwrite in place: A complete sector must be erased before the sector can be rewritten. While several approaches offer technical solutions to this problem, all seem to add undesirable complexity and cost to the drive or media and none seem likely to be available in the market before 1994.

Sony made a preliminary announcement in 1991 of a CLV 2.5" audio magneto-optic disk drive using inexpensive media and not requiring a separate erase pass. As of mid-1993, this drive is expected to be available as a computer peripheral device with about 140 megabyte capacity, and 150 kilobyte per second data transfer rate as early as 1994. Sony proposed the MD-DATA media standard for the computer peripheral version of the 2.5" drive in the last half of 1993.

Phase change optical recording involves a different type of amorphous coating, in which individual spots on the disk are changed by laser irradiation from a crystalline state, during which light is reflected, to a noncrystalline state, during which light is absorbed. Alternatively, different crystalline states are used to vary reflectivity. Media stability with time, phase reversal time, and the limited number of possible write/erase cycles still represent problem areas for rewritable phase change technology. However, if the price is competitive with tape technology, phase change media having a write/erase cycle limit of at least 1,000 cycles could compete for backup and other applications where infinite rewritability is not required. Matsushita Electric is shipping phase change drives and media with over 100,000 cycles capability, so this segment of the market seems within the grasp of the technology. Phase change media also has the advantage of offering direct overwrite, a current limitation for M-O drives and media, and thus can be faster than magneto-optic drives in write mode. The drive does not require the bias magnet typically used in M-O drives.

A third recording technology, potentially the least expensive to manufacture, is rewritable dye or dye/polymer. Only limited success has been

obtained with this technique because developers have not been able to demonstrate a large number of write/erase cycles. As a result of the Tandy announcement, much industry attention was given to possible uses of low cost drives with limited erasability media. This type of drive/media combination could be used as a replacement for cartridge tape drives and some write-once optical drives, but it is still far from being a manufacturable product as a computer peripheral.

A fourth recording technique using ferroelectric material as the active recording layer is being developed by Radiant Technologies. This material has the advantages of being writable at lower laser power than magneto-optic media and does not suffer from thermal inertia or thermal fatigue effects. It also produces large polarization effects relative to magneto-optic materials, improving signal to noise ratio. Ferroelectric materials also appear to be somewhat more stable and immune to contamination than magneto-optic materials. However, media fabricated with this technology do not appear to be directly interchangeable with other types of recordable media on existing drives. Sample media is expected to be available in late 1993.

Other proposed reversible optical recording technologies are known, but none of these have overcome all of the problems, which have included: Slow reversal cycle, limitations on the number of reversals before degradation, poor shelf life, and low recording density.

Multifunction drives are capable of operating with at least two types of media, with write-once and rewritable being the typical combination. Early 5.25" multifunction drives were not compatible with each other or with the ISO CCS format, but more recent multifunction drives can exchange media. Several firms currently producing or using CCS format magneto-optic media have agreed upon a method of designating all or portions of a magneto-optic disk as write-once portions, with status detectable by the drive. The same principle has been applied to making a portion of the disk read-only, as has been done in the ANSI/ISO standards prepared for 3.5" magneto-optic media.

* Optical libraries: Random-access libraries, commonly called "jukeboxes", are devices that automatically pick, load, unload and refile media units for an optical disk drive. While not part of the drive, they are frequently associated with the drive in high-end archival systems where large amounts of data must be accessed and maintained on-line. Current library units can store from 5 to over 200 disk units in 12", 5.25" or 3.5" formats. Typical retrieval and load times are a few seconds. Some libraries have multiple picking assemblies so that disk cartridge access/load operations can be overlapped, reducing the cartridge exchange time.

Early libraries used 12" drives and were too expensive to be attractive for use with lower capacity optical drives. However, libraries appropriate for use with small optical drives have been produced and are available for

attachment on platforms ranging from personal computers to mainframes. Numerous 5.25" libraries have been introduced by firms such as NKK, IDE, and Hewlett-Packard. Random access disk libraries available for CD players have begun to migrate to the computer world as an accessory for the CD-ROM. Pioneer is actively selling a six disk library that incorporates a CD-ROM drive, and Kubik is in pilot line production of a carousel type library storing over 200 disks.

Drives designed for use in libraries must be able to withstand many thousands of cartridge insertions by robot pickers and must accommodate electrical control of cartridge loading and unloading. They should also minimize spin-up time, load time and unload time. However, in a library environment, average access time tends to be hidden by the much longer load/unload cycle time. Drives may also be subject to an unusual amount of shock and vibration associated with the operation of the library mechanism, which can potentially cause reliability problems with mechanical and electronic components. Drive design should also minimize the formation of dust during cartridge insertion and withdrawal and avoid dust ingestion from external sources.

Integration of a library device into a computer system requires a substantial software design effort for even small systems. Integration into a mainframe environment is a major task that can involve several man-years of effort. Mainframe data access method support remains relatively limited, although IBM's 1992 announcement of 3395 library subsystem use as a virtual 3390 model 2 may eventually influence the industry to provide stronger mainframe support.

Technical issues

Most of the technical issues apply to all three of the optical drive storage technologies described above. A few, such as the overwrite issue, apply to a specific technology. Key enhancements to optical storage performance are likely in the following areas.

* Backward compatibility: As new generations of drives and media are developed, the need to remain backward compatible with previous versions is becoming a critical issue for end users who have developed large libraries of media and do not want to have to invest in new media or conversion efforts as the result of moving to new drive technology. The need for backwards compatibility is also a problem for drive designers, who may have to sacrifice otherwise feasible performance and capacity gains in order to satisfy the compatibility criteria.

* Recording heads: The optical recording head is a relatively complex device incorporating a diode laser, detector, optics, and, frequently, a fine

positioning mechanism. The result is a head assembly with relatively high mass, which slows access time and increases the power required to position the head. For the first generation of write-once optical drives, which were used with document storage systems, the long average access time, typically in excess of 125 milliseconds, was not a critical factor. However, the desire of many firms to use optical drives in data processing systems is creating pressure for faster average access time. Considerable work is under way at many firms, aimed at reducing the mass of optical head assemblies, and is beginning to bear fruit in such products as the Maxoptix 5.25" rewritable drive, which has an average seek time in the 25 millisecond range. This performance has been achieved by using a split optic system in which only the objective lens, focus and fine tracking mechanisms are mounted on the moving carriage, substantially reducing the total mass of the head assembly and, therefore, the seek time.

LMSI brought the first two-headed drive to market. The LMSI introduction had a significant impact on the plans of drive producers, many of which began seriously considering multiple heads in their optical drives. However, LMSI's subsequent production difficulties dampened enthusiasm somewhat.

The use of holographic optical elements to replace many of the heavier glass lenses and supporting structures is being explored by several firms. While providing simplicity, the transmission efficiency of holographic systems currently available is less than that of conventional optics, restricting the use of holographic optics to applications which require less write power at the surface of the media.

Molded aspheric lenses are used in smaller drives. These lenses, some of which are molded using plastic rather than glass, substantially reduce cost, weight and complexity of the optical path in the head. Other head component integration techniques explored at Osaka University and other institutions have the potential to result in a monolithic assembly in which laser and lens are fabricated as a single unit.

It is possible to design heads using composite laser assemblies that are capable of emitting separate read, write and erase beams through a common optical channel. These assemblies are intended to permit direct read-after-write operations in which the read beam can interrogate the disk immediately after a bit is written to insure that a write error was not made. Composite assemblies of this type are very difficult to fabricate and align. As error correction techniques improve, they may not be necessary to achieve adequate performance.

* Lasers: The amount of power available from the laser in the optical drive limits how fast a spot on the disk can be written, and thus, limits the rotation speed and data transfer rate that can be obtained. As improved laser diodes are found to be economically and technically suitable, a significant increase in data transfer rates and a significant decrease in latency will be

obtained. The faster 5.25" optical disk drives have reached the 10 megabit per second data transfer rates of small rigid magnetic disk drives. More powerful lasers permit the use of beam splitting techniques useful in improving tracking and direct read-during-write operations and will make it easier to use holographic lens systems at higher data transfer rates or with less sensitive media.

A second limitation related to the laser is spot size, which is a function of laser wavelength, among other factors. Work on shorter wavelength lasers may result in smaller spot sizes and an increase in bit and track density. Doubling the frequency halves the spot size, which results in a theoretical quadrupling of the storage density. However, large improvements are not anticipated in the near future due to the difficulty of producing a semiconductor laser that will operate at near blue wavelengths at room temperature with adequate power and stability and at reasonable cost. Low power blue lasers suitable for use with read-only drives may become available within the next three years. In 1993, Sony demonstrated an experimental pulsed blue semiconductor laser workable at room temperature, and IBM demonstrated a 2.5 gigabit per square inch areal density using a frequency doubled 856 nanometer laser and magneto-optic media with a blue sensitive active layer to reduce the writing power required. A read rate of 2 megabytes per second was achieved with this combination.

An anticipated near term improvement is an AlGaInP laser with a wavelength of about 680 nanometers, compared to the commonly used AlGaAs 780 nanometer devices of today. Production volumes of the improved lasers are expected in 1994, and this should result in an areal density improvement by a factor of about 1.4. These devices were available in sample quantities from Matsushita Electric in mid-1993 for about $700.

* Recording disks: Media has been an area of major challenge, especially for magneto-optic media, which requires many complex processing steps. Most read/write optical disks made to date use complex multilayer designs and sputtering techniques to deposit the various layers. But manufacturing techniques have evolved to the point that disk media is able to withstand the range of temperatures and humidities most likely to be experienced without undue media degradation. Small amounts of niobium added to the usual rare earth-transition metal alloys used for magneto-optical media give some promise of reducing the corrosion sensitivity of magneto-optic disks.

  Currently there is substantial overcapacity among media suppliers, in the aggregate. However, because write-once optical disks from different manufacturers are not widely interchangeable among drives, media availability is still a concern where specific preformatting is required and is available only from a single drive or media manufacturer. Manufacturers of rewritable drives claim a significant degree of media interchange capa-

bility between drives of differing manufacturers. This has been demonstrated for most 5.25" and 3.5" CCS format rewritable drives.

Reformulation of the active recording layer of media may be required in order to assure operation with short wavelength lasers. The need to operate across a band of wavelengths has the potential to cause future interchange problems between different generations of drives and media.

Some innovative products, such as the dye-based disks offered for use with the Ricoh write-once optical drive, offer potentially lower costs and improved environmental stability because the active layer has no metal components subject to corrosion. Rewritable dye-based media is being investigated as well, but the number of write/erase cycles demonstrated has so far not exceeded 10,000 cycles in the laboratory.

Most of the substrates used so far have been plastic. However, the ability of glass to provide smoothness, freedom from distortion at high rotation rates, minimal optical dispersion and superior environmental protection is causing this material to be preferred as a substrate material in applications where archival life and reliability are critical. While glass substrates are more expensive than plastic, a factor discouraging use, their potential for use in new generations of rigid magnetic disk drives suggests that economies of scale could develop sufficiently to make them attractive for wider use in optical media. There is evidence that glass substrates, being smoother, result in substantially improved error defect rates, which in turn can reduce drive latency due to error correction time.

The limitations of plastic when used for larger diameter disks with high stability requirements may encourage the use of glass. Media produced for the LMS 12" drives, for instance, uses glass substrates. The 5.25" magneto-optic rewritable drives sold by Matsushita, Sharp and others also use glass substrates.

Magneto-optic media will have to make a transition through one more generation to arrive at designs permitting direct overwriting in place of previously recorded data, rather than requiring a separate erase pass before writing. It is likely that more than one overwrite solution will be offered, all probably incompatible, further aggravating the media interchange problem. Several firms have discussed methods of fabricating advanced magneto-optic media that will operate without a separate erase pass. Sony's proposed IRISTER media also permits doubling the track density and tripling linear density. However, the proposed media designs are more complex and may be difficult to manufacture. The method discussed in conjunction with the Sony 2.5" audio drive (turning on the laser and then varying the field with a magnetic head) may turn out to be more manufacturable, although there are doubts it will function properly at high RPM. It remains to be seen if high performance computer peripherals can use this design technique effectively.

Media life is a declining concern. Accelerated life tests indicate that rewritable media can be expected to have a useful life of 10 years or more (some suppliers claim 30), but there is no field experience of actual lifetimes of this duration.

* Head positioning methods: The track density achieved on an optical drive is much higher than that obtainable on a magnetic disk drive because most optical drive designs use a pregrooved substrate as a device to provide tracking information to the head positioning servo. This method is known as the continuous composite servo (CCS) method. Some designs, such as those favored by ATG Gigadisc and Laser Magnetic Storage, use an embedded servo technique known as sampled servo for fine tracking. There is considerable controversy as to which approach should be considered the standard approach. The two formats are not interchangeable in present drive designs. A variant of the sampled servo, called sampled servo with RZ encoding, is in use by Literal and its licensees. Still another method, called the discrete block format, has been proposed as a standard for 3.5" rewritable drives.

  Most optical drives use a two stage head positioning mechanism in which a conventional voice coil mechanism positions the head to a region of the disk and a vernier tracking mechanism in the head then steers the laser beam to the desired track. Some drive suppliers are evolving toward elimination of the vernier tracking mechanism.

  Major increases in track density in the next two years are not expected, and most drives will remain in the range of 15,000 to 20,000 TPI. The new 5.25" 650 megabyte per side drives and media specified a 1.4 micron track pitch, or about 18,000 TPI. However, as manufacturers go to higher rotation rates to improve latency and transfer rates, it will be necessary to redesign tracking and focusing servo systems to operate at higher bandwidths.

* Semiconductor Logic: Because the shipments of optical drives are small, integration of the electronics for read/write drives into single chips or chip sets has been slow to occur. However, some chips, such as the AMD optical disk controller announced in 1992, are starting to appear. The net effect will be to reduce cost, power requirements and packaging size. Optical drives have yet to take advantage of the new 3.3 volt logic now becoming available. The relatively high masses that must be moved and the rapid spin-up and spin-down times desired may make it impractical to use 3.3 volt power in high performance drives.

* Packaging: Most early small optical drives were packaged to fit into a standard 5.25" form factor for easy mounting in personal computers widely produced in the second half of the 1980's. The next generation, offering 5.25" half-high profiles, has appeared. The first such products were CD-ROM drives, such as the ones introduced by Matsushita Electric

and Toshiba, but half-high write-once and rewritable 5.25" optical drives are now being shipped. 3.5" rewritable drives fit into a standard 41.3 millimeter high space. Fujitsu announced a one inch high 3.5" drive in 1992. 2.5" rewritable drives are in development at several firms and Sony has shown an audio version that may eventually be sold as a computer peripheral. In 1993, Fujitsu made a technology announcement of a 60 megabyte 1.8" magneto-optic drive which is expected to become available in 1995 with 128 megabytes capacity.

Several firms are working on write-once and rewritable drives using the 4.72" CD-ROM format. These drives are looked upon with disfavor by many potential CD-ROM publishers, who are concerned that piracy will become a problem if copying is made too easy. The experience of the software industry suggests that these fears are valid, and writable CD-format drives may not be sold freely until a mechanism to prohibit copying of published CD-ROM titles can be devised. Nevertheless, CD write-once drives are currently being sold in limited quantities.

Yamaha introduced a CD format write-once system in 1989 using media supplied by Fuji Photo Film. Philips, Ricoh, Sony and JVC are also now producing CD write-once drives.

Because small diameter optical disk drives are forced to conform to magnetic disk drive form factor standards, which continue to evolve, within a few years 3.5" optical drives will be required to achieve heights of 19 or 25.4 millimeters. Reduced drive height is necessary to be attractive to system integrators producing portable and desk top systems configured to accept magnetic drives in the small form factors.

There is less packaging pressure on larger diameter drives, but it is important for these drives to be designed in a way that enhances their use in automated library subsystems, or at least does not detract from it, as many of the larger diameter drives are used in optical library systems. Some larger diameter drives are tabletop or rack mounted. 12" products are typically rack mounted.

* Power: The power requirements of optical drives make them largely unsuitable for use in portable systems, although a few systems, such as the Sony DataDiscman and the Sony MMCD (multimedia compact disk) have appeared using CD-ROM drives.

* Interface: The most common interface encountered on optical drives is SCSI, covering the range from low-end CD-ROM players to larger drives intended for use with multiuser or document storage systems. Interfaces compatible with IBM personal computers are also common on CD-ROM hardware and 5.25" drives. Drives used in certain document filing systems -- largely of Japanese manufacture -- have frequently used proprietary interfaces, but the SCSI family of interfaces will remain the most common.

Higher performance drives are migrating to the newer SCSI-2 interface. Many drives now have the SCSI controller embedded within the standard drive package, eliminating the need for a separate controller card.

Early optical libraries used RS-232 channels to control the library mechanism, but later generations have tended to use SCSI, in some cases sharing a single SCSI port between library and drives to reduce cost. Some optical libraries include small computers equipped with interfaces to popular local area networks, enabling the library to operate as a server device. IBM and ATG Gigadisc are among the firms offering such capabilities.

* Software: Rewritable optical disk drives are logically similar to magnetic disk drives, so the preparation of system software that supports a rewritable optical disk is a routine task. However, software support for a write-once drive is a task of formidable magnitude. Lack of appropriate software is one of the factors that has slowed the acceptance of write-once optical drives. While drive manufacturers now supply such basic software items as routines that link the drive to major operating systems, manufacturers of complete systems or storage subsystems find that they must do the bulk of the software themselves or contract the work to a third party. Microsoft offers a CD-ROM device driver that is supplied with most CD-ROM drives shipped.

  Some firms have incorporated sophisticated firmware in their drives to avoid degradation of throughput caused by error correction, write verification, bad sector rewrites and other delay factors. While this does not affect the raw data transfer rate to or from the drive, the observed throughput can increase by as much as a factor of 10 over a drive without such features. Some drives, such as the Maxoptix RXT-HD, incorporate internal data compression and decompression as well as error correction.

  Software for CD-ROM preparation and retrieval is becoming less difficult to locate. In many cases, software is supplied on the CD-ROM, with the published material. As most CD-ROM published works are of a textual or data base nature, publishers must obtain efficient text search or data base search software. Over 50 software specialty houses make such programs available.

  Software for optical libraries requires creation of drivers for control of the library mechanism and systems software for integrating the library into the overall system. System integration becomes increasingly complex as system complexity grows. Several man-years of software development are required to seamlessly integrate optical libraries to mainframe computers. Hierarchical storage management providing automatic file migration between rigid disk drives and optical disk drives/optical libraries is expected to become increasingly common.

* Standards: Physical standards for CD and CD-ROM were initially jointly set by Sony and Philips. The initial joint design was for an audio consumer product and this effort by two major firms was sufficient to establish a de facto standard. The subsequent definition of the CD-ROM specification drew heavily upon the earlier design, and also became a de facto standard.

  Initial recording format standards for CD-ROM were prepared by the High Sierra Group, an ad hoc organization consisting of several firms concerned with CD-ROM. The work of the High Sierra group moved through the formal standards making process relatively quickly, and after only minor changes, became ISO standard 9660 in 1988. Standards interest in CD-ROM has now shifted to data compression and formatting for audio and video content, user interface standards for retrieval software, and standards for a universal cataloging method for CD-ROM. The new drives that spin the disks at higher RPM do not impact standards for the media. However, proposals for double density CD-ROM media, though not likely to be well received because they would create incompatibility problems with the installed base of drives and with present disk replication equipment, are likely to get increasing consideration over the next two years.

  The UNIX community is displeased with aspects of the standard concerning file names and directory structures and is considering endorsing a modified version of the ISO 9660 standard named POSIX, which would allow the coexistence of UNIX-compatible and "standard" directory structures on a CD-ROM disk. UNIX specialists feel this is necessary for publication of extensive file sets, such as system documentation, and for operation under UNIX and UNIX-like operating systems. The Rock Ridge group, an ad hoc working group formed by companies with UNIX interests, completed specific recommendations for ISO 9660 extensions in 1991. The Frankfurt group, a similar body, prepared proposed extensions to ISO 9660 incorporating some of the Rock Ridge concerns plus support for the multisession recording format used for CD-WO.

  Multimedia formats are an area of standards conflict. Several approaches now contend in the marketplace including CD-I, DVI, and CDTV, as well as proprietary designs from other companies such as 3DO, Sega and Nintendo. Some de facto standardization of compression formats for multimedia audio and video exist, but there are multiple contenders here, also. The JPEG and MPEG specifications are the most significant compression standards for still and motion video, respectively. An MPEG follow-on expected to be in use in 1994 will offer enough compression to enable a CD-I player to handle a typical movie on a CD-ROM disk.

  In early 1986, Sony and Philips released the CD-I (Compact Disc-Interactive) specification which defines a freestanding appliance rather than a computer peripheral. Another supplementary standard, CD-ROM XA was announced in 1988. XA is a supplement to the CD-ROM specifica-

tion that applies to digital audio data interleaving with other types of data. Such interleaving permits rapid access to audio data associated with other recorded information without requiring head repositioning. Some minor drive redesign is required to accommodate the XA format. CD-I has been aimed at consumer, education, and a few commercial applications, such as point-of-sale displays.

DVI was developed by RCA and was acquired by General Electric when it acquired RCA. General Electric subsequently sold the DVI technology to Intel. DVI is supported by Lotus, IBM and other firms having interest in business applications of multimedia rather than consumer applications.

The third multimedia format, CDTV, is being used by Commodore. It is incompatible with the other two formats. 3DO, a well-funded multimedia player startup company that will license its technology to hardware producers, uses yet a fourth incompatible format.

Physical standards for write-once optical drives are not as advanced, and lack of standardization has delayed acceptance of optical drives by OEMs. The ANSI X3B11 technical subcommittee has prepared unrecorded media standards for 5.25" write-once disks for ISO approval. X3B11 originally intended to propose only the continuous tracking servo approach, but the price for getting CCS (X3.211) through the committee was an agreement to also submit the sampled servo approach (X3.214) for inclusion in a "dual standard". X3B11 finally embraced both approaches as well as a third approach, sampled servo with RZ modulation (X3.191), sponsored by Literal. As a result, there is no universally accepted write-once standard for 5.25" drives.

A subcommittee of X3B11, X3B11.1 was established in 1989 to formulate a proposed standard for a logical file format. While the main work of the X3B11 group so far has been concerned with media interchange among drives, X3B11.1 is concerned with interchange between systems. The format proposed by X3B11.1 is independent of the type of equipment used and may have applications beyond optical storage.

Standardization efforts for rewritable drives and media have proceeded more quickly, as they were able to build on much of the work done for the 5.25" write-once effort. Draft standards for 5.25" and 3.5" families of drives and media are available now. The 5.25" rewritable CCS standard (ISO 10089) is complete, as is the 3.5" standard (ISO 10090) based on CCS. Alternate formats, such as the discrete block format (DBF) proposed by some Japanese firms, remain to be addressed. The outlook is for eventual coexistence of multiple standards, but the marketplace has already decided that the existing standards are the winners. The rewritable standards effort has focussed heavily upon magneto-optic recording and has not yet taken on a standard for rewritable phase change. ISO 11560, covering MO-WORM, was approved in late 1992.

While IBM products frequently set de facto standards, IBM's early interest and activity in the optical storage area was too weak to override the formal standards activities. Currently IBM is very active within X3B11 in the formulation of next generation 3.5" standards and next generation 5.25" standards. IBM pressed strongly for inclusion of read-only capability on 3.5" media, suggesting strong interest in software or document distribution. With the announcement of IBM's own 5.25" rewritable drives, and particularly with the joint IBM/Sony high capacity proposal, IBM is influencing standards on both a de facto and formal level.

At present, there is little standardization of 12" media. There are already so many 12" drive designs in the field that standardization of this size is unlikely in the near future, although a standards project for 12" media exists. The diversity of existing designs makes it difficult for most manufacturers to agree to changes because of the major costs of product redesign. New generations of 12" drives may be standardized to a greater degree, as working groups have been set up within the American X3B11 subcommittee and the Japanese SC23 standards subcommittees to consider standards for newer products. Progress has been slow, and most firms haven't shown much interest in a 12" optical disk standard.

A draft standard for 14" write-once media has been prepared by X3B11 and forwarded to ISO for further action. As only Eastman Kodak and PDO manufacture 14" media, they have been the primary influences on the standard. This standard is ambiguous, as it covers two thicknesses for the media, one version made by PDO and the other by Eastman Kodak. It has been formalized as ISO 10885.

As a result of criticism of the slow pace of standards generation, the various national standards committees are adopting standards prepared by ECMA using a fast-track approach. While not providing the intensive peer review of the full formal process, it helps speed up standards generation where fundamental technical issues are not involved.

* Optical library disk exchange time: The most critical aspect of the optical library is its ability to exchange disks quickly. Exchange times typically range from a few seconds to fifteen seconds, and exchange time can severely limit the number of requests a library system can service in a period of time. The use of dual picker mechanisms on the elevator assemblies of second generation libraries has helped reduce the effective exchange time seen by the system.

* Spin-up and spin-down times: While not important in freestanding optical disk drives, spin-up time (including drive initialization time) and spin-down time become important when the drives are used in automated libraries, because these times add to the total system latency experienced when a disk cartridge must be exchanged. These times typically range from two to five seconds each and are significant delays. Plastic media substrates

have less mass than glass substrates, enabling disks made with plastic substrates to accelerate and decelerate somewhat more quickly than disks fabricated with glass.

* Error correction: Error detection and correction (EDAC) will continue to be required to deal with the relatively high defect density of optical media. The techniques and designs developed to cope with this problem in optical storage may also migrate to the magnetic storage arena as storage densities increase and the impact of small physical defects on magnetic media become proportionately greater.

  Most errors that occur are single-bit errors and can be readily corrected in minimal time. ECC techniques can also handle multiple bit errors up to the design limit of the system, but the correction process can add noticeably to the latency of the data retrieval process.

  A number of algorithms are being used for the ECC function. At the present time, standards efforts favor the use of long-distance Reed-Solomon codes for the purpose of error detection and correction in read/write drives. Some Japanese firms have preferred product codes, a method of performing error correction on a multidimensional data array.

  Error correction can be implemented in chip form. This is the case for CD-ROM already, and ECC chips for other optical drives have been prepared by several firms. Algorithms and chips have been developed that will perform the bulk of the error detection and correction process, so the implementation of these functions should not be onerously expensive.

  Error correction is a complex process and can produce significant delays in data transmission from the drive to the host computer. Overall performance can be greatly improved by efficient on-the-fly error correction using sophisticated custom VLSI chips to offer this feature. The use of media with an inherently low raw bit error rate, where the errors are mostly single bit errors, also helps to minimize pipeline time for error correction.

Competing technologies

The other technologies which compete with optical storage are in a continuous state of evolution, constantly improving capacity, performance, quality, form factor, lower power, greater functionality and other key parameters. Even if optical drives were today able to compete strongly against alternate technologies, displacement of existing products by the new optical products will be far from instantaneous, even where the optical product is highly suitable for a given task. The following sections review technology contenders and expected progress in the years ahead.

Magnetic disk drives

* Rigid disk drives: Rigid magnetic disk drives are the mainstay of today's auxiliary storage devices. Except on the lower end of the performance range, they appear largely immune from serious displacement by optical drives over the next few years. The relatively high mass of the optical drive head makes it quite difficult for optical drives to match the access time performance of today's voice coil magnetic drives. Furthermore, a typical optical drive has only one data surface under the head at any one time, while a typical magnetic drive has several surfaces available, reducing effective seek time.

  Magnetic disk drive technology has continued to improve. While optical drives have improved performance to the point where they can offer 30-40 millisecond average seek time on a 325 megabyte drive, magnetic drives typically offer sub-20 millisecond times on drives of the same capacity or larger. Sub-12 millisecond times are offered by the most advanced rigid magnetic drives. Some optical disk drives are achieving 3,600 RPM rotation rates and one has reached 5,400 RPM, while magnetic drives are moving above 5,400 RPM to 7,200 RPM at the high end of the performance range. Furthermore, magnetic drives do not require a separate erase pass. Most significantly, the highest areal densities of current magnetic drives, in the 350 megabit per square inch range, are approaching the areal density of optical drives at a fast rate. Rigid drives with areal densities of a gigabit per square inch are expected to be shipping by the end of 1996. It is unlikely, therefore, that the magnetic drive will be seriously threatened by optical disk drives for the next few years in its role as a high performance system disk.

  If the 45 gigabit per square inch magneto-optic recording technique reported by Bell Laboratories in 1992 can be turned into a real product, optical recording technology might eventually take a commanding lead. Using a tapered fiber optic tube to replace the conventional M-O drive optics, the researchers achieved a 60 nanometer spot size, albeit at a writing rate of 10 kilobits per second.

  Where removability is important, the ability of an optical disk drive to perform the combined functions of a tape drive and a rigid system disk drive, or to build large on-line data libraries, may outweigh performance considerations. Such applications can include graphics design projects, data distribution, save/restore of data, or use as a system disk in a security oriented environment. Here, the rewritable optical disk will make inroads on the uses of rigid magnetic disks. But the cost of even a low-end optical drive will substantially exceed that of a low-end magnetic drive for some years to come, so mass displacement of magnetic disk drives by optical disk drives is considered to be improbable.

* High capacity flexible disk drives: It is within the capabilities of today's technology to fabricate a floppy disk drive offering over 40 megabytes of storage capacity. 20 megabyte devices are now in volume production from Iomega and Insite Peripherals. Several Japanese firms are also expected to produce floppy drives with capacities of 20 megabytes or more in the near future.

  As they gradually evolve to the 40 megabyte and 80 megabyte capacity ranges, these high capacity floppy drives could compete with the very low-end of potential new optical disk drive products in 2.5" and 1.8" form factors. The OEM prices of high capacity floppies are expected to be in the $150-200 range in 1996, competitive with the expected prices of sub-3.5" optical drives.

Alternative optical devices

* Optical cards: Three companies have announced optical cards: Drexler Technology Corporation, Optical Recording Corporation, and NTT. The optical card announced in 1981 by Drexler Technology offers up to 4.11 megabytes of read-only or write-once storage contained on a credit card sized plastic substrate. Capacity is 2.86 megabytes when formatted and with error correction. Drexler has sold licenses to produce optical cards to the Optical Memory Card Business Corporation, a Japanese organization formed by Dai Nippon Printing Corporation and three licensees, and to Canon. Twenty-six companies have purchased licenses permitting them to make optical card drives using Drexler patents.

  Optical Recording Corporation, Toppan Printing Company, Sony, Canon and Dai Nippon Printing have announced other optical card formats, but none have the momentum of the Drexler-led effort, and of these, Canon's has been the only alternate effort to proceed. Canon announced a 4 megabyte reader in 1992. NTT announced development of a 1 megabyte card in late 1991, but no product announcement has been made.

  The Drexler cards are being proposed for use by insurance or medical organizations for client/patient record keeping. The card format allows ready transportation and read back of large volumes of information. The card is capable of withstanding considerable handling and is suitable for usage by individual patients. Other potential applications include software distribution, inventory control, security/access control, and programming of numerical control machines, process controllers and other industrial automatic equipment.

  Nippon Conlux, Omron Tateisi, and Olympus Optical are sources for Drexler-compatible optical card readers. Lasercard Systems Corporation, a Drexler subsidiary, offers complete optical card based systems using the Conlux drives.

In March, 1989, a European standard for 2.6 megabyte optical cards and drives was published by the Drexler European Licensees Association, (now called the Optical Memory Card forum) which includes both European and Japanese companies. The standard presents an interchange format to allow cards to be read or written by equipment from participating manufacturers. The ANSI X3B10.4 technical subcommittee has prepared a similar standard for use in the United States. A similar ISO activity is also under way.

The write-once format and limited capacity of the Drexler card limit it to specialized applications. The cost of the drive is unlikely to decrease below the cost of a floppy disk drive, so the optical card is unlikely to displace floppy disks for software distribution.

Because of its relatively limited capacity and/or performance, the optical card is not a competitor to the optical disk drive. The optical card will make its mark in the development of new applications rather than displace existing storage devices, and will compete in such markets as point-of-sale, portable personal records, and security access markets against other portable storage devices such as semiconductor memory cards.

* Optical tape: Optical tape drives represent another potential solution for those needing a way to store large amounts of archival data. So far, only write-once technology has been shown to be feasible for these devices. While optical tape devices are inherently less capable of fast access to data than are disks, they do provide substantially greater capacity than magnetic tape in a single media unit, eliminating the need to handle as many media units per volume of data accessed. Only a few firms have been active in the optical tape field. The earliest were Docdata N.V., which has been developing a 6.2 gigabyte tape drive for use with IBM compatible tape controllers, and Laserstore, which has been working on a 2.5 gigabyte product. The Laserstore product will have a SCSI interface and be packaged in an 8" form factor. LaserTape Systems, a start-up company, attempted to develop an optical tape drive using a 50 gigabyte tape cartridge similar in dimensions to the IBM 3480 tape cartridge. The firm ran out of money in 1992 and ceased operations.

  CREO Products, a Canadian firm, has been working with ICI on a write-once optical tape drive. CREO made its first shipment to the Canadian Government in 1990, but the total number of drives shipped is small.

  A 44 gigabyte optical tape drive currently under development at DDF Pertec is actually a hybrid, using a two dimensional matrix of thin film heads to record 512 magnetic tracks on 1/2" tape and employing magneto-optic playback to achieve very high capacity and high bandwidth. This approach is being evaluated by several potential customers. A product using a 3480 type cartridge may be available in 1996.

* Electron Trapping: An approach being developed by Optex Corporation, involves "electron trapping," by shifting the energy level of electrons in a material which holds them in a stable state for long periods in either the high or low energy state. A visible wavelength laser pulse moves an illuminated area to a high energy state. An infrared laser pulse causes the electrons to revert to the low energy state, emitting light as they do so. The presence or absence of light in response to a read (infrared) pulse yields a bit of information. The process is infinitely reversible, but is subject to interference from unwanted ambient light. In its current form, the design requires multiple lasers operating at different wavelengths.

* Holographic storage: Holographic storage has been a theoretical possibility for several decades, but limitations of materials and economics have kept it from being a practical reality. Holographic storage requires a three-dimensional storage medium exhibiting photorefraction, plus appropriate electronic scanning devices for data writing and reading. Storage cell materials used have typically included lithium niobate, gallium arsenide and other photorefractive crystalline substances.

  Several firms and the Department of Commerce Advanced Technology Program are cosponsoring a research program at MCC (Microelectronics and Computer Technology Corporation) to develop a prototype rewritable fast high capacity holographic memory. If successful, the sponsoring companies will then have the rights to further develop and manufacture products using the MCC designs. An operating prototype was shown by MCC in 1992. In late 1992, MCC created a subsidiary corporation, Tamarack Storage Devices, to further develop holographic memory devices. The first projected product, a holographic WORM fitting in a full size 5.25" form factor and offering 50 gigabytes of capacity is scheduled for prototype status in early 1994. If successful, holographic memories might be marketed by 1995.

  The MCC holographic memory is targeted for formatted capacities in the 200 megabyte to 50 gigabyte range, with 1 to 10 microsecond access times. Data rate can range from 1 to 50 gigabytes/second, and all of this will be packaged in a 5.25" full size form factor. The active memory element is an array of strontium barium niobate or lithium niobate crystal fibers. There are no moving parts, as the crystal array is scanned using solid-state acoustically modulated scanners. A CCD array is used for readout.

  In 1991 IBM and the University of California (Irvine) both announced some details of various experimental holographic memories currently under development, but neither is close to being a real product. The IBM approach uses an amorphous epoxy (NNDN-NAN) to which an organic photoconductor material (DEH) has been added as the memory element. These materials are relatively inexpensive compared to crystalline materials, but so far have not produced the diffraction efficiency obtainable from

crystalline materials. The U.C. approach involves photochromic materials mixed with a polymer material. It must be operated at very cold temperatures for good performance.

Magnetic tape drives

* High performance tape drives: Magnetic tape drives have shifted away from reel-to-reel format in favor of cartridge formats. The IBM 3480 set a standard for high-end tape drives and imitators have appeared. 3480 class products are competitive with the lower end of the optical disk product lines in terms of capacity and are superior in terms of data transfer rate, but are inferior in terms of average access time. Rewritable optical disk drives have the potential to displace a significant portion of the magnetic tape drives used for save/restore applications as optical drive and media prices decline.

  Storage Technology Corporation has achieved substantial marketing success for several years with an automated tape cartridge library that uses standard IBM 3480 tape cartridges and can hold up to 6,000 tapes in each modular unit. After years of delays, IBM also introduced a tape library system for mainframe markets. They are being challenged in some applications by optical drive based systems, as IBM has introduced rewritable disk based library storage systems supported as virtual 3390 magnetic disk drives.

  Other helical scan tape drives can also compete for archival and save/restore applications. A variety of recording formats, all incompatible, are being offered, including modified VHS videotape recorders, 8 millimeter cartridge, and DAT (digital audio tape), offered by several companies. These products offer large capacities (from 1.2 to 5 gigabytes) and a low cost per bit stored, but suffer from relatively long access times, as do all tape storage systems. For most of them, data transfer rates are unimpressive, lying in the 180 to 500 kilobyte per second range. However, data compression techniques can multiply the effective capacity and transfer rate by a factor of 2 to 5. Because all of these technologies are based upon consumer electronics designs, media is widely available. The availability of existing consumer products reduces the cost of developing and manufacturing derivative products as computer peripherals. However, much redesign is required to transform consumer grade helical scan tape products into reliable computer peripherals.

  The most notable success in the helical scan computer peripheral market is Exabyte, which has achieved excellent markets for its 8 millimeter format drives. Much as CD-ROM has benefited from the sales and technology of CD audio players, the data version of 4 millimeter DAT should also benefit as consumer product sales grow. However, it remains to be seen if DAT can be price competitive against other technologies competing for the save/restore niche.

* Low performance tape drives: Cartridge tape drives using parallel track formats have been increasing in capacity and performance since their introduction in the 1970s. Three tape widths are in use: .15", .25", and .5". Tape capacities range from 40 megabytes to 5 gigabytes in the .25" and smaller tape formats. The .5" parallel track tape cartridge drives offer 200 to 400 megabytes in a 5.25" form factor. Drives operating in a serpentine mode can store up to 2.6 gigabytes. Some manufacturers adopted the physical format of the IBM 3480 cartridge in their drives but not the recording format; such products are less expensive than the 3480 but don't offer media interchangeability with IBM systems.

  These products are threatened to some degree by write-once technology, and will definitely be impacted by small rewritable optical disks offering similar or greater capacity at equivalent prices. The optical drives also have the advantage of being able to share a controller with the magnetic disk drive being backed up, resulting in overall cost savings for system OEMs. Given the current state of optical technology, displacement effects won't be felt for several years.

  The primary use of low-end cartridge tape drives is to back up rigid disk drives. They are also occasionally used for software distribution, especially for multiuser systems. Because the price of optical media is expected to be several times that of cartridge tape media, the use of optical media for software distribution will not become widespread until media costs are approximately equivalent.

  Most programs load from the distribution media sequentially, and random access is not as important a consideration as it would be in general purpose storage/retrieval operations. However, data transfer rate is an issue for many users and some optical disk drives can outperform tape drives, at least in read mode.

  Low performance reel-to-reel tape drives are currently used for data logging, for program and data interchange, and for hard disk backup on minicomputers and some multiuser microcomputers. These products are relatively expensive and bulky, and are vulnerable to gradual displacement as optical storage devices and high capacity tape cartridge devices come into wide use.

DEFINITIONS

Many basic terms have varying meanings within the computer industry, depending upon the role of the person speaking. In this report, such terms are used in the way most disk drive and optical library manufacturers use them.

Market classification

Market class is used here, arbitrarily, to differentiate captive, PCM/Reseller and OEM/Integrator disk drive and optical library marketing activities.

Captive: Disk drives or libraries manufactured internally or by a subsidiary of a computer manufacturer, and sold or leased primarily for use with systems offered by the manufacturer. Note that the term is used to describe the products, not the manufacturer; drives and libraries sold to PCM/Reseller or OEM/Integrator market classes are classified accordingly.

Examples:

* Drives sold by Canon with its office systems are considered captive, if internally manufactured. Libraries sold by Hitachi with its systems are captive, if internally manufactured.

Noncaptive: Any public sale or lease by any disk drive or library manufacturer, except sales or leases of internally manufactured drives by computer system manufacturers primarily for use with their own systems. Both OEM/Integrator and PCM/Reseller shipments are included in the noncaptive sales channel.

Example:

* Drive shipments by Sony are noncaptive, except for drives sold with systems made by the parent company or other subsidiaries.

PCM/Reseller: Disk drives and libraries sold or leased by "plug compatible manufacturers" or their distributing organizations directly to end users for use with systems sold by another manufacturer. Also includes drives and libraries sold in the "aftermarket" -- shipments by drive manufacturers to subsystem producers, distributors, retail chains, mail order firms and individual dealers. The term includes drives and libraries to be connected to systems of all types, including personal computers, minicomputers and mainframes, or drives and libraries sold as add-on devices by distributors and dealers. This category also includes value-added resellers combining drives, enclosures and software to produce storage subsystems (but not complete systems).

OEM/Integrator: Drives and libraries sold by the original producer to system manufacturers which resell them as part of complete computer systems. Also includes sales to system integrators or value-added resellers which combine

finished system components and software to provide complete systems for specific applications. Sales by a disk drive or library manufacturer to a second drive or library manufacturer for resale are included only in shipment totals for the originating manufacturer, except when drives or libraries are produced on a contract manufacturing basis with a design supplied by the disk drive or library manufacturer which finally sells the drive to a third party.

Geographic classification

Geographic analysis is based upon U.S. and non-U.S. regions. Together, these two regions comprise the worldwide market.

U.S. vs. Worldwide SHIPMENTS: Shipments are classified U.S. or worldwide depending on the country in which the headquarters of the purchasing company is located.

Examples:

* An OEM shipment by a U.S. drive manufacturer to a European system manufacturer is included in worldwide totals, even if the drive is integrated into a system within the U.S.

* An OEM shipment by a Japanese drive manufacturer to a U.S. based system manufacturer is included in U.S. totals, even if the drive is integrated into a system in Taiwan, regardless of the final destination of systems in which the drives are used.

U.S. vs. Non-U.S. MANUFACTURERS: Manufacturers are classified U.S. or non-U.S., depending on the location of the firm's headquarters, regardless of the location of individual manufacturing plants.

Example

* Maxoptix is considered a U.S. manufacturer, even though it manufactures some of its disk drives in non-U.S locations.

* LMSI is considered a non-U.S. manufacturer, since the majority ownership is non-U.S.

Units of measurement

Spindles: The basic unit in counting disk drives. One spindle or spindle disk assembly consists of the disk drive mechanism required to utilize a single disk or disk stack. All DISK/TREND unit totals are counted in spindles. Optical drives currently all have one spindle, but future drives may have more than one spindle.

Positioners: The basic unit used in counting optical libraries. One positioner consists of the robotic mechanism needed to service a related number of optical drives and disk cartridge storage slots. A few optical libraries have more than one positioner unit in a physical system.

Revenue: Based on sales of disk drives or libraries alone, as normally sold by individual manufacturers. Controllers and library units sold as separate units are not included in disk drive revenue, nor are spare parts or service. When individual disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Library revenue is reported without the value of installed drives unless the sale is always made on a "drives included" basis. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Reseller or OEM/Integrator levels. All prices are in 1993 constant dollars.

Forecasts: Expected unit shipments and revenues for current or announced products in new production. Evolutionary improvements within existing formats are included, but completely new configurations or technologies are not included in the forecasts.

Examples:

* Enhancements such as double surface versions of existing single surface configurations and revised encoding schemes are anticipated in DISK/TREND forecasts.

* Innovations such as nonstandard size disks or new physical configurations may require establishment of new DISK/TREND product groups.

Application classification

Shipments of disk drives are classified by the following computer applications:

Mainframe/superminicomputer: Disk drives or libraries attached to the processor or to a terminal associated with a mainframe or superminicomputer.

Minicomputers/multiple user microcomputers: Drives and libraries attached to smaller general purpose processors typically serving multiple users, including network file servers. Examples: IBM System AS/400, DEC 433MP, Hewlett-Packard 3000.

Personal computers: Attached to a general purpose microcomputer normally for a single user. Examples: IBM PS/2, Apple Macintosh, Compaq Deskpro.

Office systems/workstations: Specialized equipment for dedicated use in specific office applications such as word processing, electronic mail or document storage. Specialized hardware is normally used. Examples: Toshiba TOSFILE, Hitachi HITFILE.

Nonoffice systems/workstations: Attached to dedicated processors and workstations used in a nonoffice application, such as order processing/shipping, point-of-sale, medical, factory production control, law enforcement, CAD/CAM/CAE, military, etc.

Consumer and hobby systems: Systems sold primarily to consumers for nonbusiness applications. Examples: Sony Data Discman, NEC PC Engine, most Atari models. Multimedia systems for home use, such as the Commodore CDTV and most CD-I players are also included in this category.

Other applications: Any application not included above.

CD-ROM OPTICAL DISK DRIVES

1993 DISK/TREND REPORT

CD-ROM OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

4.72" disk diameter

Chinon	CDS-430, CDS-431, CDS-525
Goldstar	GCD-R300, GCD-R400
Hitachi	CDR 1700S, CDR-1900S, CDR 3700
Kyocera	DI-J43000
Laser Magnetic Storage	CM 205, CM 214, CM 215, CM 206
Matsushita Electric	CR-563, LK-MC501, LK-MC521
Matsushita Electronic Components	EBP-103, EBP-302, EBP-601
Mitsumi Electric	CRMC-LU0, CRMC-FX-D, CRS-XP
NEC	PC-CD160F, CDR-74, CDR-84
Philips (Magnavox)	CM 405ABK, CDI-360, CDF 100
Pioneer	DRM-602X, DRM-604X, DRM 1804
Samsung Electronics	SCDR-300
Sanyo	ROM-PD1, ROM-4015, ROM-4026U
Sony	CDU-535, CDU-561, CDU-6211
Texel (Shinano Kenshi)	DM-5028, DM-3028
Toshiba	XM-3401B, XM-3301B

3.15" disk diameter

Chinon	CDS-355
Sharp	PU-CDI
Sony	Data Discman
Toshiba	XM-8100B

A CD-ROM optical drive is equipped only to read an appropriate optical disk. It does not have a laser capable of developing write power, a method to switch the laser into a writing mode, nor electronics required for writing data. The optical read-only drive is sometimes referred to generically as OROM (Optical Read-Only Memory), but all drives in this product group are of the CD-ROM type and use 4.72" (12 cm.) or 3.15" (8 cm.) media.

CD-ROM drives and media are a form of electronic publishing. Data is placed on the disks during a mass replication process analogous to the printing of a book or the stamping of a phonograph record. The demand for CD-ROM storage is driven by the information that publishers provide for it. In addition to the estimated 3,500 titles now sold to the public by CD-ROM publishers, there are an approximately equal number of "titles" published by companies for internal use. Typical internal titles include catalogs, parts lists, policy/procedure manuals,

and equipment maintenance documentation. The desire to publish internally distributed data has spawned a do-it-yourself CD-ROM publishing industry that continues to grow as the price of authoring tools comes down and they become easier to use.

In this report, CD audio players equipped with electronics to read CD-ROM formatted disks are counted as CD-ROM drives. Drives of this type are most often used with electronic games or other consumer applications.

Market status

In the second half of 1992, shipments of CD-ROM drives sharply accelerated as a result of increasing acceptance of CD-ROM drives as factory installed peripheral devices by system manufacturers. The pace of shipments has continued to accelerate in 1993. Apple has indicated that beginning in late 1993 all Macintosh systems will include a CD-ROM drive, and a number of manufacturers have introduced systems for users interested in multimedia that incorporate CD-ROM drives. The sudden increase in shipments caught drive manufacturers by surprise, resulting in scarcities of drives. Most manufacturers have increased production capacity substantially, but suppliers of optical pickups for CD-ROM drives are unable to meet demand and represent a limiting factor on current shipment levels.

Unit shipments increased 76.1% in 1992 to over 2.5 million units, up from about 1.4 million units in 1991. Revenue increased 61.4% to over $480 million, but declining prices and product mix kept revenue growth from matching shipment growth. Booming sales and the resulting shortages probably kept companies with smaller market shares in the CD-ROM business and may represent a second chance for some. CD-ROM drives are made almost entirely by non-U.S. companies. With the exception of the Philips companies, all of the currently active non-U.S. suppliers are Asian companies. A few ruggedized drives are produced in the United States.

Nearly all CD-ROM drives use 4.72" diameter media. Sony introduced a 3.15" CD-ROM in the Data Discman in 1990, and until Toshiba announced a 3.15" drive in 1992, it was the only one in production. Chinon and Sharp introduced 3.15" drives in late 1992. As of mid-1993, Sony and Sharp are the primary

producers of information products that incorporate a 3.15" drive. The Sony drive uses a proprietary format, while the Toshiba and Chinon drives will play disks in the standard CD-ROM format. Other firms are considering introducing a 3.15" drive but have delayed because of an insufficient number of supporting titles and because Data Discman uses a proprietary format.

IBM, Hewlett-Packard, DEC, Sun Microsystems and other firms use the 4.72" CD-ROM to distribute system documentation or software. An increasing number of firms, including Sony, Fujitsu and Tandy include CD-ROM as an integral part of some system models, but the majority of drives are still sold in external or add-on configurations. IBM offers a CD-ROM add-on kit for internal installation.

Sony, the Matsushita companies and Toshiba were the leading noncaptive producers in 1992, followed by NEC and Mitsumi Electric. NEC remained the leading captive producer on the strength of sales for its game products.

CD-ROM drives capable of operating with multimedia titles have entered the marketplace, with such features as embedded XA support, improved seek times, and doubled spin rate and transfer rate to support full screen, full motion video. CD-I, DVI and CDTV equipment, titles and authoring equipment have become more readily available, and an explosion in the number of multimedia titles is expected in late 1993. Such CD-ROM drives are being incorporated in computer systems and in computer based players that attach directly to a television receiver or monitor. Philips, Apple and Tandy are among the companies marketing such equipment.

Pricing of titles impacts sales of drives. In some cases, such as the U.S. Government Printing Office release of the federal legal code on CD-ROM, the cost of subscribing to the disk is so low that users find the subscription plus the cost of a CD-ROM is less than the subscription cost of the paper-based product. This is an encouraging trend for government publications, where charges are based on production cost, but it seems unlikely to spread to the commercial world, where prices are more frequently set upon the basis of the perceived value of the information, rather than production costs. Nevertheless, low pricing is one of the reasons that the government sector has moved relatively quickly to embrace CD-ROM.

Marketing trends

The strong current shipments of CD-ROM drives will continue for several years. Over 18.4 million CD-ROM drives are forecasted for shipment in 1996, with revenues expected to climb to almost $2.5 billion. Shipments of 3.15" drives, about 4.8% of 1992 shipments, are expected to make up only .6% of unit shipments in 1996. Lack of titles published in the 3.15" format continues to hamper growth for this format.

The introduction of multimedia (interleaved data, audio, and video) on CD-ROM is a major factor increasing the size of the market for CD-ROM, especially in the consumer, education, industrial training, and point-of-sale markets. Low volume shipments began in 1991 and have reached significant volume in 1993.

Average OEM prices are expected to decrease from $198 in 1992 to $126 in 1996, under the stimulus of increased competition, larger quantities and an increasingly consumer oriented share of the applications mix. Prices for lower performance drives are expected to dip under the $100 mark, but the large number of high performance drives shipped will keep average prices higher. Older CD-ROM drives have been advertised by mail order firms below the $200 retail level. Non-U.S. firms will continue to be the major producers, but Asian countries other than Japan are expected to eventually obtain a share of the market. Some contract production has already been moved from Japan to other Asian locations, and this move should eventually stimulate local manufacturing of CD-ROM drives.

About 83% of 1996 shipments are projected as OEM shipments, up from about 76% in 1992. Reseller shipments, 20% of the 1992 total, will decline to 14.3% in 1996. The share of captive shipments is expected to decline from 4.1% in 1992 to 2.9% in 1996. Both captive and reseller unit shipments are actually increasing, but will decline as a percentage of the total because OEM sales will grow faster.

Low-end drives (with average access time slower than 500 milliseconds) are expected to decline as a percentage of total shipments. 18.9% of 4.72" drive shipments in 1992 were low-end, and will decline to 11.1% of such shipments in 1996 because multimedia titles require higher performance drives to support

smooth video motion. If low-end 3.15" drives are included, the low-end drives were 22.9 % of 1992 shipments and will account for 11.6% in 1996. It is possible that the growth of low-end drives later in the period may be higher than indicated if the growth of demand for Eastman Kodak's Photo-CD player and low-end CD-I systems is stronger than anticipated.

Large numbers of games using CD-ROMs are expected to be sold by game or multimedia player manufacturers. Nintendo has deferred its CD-ROM based games, but Sega has begun shipments. NEC has offered CD-ROM drives as an option for its PC Engine home computer system for several years.

The use of CD-ROM as a vehicle for multimedia data storage is expected to grow rapidly over the next several years. The best known multimedia formats are CD-I, sponsored by Sony and Philips, and DVI, which has been embraced by Intel, IBM, Lotus and other major companies. DVI chips and boards are currently available for developers, and this format appears most likely to succeed in the business oriented marketplace. CD-I has attracted most of its followers in the education, point-of-sale and consumer camps, with the Eastman Kodak Photo CD program, introduced in 1992, being the most conspicuous example. Kodak has also demonstrated Photo CD on the DVI system. CDTV, Commodore's consumer oriented CD-ROM multimedia player using still a third format, was introduced formally in the spring of 1991. CDTV is not compatible with the other major multimedia formats. 3DO is a well funded startup company that will license its proprietary format for multimedia players, although the firm says its players will be able to read some other formats.

While CD-ROM sales are expected to benefit from multimedia activities, the multimedia area has been over-marketed to the point where the expectations of many may be overinflated. Until users and suppliers learn what capabilities are really useful in various applications, a process that may take several years, multimedia growth will not reach its full potential. Conflict between various multimedia standards will also retard growth. Game applications will probably be the fastest growing multimedia application area for the next several years. Furthermore, multimedia titles may require a substantial investment of time and money to procure rights to include copyrighted material or to script and produce a title making extensive use of full motion video.

Applications

CD-ROM drives are used mostly with micro-based systems, including personal computers, multiple user microcomputers, games and consumer appliances based upon microcomputers. The consumer applications potentially appear to be one of the fastest growing areas of CD-ROM use. A significant new application is in the Eastman Kodak Photo CD program, which converts photographic images to video files on a CD-WORM, creating a write-once recording in the CD-ROM format that can be played back on CD-ROM drives equipped to handle the multisession recording format used. Eastman Kodak has extended the application of its product to include data files as well as images.

Individual personal computers accounted for 52.7% of CD-ROM drive unit shipments in 1992. Consumer computer and other applications, notably games such as the NEC PC Engine, accounted for 16%. CD-ROM drive use on multiuser systems increased to 15.4% in 1992, representing increasing usage on file servers. In 1996, single user business computers will remain the largest application for CD-ROM drives, capturing 48.2% of the drive shipments in 1996. Consumer applications, led by entertainment and education uses, are expected to be the second largest application area, with 31.2% of the units sold. Multiuser systems will use 10.5% of the drives shipped.

Other than consumer applications, applications for CD-ROM titles tend to be oriented to vertical markets. So far, there has been no broadly based application (such as spreadsheets or word processing) that has successfully spanned a broad range of industries or markets. A "hit" title may sell 5,000 copies, although a few have done substantially better. A wildly successful application with a universal market seems unlikely, and the most probable outlook is for CD-ROM to succeed through moderate sales of large numbers of niche-oriented applications.

CD-ROM has the inherent capability to store and recover digitized images and audio, a characteristic which suggests many applications in the field of technical training, language instruction, and other educational uses. The generic ability to handle text, audio and video data is often referred to as "multimedia". Multimedia is not restricted to any particular type of storage medium, but the large amounts of storage required by digitized audio and video make CD-ROM

an appropriate vehicle for distribution of multimedia titles. Today's 3.15" CD-ROM is not expected to be an important multimedia vehicle because of its limited storage capacity.

The rate of growth of demand for multimedia capable systems is impacted by the availability of multimedia titles, confusion caused by the presence of competing formats and the considerable costs in money and time of authoring a professional multimedia product. Hardware expense is also a factor, although becoming less so as prices continue to decline. While equipment shipments from Commodore and Philips began in 1991, volume is building only gradually, with 1993 being the first year of significant shipments. Philips has announced shipments of approximately 100,000 CD-I players in 1992, and has stated it hopes to double this in 1993. Sony began shipping the MMCD, a self-contained player with multimedia capabilities in 1992.

The 3.15" format is expected to be heavily oriented toward consumer applications, but business applications may eventually use 3.15" drives where portability is required, such as field maintenance. Some of the data bases currently published are small enough to fit within the capabilities of the 3.15" drive, but users of desktop and file server type installations will want the flexibility of using either 3.15" or 4.72" media and will prefer the 4.72" drive. Furthermore, all of the CD-ROM firms mastering the 3.15" format are in Japan, so there is less incentive for U.S. publishers to use the 3.15" CD-ROM format.

The published content of a CD-ROM disk can be of broad general interest, such as an encyclopedia, dictionary or atlas, or specific to a company, such as a manual or parts list. Typical data bases currently distributed include U.S., state and local statistics and regulations, information on poisons and drug side effects, legal research materials, construction or automotive materials catalogs, and selected professional publications. Text oriented data bases are especially suitable for implementation on CD-ROM memory. These include legal cases, encyclopedias and other educational materials, news files, technical papers, computer manuals, company procedure manuals and all types of reference works. Video and audio data bases containing static images (clip art), video sequences and sound sequences are also available.

Government use of CD-ROM has expanded rapidly because CD-ROM use

permits major savings in printing, inventory and distribution costs. In some cases, it has been possible to make government statistics and documentary information available to the general public that was not previously available due to the cost of dissemination. Where governments use CD-ROM to distribute libraries of forms, the process of updating the forms is simpler because only a new disk needs to be sent and the number of obsolete forms discarded can be reduced. The CD-ROM most widely distributed within the U.S. government concerns the management of hazardous materials. This disk is currently distributed to over 7,000 sites.

Major companies, including IBM, Sun Microsystems and Hewlett-Packard have begun distributing software and documentation on CD-ROM as part of a major effort to reduce costs and improve service to customers. A few CD-ROM disks containing software are also available from independent publishers. Other types of company data distributed on CD-ROM include product information and product demonstrations. MCI distributes billing data on recordable CD disks, permitting customers to analyze billings on systems equipped with CD-ROM drives.

Education and industrial training are current areas of applications strength for CD-ROM, and these segments have become early and significant users of CD-ROM multimedia capabilities. Many titles are being marketed to both consumer and education markets.

In the consumer area, games, music and arts, and the Kodak Photo CD image library seem likely to develop as large scale applications of CD-ROM and multimedia technology, but as noted above, there is significant overlap of educational and reference titles into the consumer market. The development of the consumer market is aided by the availability of multimedia players and systems such as the Tandy "Sensation", which incorporates a CD-ROM player in a relatively inexpensive home computer. Fujitsu's FM Towns system is a similar, though more expensive, home system.

Photo CD applications will probably develop in the industrial photography area at a faster rate than in the consumer area, but the consumer market is potentially larger in the long run. Another effect of the Photo CD effort will be to create a de facto standard for communicating images between personal comput-

ers and television monitors. Whether Photo CD achieves success or not, it will influence the direction of writable CD recording standards.

Technical trends

The basic technology in this product group is relatively stable, as it derives from the consumer CD player, but significant product differentiation in terms of performance and embedded features has occurred. The areas receiving the most attention are:

Multimedia support: Integration of audio and video content into CD published materials is increasing. Both hardware and software development are required. The XA format, which permits interleaving of audio and data, requires new functions to be added to existing drive electronics. Newer drives have embedded XA capability. Older CD-ROM drives are not able to operate with the XA format and will need modification or special adapters. An interesting trend is the inclusion of CD-ROM drive interfaces on sound synthesizer cards for IBM PC compatible computers. However, these interfaces often support only the CD-ROM drives of a particular supplier.

Capacity: Pressure for increased capacity per disk is mounting. Legal data bases may span several disks, and a 1993 multimedia game requires two disks. A few companies have investigated expansion of CD-ROM recording capacity to two or four times the current level. NEC, for instance, has proposed a quadrupled capacity with the capability to hold one hour of full motion video on a CD-ROM disk. Because of the perceived need to retain backward compatibility with the existing disk format, these efforts have been slow to bear fruit, and higher capacity drives and disks, though desirable, are not anticipated in the next two year period except, possibly, as technology announcements. Another obstacle is the investment and time that will be required to upgrade mastering facilities to be able to produce any new high capacity format.

Adoption of data compression technology may forestall the need for an early move to higher capacity where text data bases are involved, but may not defer upgrade pressures from suppliers of video and audio content, which is often compressed already.

Caddy: CD-ROM drives used in critical applications may require a cartridge (caddy) to contain the disk. The cartridge holds the disk in place within the drive, preventing loss of focus due to vibration, shock, or mounting in other than a horizontal position, and permits the drive to be used in vehicles or to be mounted in a vertical position within a system enclosure. By mid-1989 most of the Japanese suppliers had adopted a common approach. The caddy issue is unlikely to impact drives used in consumer

oriented applications. Because of cost pressures, game machines and other consumer oriented CD-ROM designs will do away with the caddy and use top loading or drawer loading designs. However, the reliability and avoidance of handling damage provided by caddies is expected to make them a necessity in high-end drives used with file servers. Jukebox designers may find the caddy easier for the picker mechanism to handle than unprotected disks.

Standards: The early establishment of the Sony/Philips de facto standard for CD-ROM became the basis for CD-ROM physical disk interchangeability and provided a mechanism for identification of a disk and files upon the disk. The High Sierra group, an ad hoc task force consisting of a group of companies interested in CD-ROM, subsequently prepared a proposed recording standard and submitted it in 1986 to ANSI and ECMA. This has now become ISO standard 9660. Unfortunately, there are also proprietary formats, many developed by companies pursuing multimedia capabilities. At least 14 recording formats are in current use. Some systems are capable of reading more than one format, but there are no systems that can read them all.

The XA format proposed by Philips, Sony and Microsoft in 1988 extended the standards process into the interactive format area. While many of the drives currently marketed claim XA compliance, there may be unfavorable interactions between the drive and the controller preventing full compliance. Some manufacturers expect to be shipping fully XA compliant drives by late 1993.

ISO 9660 required modification to fit the needs of the UNIX operating system, and an ad hoc task force called the Rock Ridge group has prepared proposals to that end. Another standards extension for CD-ROM accommodates disks written using a new multisession recording standard. A further extension to cover multisession recording was prepared by the Frankfurt group, a similar organization. This proposal has become the ECMA 168 standard. The Kodak Photo CD system makes use of this standard.

In general, a drive that can read a Photo CD disk is XA compliant, but may not be able to read multisession disks. By late 1993, most manufacturers are expected to offer drives capable of dealing with XA, and single or multisession Photo CD formats.

Standards for motion video compression being worked out by MPEG (Motion Picture Experts Group) have been adopted for CD-I, with the first MPEG decoder chips available in 1992. The more complex encoder chip sets are making their appearance by mid-1993. A similar group, JPEG, is concentrating on compression standards for still video images. These standards, while important for multimedia software generally, will apply regardless of the storage device used.

Related standards issues may not involve the drive directly. A standard user interface is highly desirable so that end users do not have to learn a host of different data retrieval formats. More standardized interfaces between data retrieval software, data, and user interfaces are required.

Performance: Average access times, which decreased below the .5 second range in 1986 have dipped well under 400 milliseconds since 1989 and have breached the 300 millisecond barrier. Further reductions in seek time without raising cost significantly are difficult. Users will get faster data transfer rates, especially when multimedia is used, by means of faster rotation rates. Several firms have announced drives with at least double the current data transfer rate, with the improvement in performance achieved by doubling the rotation rate. Pioneer has made an announcement of a quadrupled rate drive.

Software: Development of software to support use with major operating systems and application programs, such as text search and the spectrum of multimedia applications, continues. While drivers are available for support of CD-ROM on most computing platforms, specific combinations of drives, operating systems and drivers still exhibit incompatibilities. Additional development of drivers is needed to support new generations of data compression/decompression techniques.

Interface: CD-ROM drives have typically been designed with SCSI interfaces. Cost pressures are prompting the appearance of drives with interfaces specific to a sound card incorporated in a personal computer that also connects to the CD-ROM drive. Dedicated use systems, such as the Sony MMCD, use a proprietary interface.

Cost reduction: Cost reduction programs are continuing. Plastic molded lenses, for instance, have replaced polished glass lenses. In some low performance drives, stepping motors are used rather than more expensive positioning methods.

Packaging: The packaging of CD-ROM drives has changed rapidly. In 1986, most of the drives shipped were not compatible with the full height and half high form factors that have been adopted for 5.25" magnetic disk drive products. Today, CD-ROM drives are half high models. However, since the computer industry has moved to the 3.5" packaging profile, CD-ROM drives are frequently mounted externally to the desktop computers and internally in tower configurations.

Authoring systems: Publishers of CD-ROMs require tools to help them prepare various types of content including text, data bases, audio and video for mastering and replication. Multimedia projects, in particular, are complex and require sophisticated tools to help nonexperts prepare multimedia titles. The advent of write-once CD drives will encourage product offerings that include all software and hardware tools needed to produce the playable disk.

Networks and libraries: System integrators are considering adding CD-ROM capabilities on file servers. As a result, there is interest in jukeboxes for CD format drives, but the slow access time of the CD-ROM has led most server designers to design multiple drive configurations. A few firms (Kubik and Pioneer) have announced autochangers for CD-ROM. The relatively slow bandwidths and throughput obtained from heavily loaded networks may make it impractical for servers containing multimedia formatted disks to adequately respond to user expectations for image motion and audio continuity. Fiber optic based networks may be needed to use multimedia in a network environment efficiently.

Reliability: Some CD-ROM drives have experienced failures due to the accumulation of dust on the lens. The industry has responded with a variety of solutions, including lens cleaning kits and self-cleaning drives. The best solution seems to be avoidance of designs that allow dust-laden air to be pulled through the drive. Dust resistant designs began appearing in 1990 and 1991 from Toshiba, Mitsumi and others.

There is also concern about the long-term stability of the disks. Accelerated environmental testing shows a wide variety of resistance to temperature and humidity, with the major variation the result of imperfect sealing of the protective layer of the disk, especially at the edges.

Writable CD: Writable CD-format media and systems are expensive but are becoming more readily available. Philips, Sony, Yamaha and JVC currently are shipping drives, usually as part of a complete mastering system. Some companies are exploring rewritable CD-ROM format recording. The prospects for writable CD-format drives are reviewed in the discussion of read/write drives with under 1 gigabyte capacity.

Potential competition: There is potential competition for CD-ROM from the 2.5" minidisk magneto-optic drive announced by Sony in the Spring of 1991. The drive has both rewritable and read-only capabilities. In mid-1993, Sony announced a proposed data standard for the 2.5" drive, which it calls the MD-DATA drive. The 150 kilobyte per second data transfer rate, CLV speed control and 2,048 byte sector size suggest that it may well compete with the 3.15" CD-ROM, especially for portable applications.

In addition, the 3.5" magneto-optic drives announced by IBM and Sony also have read-only capability and could be used in many of the same applications as CD-ROM drives. However, their capacity is lower and their price substantially higher, which makes strong competition with CD-ROM drives unlikely.

Forecasting assumptions

1. CD-ROM drive production capability will be able to meet demand after 1993, although there will be some constraints due to component shortages through 1994.
2. The ISO formatted disk interchange standard for CD-ROM will continue to be accepted by drive manufacturers and publishers. XA and multisession capability will be incorporated in most new CD-ROM models by late 1993, excluding the drives shipped by 3DO and some game producers.
3. Non-U.S. suppliers will continue to dominate the CD-ROM hardware market. There will be no significant production by U.S. firms.
4. There will be no significant shipments of expanded capacity CD-ROM drives during the forecast period.
5. CD form factor write-once or rewritable drives will appear mainly in CD-ROM mastering applications and will have little negative impact on CD-ROM sales. No other form of read-only optical memory will seriously challenge CD-ROM through 1996.
6. The CD-I format will impact primarily the home and education markets. Production hardware appeared in the latter part of 1992, but there will be moderate growth while programs and published materials are prepared. CD-I will have relatively minor impact on the CD-ROM in the business market.
7. Media mastering and replicating capacity will be adequate and will not restrict growth for CD-ROM optical memory markets.
8. CD-ROM drives will be available in selected PC systems from almost all major producers by late 1993. Apple will include CD-ROM drives in all Macintosh models.
9. There will be only minor impact on CD-ROM shipments from the Sony 2.5" minidisk or other unannounced low-end optical drives through 1996.

TABLE 17

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	.1	.1	.1	.1	.1	.1	.1	.1	.2	.2
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. REVENUES	.1	.1	.1	.1	.1	.1	.1	.1	.2	.2
Non-U.S. Manufacturers										
Captive	21.0	74.9	29.4	94.5	33.9	112.3	35.9	133.0	36.5	148.1
PCM/Reseller	78.4	135.1	136.7	216.7	214.5	340.0	250.1	392.4	255.0	403.5
OEM/Integrator	257.5	344.9	548.6	780.4	950.6	1,351.6	1,204.7	1,712.2	1,381.6	1,943.0
TOTAL NON-U.S. REVENUES	356.9	554.9	714.7	1,091.6	1,199.0	1,803.9	1,490.7	2,237.6	1,673.1	2,494.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	357.0	555.0	714.8	1,091.7	1,199.1	1,804.0	1,490.8	2,237.7	1,673.3	2,494.8
OEM Average Price ($000)		.198		.160		.151		.143		.126

TABLE 18

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	.1	.1	.1	.1	.2	.2	.2	.2	.3	.3
OEM/Integrator	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	.1	.1	.1	.1	.2	.2	.2	.2	.3	.3
Non-U.S. Manufacturers										
Captive	70.0	226.0	103.0	313.0	140.0	403.0	158.0	482.0	169.0	539.0
PCM/Reseller	337.0	560.0	684.0	1,122.0	1,047.0	1,665.0	1,392.0	2,193.0	1,590.0	2,533.0
OEM/Integrator	1,270.0	1,741.0	3,404.0	4,863.0	6,212.0	8,945.0	8,305.0	11,970.0	10,818.0	15,406.0
TOTAL NON-U.S. SHIPMENTS	1,677.0	2,527.0	4,191.0	6,298.0	7,399.0	11,013.0	9,855.0	14,645.0	12,577.0	18,478.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,677.1	2,527.1	4,191.1	6,298.1	7,399.2	11,013.2	9,855.2	14,645.2	12,577.3	18,478.3
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	3.2	5.6	7.4	11.9	14.8	22.9	24.6	37.5	37.2	56.0

TABLE 19

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues			Forecast											
	1993			1994			1995			1996		
	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"
U.S. MANUFACTURERS															
PCM/Reseller	.1	--	--	.1	--	--	.1	--	--	.1	--	--	.2	--	--
TOTAL U.S. REVENUES	.1	--	--	.1	--	--	.1	--	--	.1	--	--	.2	--	--
NON-U.S. MANUFACTURERS															
Captive	10.4	27.9	36.6	10.8	50.4	33.3	20.3	60.0	32.0	31.9	71.1	30.0	44.9	76.7	26.5
PCM/Reseller	125.8	9.3	--	188.9	23.0	4.8	300.3	35.2	4.5	339.7	48.5	4.2	342.1	57.5	3.9
OEM/Integrator	298.7	46.2	--	707.7	72.7	--	1,261.3	90.3	--	1,617.6	94.6	--	1,847.3	95.7	--
TOTAL NON-U.S. REVENUES	434.9	83.4	36.6	907.4	146.1	38.1	1,581.9	185.5	36.5	1,989.2	214.2	34.2	2,234.3	229.9	30.4
WORLDWIDE RECAP															
Captive	10.4	27.9	36.6	10.8	50.4	33.3	20.3	60.0	32.0	31.9	71.1	30.0	44.9	76.7	26.5
	+3.0%	-62.8%	+10.6%	+3.8%	+80.6%	-9.0%	+88.0%	+19.0%	-3.9%	+57.1%	+18.5%	-6.2%	+40.8%	+7.9%	-11.7%
PCM/Reseller	125.9	9.3	--	189.0	23.0	4.8	300.4	35.2	4.5	339.8	48.5	4.2	342.3	57.5	3.9
	+32.4%	-33.1%	--	+50.1%	+147.3%	--	+58.9%	+53.0%	-6.2%	+13.1%	+37.8%	-6.7%	+.7%	+18.6%	-7.1%
OEM/Integrator	298.7	46.2	--	707.7	72.7	--	1,261.3	90.3	--	1,617.6	94.6	--	1,847.3	95.7	--
	+38.9%	+178.3%	--	+136.9%	+57.4%	--	+78.2%	+24.2%	--	+28.2%	+4.8%	--	+14.2%	+1.2%	--
Total Revenues	435.0	83.4	36.6	907.5	146.1	38.1	1,582.0	185.5	36.5	1,989.3	214.2	34.2	2,234.5	229.9	30.4
	+35.8%	-20.9%	+10.6%	+108.6%	+75.2%	+4.1%	+74.3%	+27.0%	-4.2%	+25.7%	+15.5%	-6.3%	+12.3%	+7.3%	-11.1%
ANNUAL SHARE, BY DIAMETER	78.5%	15.0%	6.5%	83.2%	13.4%	3.4%	87.8%	10.3%	1.9%	89.0%	9.6%	1.4%	89.7%	9.2%	1.1%

Note: 4.72" H are high performance drives with average seek time of 500 ms.or less.
4.72" L are low performance drives with average seek time of more than 500 ms.

TABLE 20

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments			Forecast 1993			1994			1995			1996		
	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"	4.72" H	4.72" L	3.15"
U.S. MANUFACTURERS															
PCM/Reseller	.1	--	--	.1	--	--	.2	--	--	.2	--	--	.3	--	--
TOTAL U.S. SHIPMENTS	.1	--	--	.1	--	--	.2	--	--	.2	--	--	.3	--	--
NON-U.S. MANUFACTURERS															
Captive	11.0	93.0	122.0	12.0	168.0	133.0	25.0	250.0	128.0	42.0	320.0	120.0	68.0	365.0	106.0
PCM/Reseller	508.0	52.0	--	959.0	143.0	20.0	1,410.0	233.0	22.0	1,807.0	362.0	24.0	2,024.0	483.0	26.0
OEM/Integrator	1,430.0	311.0	--	4,262.0	601.0	--	8,085.0	860.0	--	10,930.0	1,040.0	--	14,210.0	1,196.0	--
TOTAL NON-U.S. SHIPMENTS	1,949.0	456.0	122.0	5,233.0	912.0	153.0	9,520.0	1,343.0	150.0	12,779.0	1,722.0	144.0	16,302.0	2,044.0	132.0
WORLDWIDE RECAP															
Captive	11.0	93.0	122.0	12.0	168.0	133.0	25.0	250.0	128.0	42.0	320.0	120.0	68.0	365.0	106.0
	+10.0%	-49.2%	+10.8%	+9.1%	+80.6%	+9.0%	+108.3%	+48.8%	-3.8%	+68.0%	+28.0%	-6.2%	+61.9%	+14.1%	-11.7%
PCM/Reseller	508.1	52.0	--	959.1	143.0	20.0	1,410.2	233.0	22.0	1,807.2	362.0	24.0	2,024.3	483.0	26.0
	+148.5%	+92.6%	--	+88.8%	+175.0%	--	+47.0%	+62.9%	+10.0%	+28.2%	+55.4%	+9.1%	+12.0%	+33.4%	+8.3%
OEM/Integrator	1,430.0	311.0	--	4,262.0	601.0	--	8,085.0	860.0	--	10,930.0	1,040.0	--	14,210.0	1,196.0	--
	+90.8%	+106.0%	--	+198.0%	+93.2%	--	+89.7%	+43.1%	--	+35.2%	+20.9%	--	+30.0%	+15.0%	--
Total Shipments	1,949.1	456.0	122.0	5,233.1	912.0	153.0	9,520.2	1,343.0	150.0	12,779.2	1,722.0	144.0	16,302.3	2,044.0	132.0
	+102.2%	+26.3%	+10.8%	+168.5%	+100.0%	+25.4%	+81.9%	+47.3%	-2.0%	+34.2%	+28.2%	-4.0%	+27.6%	+18.7%	-8.3%
ANNUAL SHARE, BY DIAMETER	77.2%	18.0%	4.8%	83.2%	14.5%	2.3%	86.5%	12.2%	1.3%	87.4%	11.8%	.8%	88.3%	11.1%	.6%

Note: 4.72" H are high performance drives with average seek time of 500 ms.or less.
4.72" L are low performance drives with average seek time of more than 500 ms.

TABLE 21

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI				
General purpose	--	--	37.0	.2
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	389.2	15.4	1,940.2	10.5
PERSONAL COMPUTERS				
Business and professional, single user	1,331.8	52.7	8,906.5	48.2
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	75.8	3.0	295.7	1.6
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	303.3	12.0	1,459.8	7.9
CONSUMER AND HOBBY COMPUTERS	404.3	16.0	5,765.2	31.2
OTHER APPLICATIONS	22.7	.9	73.9	.4
Total	2,527.1	100.0	18,478.3	100.0

TABLE 22

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	4.72" H	4.72" L	3.15"	Total		4.72" H	4.72" L	3.15"	Total	
Sony	425.0	--	--	425.0	26.4	484.0	--	--	484.0	21.0
Matsushita Electric	294.0	--	--	294.0	18.3	300.0	121.0	--	421.0	18.3
Toshiba	230.0	--	--	230.0	14.3	280.0	--	--	280.0	12.2
NEC	140.0	15.0	--	155.0	9.6	230.0	42.0	--	272.0	11.8
Mitsumi Electric	170.0	--	--	170.0	10.6	260.0	10.0	--	270.0	11.7
Hitachi	117.0	--	--	117.0	7.3	206.0	--	--	206.0	9.0
LMSI	73.0	--	--	73.0	4.5	134.0	--	--	134.0	5.8
Other U.S.	.1	--	--	.1	--	.1	--	--	.1	--
Other Non-U.S.	28.0	115.0	--	143.0	9.0	44.0	190.0	--	234.0	10.2
TOTAL	1477.1	130.0	--	1607.1	100.0	1938.1	363.0	--	2301.1	100.0

Note: 4.72" H are high performance drives with average seek time of 500 ms. or less.
4.72" L are low performance drives with average seek times of more than 500 ms.

READ/WRITE OPTICAL DISK DRIVES LESS THAN 1 GIGABYTE

1993 DISK/TREND REPORT

READ/WRITE OPTICAL DISK DRIVES
LESS THAN 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

3.5" disk diameter

Chinon	MO 100 (E), MO 300 (E)
Fujitsu	M2511A (E)
IBM	MD 3125B (E)
Laserbyte	LB3128 (E)
Matsushita Electric Industrial	LF-3100 (E), LF-3000E (E)
MOST	RMD 5200-S (E)
NEC	PC-OD301 (E)
Olympus	MOS300E (E)
Ricoh	RO-3010E (E), RO-3012E (E)
Seiko Epson	OMD 5010 (E)
Sony	SMO-D301 (E), SMO-E301 (E)
Teac	OD-3000 (E)
Toshiba	OD-D300B (E)

4.72" disk diameter

JVC	XR-W1001
Philips Consumer Electronics	CDD521
Ricoh	RS-9200CD
Sony	CDW-900E
Yamaha	YPR-102

5.25" disk diameter

Asaca	AMD-1340NS
Canon	MO-5001S (E), OM-500D (E)
Fujitsu	M2507B (E), M2511A (E)
Hewlett-Packard	C1716T (E), C1716A (E)
Hitachi	OD 101-1, OD-112-1 (E)
Honeywell	AN/MU-928
IBM	0632-C1X (E), 0632-C2X (E)
Kawasaki Steel	KL1200S
Laser Magnetic Storage	510
Literal	525 GB, 525 GBX2, I-525MF (E)
Matsushita Electric Industrial	LF-5010, LF-7012 (E), LF-9000(E)
Maximum Storage	APX-3200, APX-5100
Maxoptix	Tahiti II (E), T3-1300
Mitsubishi Electric	MW-5E3, ME-5E1 (E)
MountainGate Data Systems	CR6000, CR6800
Mountain Optech	CS-400, SEL-2C, SE-400M, CS-1000 (E)
NEC	PC-OD102, N7915 (E), ODD-155 (E)
Pioneer	DD-M5101, DE-U7001 (E)

5.25" disk diameter (continued)

Ricoh	RO-5043, RO-5030E (E), RO-5031E (E)
Sharp	JY 700 (E), JY-750 (E)
Sony	SMO-E511 (E), SMO-F521 (E)

(E) indicates erasable or multifunction drive.

Two types of drives are included in this group: Write Once Read Many, (WORM) and Erasable (Rewritable). Provided that a drive is capable of writing and reading, it is classified in this group even if it can also be used with read-only media. CD-Write-Once (CD-WO, CD-WORM) also fits into this category. Multifunction drives capable of using either rewritable or write-once media are considered rewritable drives for purposes of this report. Multifunction drives (MO-WORM) first appeared on the market in 1990.

The read/write drives discussed in this section are typically used with small computer systems of the mini and micro class and with intelligent workstations. Small automated libraries (jukeboxes, in industry parlance) used in departmental level mass storage subsystems are usually equipped with 5.25" read/write drives and 5.25" drives are increasingly being used in larger libraries as well.

This year's report again has separate disk diameter shipment and revenue tables for write-once and rewritable drives.

Market status

For this portion of the optical drive industry, 1992 was a somewhat better year. Although 5.25" write-once drive shipments continued to decline, growth for 5.25" rewritable and multifunction drives continued. 3.5" drives did better than expected, and 4.72" write-once drives promised future significant shipments.

Shipments of 3.5" drives rose significantly as prices continued to decline. Although OEM demand has been small, the reseller market is moving increasing numbers of drives. The Apple Macintosh add-on market, where there is less price sensitivity, has been the strongest 3.5" market segment.

1992 unit shipments reached 379,400 units, up 76.9% from 1991. Write-once drive shipments declined 22.8% to 33,800 units, but this decline was offset by a 102.4% increase in shipments of rewritable and multifunction drives, most of

which was in the 3.5" segment. 5.25" write-once shipments are being heavily impacted by multifunction drives.

Sony, Matsushita Electric, Olympus and Ricoh were the leading producers. Matsushita remains the leading manufacturer of write-once drives, while Sony continues as the leader in rewritable drives. Rewritable drive shipments again outnumbered write-once drive shipments, with rewritable drives capturing 91.1% of unit shipments. 52.2% of the rewritable drives shipped in this product group were 5.25" drives, and 3.5" drives accounted for 47.8% of 1992 shipments. This gain is the result of lower prices and, perhaps, improved performance.

1992 worldwide revenues increased 12.1% to $656.4 million, with all of the gain coming from sales of 3.5" drives. Revenues for 5.25" drives actually declined 6.5% to $400.3 million, although 5.25" drive unit shipments rose 17.3%. U.S. firms accounted for 22.3% of 1992 revenues, up from 11.7% in 1991. The U.S. market accounted for 45.8% of worldwide revenues in 1992, down from 48.3% in 1991.

Marketing trends

5.25" rewritable drive shipments are expected to grow continuously through 1996. 5.25" write-once drive shipments are projected to continue their decline, but 4.72" write-once drive shipments are expected to grow to over 63,000 units annually in 1996. This forecast could be substantially exceeded if drive prices fall more than expected.

Under the spur of declining price and increasing capacity, shipments of 3.5" rewritable drives will grow. Demand for the 230 megabyte 3.5" drives expected to enter the market in late 1993 will be strong if these new drives are introduced as anticipated, at prices at or below the mid-1993 price levels for 128 megabyte drives. While 3.5" drive capacity may increase this year, most OEMs are unlikely to display great interest until capacity increases to that available on one side of 5.25" drives (325 megabytes), or drive prices decline below $400, permitting competition with other technologies.

The forecasted growth in 3.5" erasable drive shipments results from price competition due to an increasing number of sources, plus expected capacity and

performance improvements. Growth could be even larger if OEM prices drop to the $400 level to allow optical drives to compete more effectively with small tape drives and other removable products such as SyQuest's 3.5" 105 megabyte removable cartridge magnetic drive.

Multifunction drives are doing better. Although interest in MO-WORM initially grew slowly because most customers interested in write-once technology were already committed to previous technologies and had little incentive to change, new customers for write-once applications are more likely to accept magneto-optic multifunction drives, because MO-WORM can share cost decreases and capability increases with rewritable magneto-optic media.

For the total product group, 558,500 units are expected to ship in 1993, growing to 1,521,900 units in 1996. Rewritable drives are expected to account for 94.8% of shipments in 1996, of which 33.3% will be 3.5", and 44.2% will be 5.25" units. Shipments of 2.5" drives usable as computer peripherals from Sony and others are expected to begin in the last half of 1994. Only 5.2% of the forecasted 1996 overall total will be write-once units, and the majority of these, 79.7%, are expected to be 4.72" drives operating in CD-ROM compatible format.

In May of 1991, Sony made a preliminary announcement of a 2.5" magneto-optic drive aimed at the audio market, and announced a proposed media standard for the MD-DATA, a 2.5" CLV computer peripheral in mid-1993. Sony and other companies are expected to produce the 140 megabyte 2.5" drive in 1994. The Sony product requires no erase pass before writing, a feature that can be expected in computer peripherals in the future. The Sony technique is to use the laser to increase the temperature of the recording layer to the point where writing is possible, combined with a magnetic head that actually writes the data.

Fujitsu made a technology announcement of a 60 megabyte 1.8" magneto-optic drive in late 1992. The prototype exhibited had a 20 millisecond average seek time, 1,800 RPM rotation rate, and 860 kilobit/second data transfer rate. No firm indication as to availability was given, but Fujitsu indicated it plans a 128 megabyte version for availability in the 1994-1995 time frame. Fujitsu intends it for use in a portable computer.

The 4.72" write-once drive is capable of producing disks readable by a CD-ROM. The first such products, based on CD-ROM mechanisms, had modest

performance, and were available only as part of mastering systems produced by Yamaha and Sony. JVC announced a relatively inexpensive CD-WO drive in 1992 that is expected to achieve a modest popularity with companies wishing to publish their own CD-ROM format disks for internal use. Ricoh announced its CD-WORM drive in 1993. Sony and Philips have announced 4.72" write-once drives that will be used in the Eastman Kodak Photo CD program and other multisession recording applications. Tandy, Sony, Ricoh and Philips have discussed the possibility of rewritable CD format drives and media, but have given no firm indication of availability, detailed specifications, or price because the rewritable media most likely to be used with the recording CD drives is not yet readable on standard CD-ROM drives due to differences in reflectivity.

The average capacity of drives in this product group is expected to substantially expand over the next several years. Optical library users, in particular, desire expansion of 5.25" media capacity to 3 or 4 times the current 325 megabytes per side offered by most drives today. IBM, Sony, Hewlett-Packard and NEC are among the firms announcing 650 megabyte per side drives in 1993, and other producers are expected. Hitachi has shown prototypes of its triple capacity drive and indicated that it might be in production in the fall of 1993. Discussion has begun of a standard for a 5.25" quadruple capacity drive which is discussed further in the chapter on drives over a gigabyte in capacity.

With multiple sources for the double capacity drives, it is anticipated that their production will rapidly displace production of 325 megabyte per side drives.

Applications

Write-once and rewritable optical drives under 1 gigabyte are used primarily as a method for storing images in office, medical, design and other specialized systems. If available at a low enough price, the anticipated 2.5" drives may also acquire the role of a data distribution device. When attached to file servers, often as an element of an optical library, the drive may provide a general storage capability in a hierarchical storage subsystem.

Because of limitations in performance, packaging, power dissipation and price relative to rigid magnetic disk drives, optical drives do not compete well against rigid drives unless high capacity and removability are mandatory.

Specific applications for drives in this product group include:

Save/restore operations

* Archival storage of files.

Reference level storage

* Storage of programs, freeing up fixed magnetic disk drives for data.

* Storage of data bases frequently used but infrequently changed.

Document storage and processing

* Image storage for use in departmental or small organizational CAD/CAM, medical, law enforcement, and financial record systems.

* Office automation systems, especially those involving storing images of documents.

* Convenient storage of all files and programs related to a particular document.

Data distribution

* Production and distribution of updatable data bases in quantities too small to warrant mass replication costs or where replication delays are too long for timeliness.

* Exchange of files created by desktop publishers, typically for sending data to printing houses for prepress operations or for generation of presentation materials at service bureaus.

System disk

* Function as system disk where moderate performance is adequate and high capacity with removability is needed.

* Replacement of older, lower capacity rigid disk drives where removability is desired as well as higher capacity.

Graphic presentation and multimedia

* Contains large files required for presentations involving complex graphics, audio and video.

The faster erasable drives such as the Maxoptix "Tahiti" series have found uses as system disks in high security applications requiring vault storage of recorded media when the equipment is unattended. They are also an attractive replacement for magnetic disk pack drives, offering equivalent performance and much lower cost and space requirements.

3.5" drives are used to provide project oriented storage on a single volume, and are frequently used in desktop publishing environments. They have been particularly successful as add-on devices to Apple Macintosh systems, which are frequently used in a desktop publishing role.

Personal computers remained the largest application for optical drives in this product group in 1992. They accounted for 56.2% of the units shipped, a strong increase reflecting the growth of 3.5" drive shipments. The shares of office workstations and nonoffice workstations were to 12.8% and 17.6% respectively. Multiuser systems share declined to 11.3%. The decline is due to the changing mix between 3.5" and 5.25" drives, as 3.5" drives are currently rarely used on multiuser systems.

The increasing capacities of 5.25" drives will expand usage with workstations, office systems and multiuser systems. 3.5" drives are expected to increase in capacity to the 500 megabyte range during the forecast period and usage will spread beyond personal computers to small workstations and office systems. 2.5" drives are expected to develop usage in consumer and hobby systems and, to some extent, with personal computers during the forecast period.

About 5% of the production of 5.25" drives in this product group is expected to be used in optical library subsystems, such as those sold by Hewlett-Packard, IDE, Hitachi, NKK and others. Jukebox applications are expected to consume 5% of 5.25" drive shipments in 1996, but only a very small percentage of 3.5" drives in that year. 2.5" drives are not expected to be used in optical libraries during the forecast period.

Media with both a read-only section and a writable section, when available, can serve as a vehicle for software and data base distribution, providing that cost of the media is low. The writability feature permits timely update of a previously installed data base. Furthermore, the ability to write gives the data base publisher certain security and antipiracy options not readily available on read-only

media, in that individual disks or sections of disks can be serialized or encrypted for use on a specific system or group of systems at nominal cost.

Many departmental level systems for document or image storage use the read/write drives in this product group. Engineering documentation and medical and record management applications tend to favor write-once technology, whereas rewritable or multifunction drives are the choice in applications such as desktop publishing, design, and project management where stored information changes frequently. Departmental applications may use small library units with less than 40 media units to contain all the required records in a conveniently accessible form. Larger organizations will use libraries containing hundreds of disks. Entry level systems will be found in office automation, medical, law enforcement, CAD/CAM, and smaller financial applications, and their larger cousins will be found in corporate or divisional information centers of large financial institutions, government agencies, transportation firms, defense contractors and aerospace firms.

The information management functions of larger organizations are more likely to prefer write-once storage because of its archival nature and perceived greater security. Smaller organizations or individual work groups in large organizations are more likely to prefer rewritable drives and media for the flexibility and ease of storage management they provide.

Erasable optical storage has an opportunity to significantly displace tape storage devices for backup when OEM drive prices decline below $500. However, the current high user price of the media ($80 to $150, compared to $15 to $20 for a tape reel or cartridge) would still limit acceptance. 5.25" rewritable media prices have begun to decline due to competitive pressure and the influence of 3.5" media, which is being priced in the $50 to $70 range. Further declines are expected as volume increases.

Technical trends

Drive technology continues to improve and the rate of product development for the next few years is expected to accelerate. The key areas of change are reviewed below.

Capacity: Capacity of 5.25" rewritable drives has increased to 650 megabytes per side and may yet increase to 980 megabytes in 1993 if Hitachi begins shipments as anticipated, with some firms proposing 1.3 gigabytes per side as a possibility in 2 years. Similar improvements in write-once technology are possible, though less certain. 3.5" drive capacity is expected to increase to 230 megabytes in 1993 and may reach 325 megabytes. The increases will be due to a combination of factors, including improved optics and shorter laser wavelength permitting smaller spots and higher BPI and TPI, reduction of track pitch from 1.6 microns to 1.4 microns (about a 40% improvement), the adoption of pulse width modulation, zoned recording (about a 33% improvement), and variable track pitch (about 40-50% improvement). Changes in encoding methods might also modestly improve capacity. For drives dedicated to image storage, embedded data compression implemented in a single chip or small chip set should be feasible. It is unlikely that all of these possibilities will be implemented on any one drive in the near term, but they are expected to be standard features by 1995. Some of these techniques, such as zoned recording, are used on certain optical drives currently in production.

The second generation approaches have some things in common, including zoned recording, use of M-O media, continuous composite servo format, multifunctional design, 1.4 micron track pitch or less, downward compatibility and 780 nanometer lasers.

In addition to drives with removable disks, some companies are developing magneto-optical drives with nonremovable media. Fujitsu has produced a few 8 inch diameter products, and fixed multidisk 5.25" drives offering very high capacity could be in production by mid-1995.

A few companies have looked at the possibility of 325 megabytes per side using pulse width modulation. Others are considering the use of double sided 3.5" media. MOST has begun shipments of a 256 megabyte drive, although it uses a unique recording format. Canon has discussed a future 350 megabyte drive, and several companies are researching 3.5" drives in the 512 megabyte range.

Write-once recording: A variety of optical recording technologies and media fabrication processes are in use, creating interchange problems and OEM confusion. At present, pit forming or bubble forming writing methods are in the majority, but writing using the phase change between amorphous and crystalline states to vary reflectivity at a spot is becoming more common. Sony, Fujitsu and Matsushita are currently using phase change recording. Write-once dye-based media is being used by Pioneer and Ricoh. In general, media using these separate recording methods are not interchangeable, although more sophisticated drives capable of detecting media type could accommodate some degree of interchange.

Hewlett-Packard, Sony and several other drive and media companies are

offering MO-WORM, a form of magneto-optic media which the drive can recognize as write-once media by virtue of a prestamped pattern on the disk. This approach has the benefit of allowing erasable drives capable of recognizing the pattern to operate as multifunction drives. It is anticipated that this will gradually become the dominant form of write-once recording, but that it will take many years for MO-WORM to completely displace ablative writing in the installed base of systems.

Rewritability: There are several technologies contending for acceptance in rewritable optical media, but magneto-optical media is the most commonly used method capable of meeting user demands for sensitivity, erasability, and stability. The most challenging problem at present is the elimination of the need for a separate erase pass before writing. Technical problems and uncertainty about adequate yields for the complex media structures required suggest that direct overwrite may not be available on a production basis until mid-1994.

Multifunctionality can be achieved on magneto-optic media by designating some portion of the media as write-once or read-only. A group of 14 drive and media producers, including Hewlett-Packard, Maxoptix, Ricoh, and Sony jointly proposed a de facto standard for adding write-once functionality to magneto-optic media. This has been embodied in ISO draft standard 11560.

Magneto-optical techniques are not the only solution. Progress has been made in erasable phase change and other types of erasable recording, even though these technologies are behind magneto-optical in development. Phase change media offering at least 100,000 write cycles was introduced in 1990, and there are prospects for extending the number of write cycles to well over one million.

Phase change media permits the interchange of write-once and erasable media on a single drive. It also provides direct overwrite capability and may permit simpler drive designs than for M-O drives. Phase change media as yet does not have specific standards in place, and efforts to create standards have been initiated.

Dye-based media may eventually become commercially significant for erasable optical disks. Still in R&D status, this type of media is potentially less subject to degradation problems, uses inexpensive materials and appears less expensive to produce because it is likely to be solvent coatable. Obtaining an adequate number of write/erase cycles is technically difficult, and dye-based erasable media is not likely to be available for several years. Furthermore, multiple lasers may be required in drives using dye-based media, raising drive cost.

Media lifetime: While accelerated life tests seem to indicate that media lifetimes of 10 years or more are achievable, this aspect of media perform-

ance will remain unproven until actually demonstrated. Some suppliers are claiming in excess of 30 year lifetimes, but archivists remain concerned about media lifetime and whether future generations of drives will be compatible with today's media and recording formats. Because organic recording layers such as dyes seem to have better corrosion resistance than the metal films typically used, they may eventually displace the original metal film types used for write-once recording.

Substrates: Plastic is the currently preferred material, in order to reduce media cost and improve manufacturability. At present, polycarbonate appears to remain the plastic material of choice because of its relative stability and moisture resistance.

While casting polycarbonate with low birefringence (a form of optical distortion) is difficult, proper formulation and control of the molding process has been shown by some substrate manufacturers to permit fabrication of substrates adequate for 5.25" media. Making polycarbonate 12" substrates is even more difficult because of the problem of holding tight tolerances over a larger area.

Glass is used as a substrate for some media. The material is free of birefringence effects that distort the optical path, is nonpermeable to moisture, is flat, and distortion free. The flat glass surface, coupled with high purity materials, can produce media with inherent defect levels considerably better than average. This has the advantage of reducing overall latency in the drive due to the reduced need to perform error correction during data reads. Glass also is less likely to deform at high spin rates, reducing runout and servo tracking difficulties. Glass is denser than plastic, resulting in longer spin-up and spin-down times, a disadvantage when used in optical libraries.

Average access times: One of the major limitations of optical drives is average access time (seek time plus latency), which exceeds 40 milliseconds on most 5.25" drives so far announced. Performance is increasing, as evidenced by Maxoptix' T3-1300, introduced in 1993, which has an average access time in the 25 millisecond range. Newer 3.5" optical disk drives typically have average access times below 40 milliseconds due to their smaller size and shorter stroke lengths. Increasing rotational speed has helped to improve performance as has the wide adoption of split-optic heads.

The first generation of magneto-optical drives have an additional latency for writing operations caused by the need to erase each sector before writing. This lack of overwrite capability requires that an additional complete rotation be performed before the drive is ready to write in the selected sector. Several techniques have been proposed to eliminate the need for an erase pass, and it is likely that future generations of M-O drives will not require a separate erase pass. The overwrite solution will come at the

expense of additional complexity in the drive, media or both, so there will be a trade-off of performance for cost. Phase change drives do not need an erase pass.

Optical drives may have additional latency associated with write operations due to write verification delays. In both read and write operations, latency is increased if media defects have forced a file to be written in non-contiguous segments, as is frequently the situation.

The long access times of today's optical disk drives are less significant when the optical drive is used in an automated library, because the disk exchange and drive spin-up times are lengthy in comparison to the drive access time. Reduction of drive spin-up time is important when the drive is used in a library based system in order to minimize the length of the waiting-for-access queue. Spin-up times of 2 seconds or less are desirable. Plastic substrates usually have less mass than do glass substrates, so are preferable to minimize spin-up time, but are less likely to have a long archival life.

Most optical disk drives rotate at lower speeds than typical magnetic disk drives, so optical drive rotational latency worsens the performance of optical drives in comparison with magnetic drives. A few drives, such as the Hewlett-Packard 5.25" drive and Ricoh's most recent rewritable drive spin at 3,600 RPM. Toshiba's OD300B 3.5" drive also operates at 3,600 RPM. Erasable media requires slightly less write power than write-once media, an advantage which can be translated into higher rotation speeds for erasable drives. RPM is expected to increase to 3,000-3,600 RPM for newer drive designs, and one, Fujitsu's 5.25" drive, operates at 5,400 RPM. Maxoptix and NEC also offer drives with RPM exceeding 3,600 RPM. However, drive manufacturers are having difficulty operating at high spin rates with double capacity media. Some drives that operate at 3,000 RPM or higher with 325 megabytes per side media must drop to lower RPM when operating with double capacity media.

Error rate: Error correcting codes are used to compensate for the high raw error rate of optical media. The codes used, typically long distance Reed-Solomon codes, are able to deal with the higher defect density that occurs at the end of media life. While there is a reduction of data capacity on the disk to accommodate the redundancy needed by ECC methods, the loss may be as little as 8%, depending upon the ECC technique used. Where media have a high defect density, the error correction process can add substantial latency to data retrieval times. Drives will ultimately incorporate more sophisticated ECC circuitry capable of doing on-the-fly error correction so quickly that ECC latency will not be observed.

Packaging: Most optical disk drives using read/write 5.25" disks are still packaged to conform with the envelope of a full height 5.25" floppy disk drive, limiting use to external mounting with many personal computers.

Half-height designs are starting to become available. Ricoh announced a half-high model in 1988 and Pioneer offers a half height mechanism. 3.5" models will fit the 41.3 mm profile, but difficulties in reducing the size of the optics have delayed development of smaller profile drives. Fujitsu is the first company to announce and to ship a 25.4 mm high 3.5" drive.

Military interest has spurred the design of ruggedized optical drives. At least two firms are actively engaged in pursuing this product area, including MountainGate and Mountain Optech.

Many drive producers are improving packaging through integration of logic functions into custom designed VLSI chips or using chip sets available from semiconductor companies for interface functions.

Standards: ANSI X3B11, ECMA TC31, ISO TC91/SC23 are all involved in standardization programs for unrecorded 5.25" and 3.5" media. ISO standards 9171-1 and 9171-2 cover write-once media in CCS and sampled servo formats. ISO international standards 10089 and 10090 cover rewritable 5.25" and 3.5" media respectively. ISO 11560 covers MO-WORM. The ANSI version will not cover the sampled servo format. The 5.25" rewritable cartridge borrows from the work done on the write-once standard, but the same conflicts on the track following servo that bedeviled the write-once standards caused enough conflict to delay the appearance of erasable 5.25" and 3.5" drive standards. Most 5.25" rewritable drives adhere to the CCS format, as do all the 3.5" drives formally announced to date. A 3.5" sampled servo format known as DBF (Discrete Block Format) was proposed as an alternative to the CCS format, but has less capacity (117 megabytes) and was not well received.

Standards for 5.25" 650 megabyte per side media have already been approved by ECMA (ECMA standard 184) and are being processed by ISO as DIS 13549. Several companies, including IBM, Sony, Olympus, Hewlett-Packard and Maxoptix are supporting a downward compatible 1.3 gigabyte per side 5.25" media proposed standard, which is being addressed by the ANSI X3B11 technical committee. A proposal for triple capacity media is being considered by ECMA, with approval expected in late 1993. ECMA is also considering proposed standards for 230 megabyte 3.5" and 256 megabyte 3.5" media. Participants in the standards making process are taking advantage of "fast track" procedures to release standards on a more timely basis than has been the case in the past.

Since June, 1989, the X3B11.1 technical subcommittee has been working on a logical interchange format. Final ANSI approval is expected in 1993. It has also been approved by ECMA, and is designated ECMA 167. The format proposed is transparent to track following approach, operating system used, or whether the media is rewritable, write-once or read-only (OROM). This will be an important standard, because at the present time media written on the same drive but on different systems using different

controllers and driver software could well be incompatible. It does not cover sequential file organization of the type used in CD-ROM drives.

No standard device level interface for optical drives exists, but at the system level, SCSI appears to have the status of a de facto standard. The IBM PC/AT interface, usually achieved by use of a host adapter, also has de facto standard status for both CD-ROM and read/write small drives. Unfortunately, different versions of SCSI and some differences between internal controller design have caused interchangeability problems.

Software: Read/write optical disk drives require specific supporting software, including drivers, operating system utilities, and applications. Basic software must address problems presented by the nature of the optical disk drive:

* More storage capacity is available than older small computer operating systems can handle.
* Write-once disks require nonstandard file management utilities and drivers. File updates may result in degraded performance if files and directories are dispersed across the disk.
* Magneto-optical disks require modified system software to handle the overwrite requirement, or must have this function performed by the disk electronics or controller.
* File management functions in the computer operating system must be modified so that the optical disk appears to the operating system to be identical to a magnetic disk drive.

An additional software problem expected to develop is related to the probable migration of multimedia formats to read/write optical drives. The exact formats used on CD-ROM may not be directly transferable to read/write disks that conform to standards other than ISO 9660.

Another problem area addressable by software is improvement of media interchange. Drivers that can accept the differing data formats generated by various drive and controller combinations can provide some degree of data interchangeability between drives using media with differing formats, provided that those drives operate on a single system. An example is the Optisys System 2000 interface software package, which can operate with a variety of write-once and rewritable drive and controller combinations.

Competing Products: Strong competition for the 3.5" 128 megabyte optical drive will be provided by the SyQuest 3.5" 105 megabyte cartridge drive. The OEM price, in the $300 range, is substantially under the price expected for 3.5" M-O drives for the next 2 years. Performance of the SyQuest drive is also superior to that of current M-O drives.

Forecasting assumptions

1. 5.25" drives with over 1 gigabyte of capacity per side will start to divert shipments of 5.25" drives from this product group beginning in 1995.
2. Rewritable and write-once media will be available in adequate production quantities throughout the forecast period.
3. 4.72" write-once drives will be available from multiple sources throughout the forecast period. No 4.72" rewritable storage is anticipated within the forecast period.
4. No 2.5" drives will be offered in this product group until mid-1994.
5. Requirements of the document storage systems industry and the conservatism of information resource managers will extend the life of 5.25" write-once drives through 1995, although they will be displaced by multifunction drives in most new installations.
6. 230 megabyte 3.5" drives will be introduced in late 1993 by major producers. Higher capacity 3.5" drives will be introduced in 1994 and 1995.

TABLE 23

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	38.3	74.4	58.9	110.4	78.2	141.8	86.5	153.4	94.8	168.9
PCM/Reseller	13.5	19.8	14.6	21.8	24.4	39.7	31.6	53.2	39.2	64.1
OEM/Integrator	32.0	51.9	48.7	78.3	57.8	97.0	66.3	112.3	72.6	125.2
TOTAL U.S. REVENUES	83.8	146.1	122.2	210.5	160.4	278.5	184.4	318.9	206.6	358.2
Non-U.S. Manufacturers										
Captive	15.4	100.6	22.0	145.5	26.6	173.1	33.6	202.1	40.8	226.8
PCM/Reseller	109.3	159.2	148.1	229.4	172.7	294.2	184.8	329.0	183.4	332.3
OEM/Integrator	92.3	250.5	141.1	288.7	204.9	364.9	248.5	446.0	294.6	501.8
TOTAL NON-U.S. REVENUES	217.0	510.3	311.2	663.6	404.2	832.2	466.9	977.1	518.8	1,060.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	300.8	656.4	433.4	874.1	564.6	1,110.7	651.3	1,296.0	725.4	1,419.1
OEM Average Price ($000)		1.461		1.297		1.121		.903		.700

TABLE 24

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992 Shipments		Forecast							
			1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	10.8	20.4	18.4	32.5	25.0	43.0	31.0	52.0	37.0	62.0
PCM/Reseller	5.4	7.9	7.0	10.3	14.3	23.8	20.9	36.7	28.0	48.7
OEM/Integrator	15.7	27.6	24.6	42.0	32.1	54.6	40.5	69.0	49.5	85.1
TOTAL U.S. SHIPMENTS	31.9	55.9	50.0	84.8	71.4	121.4	92.4	157.7	114.5	195.8
Non-U.S. Manufacturers										
Captive	2.6	22.6	4.0	36.6	6.8	49.3	10.1	65.6	14.6	82.1
PCM/Reseller	79.9	121.6	123.4	196.2	177.2	309.0	210.4	383.8	235.1	434.3
OEM/Integrator	58.0	179.3	105.2	240.9	179.4	357.2	280.8	549.3	439.1	809.7
TOTAL NON-U.S. SHIPMENTS	140.5	323.5	232.6	473.7	363.4	715.5	501.3	998.7	688.8	1,326.1
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	172.4	379.4	282.6	558.5	434.8	836.9	593.7	1,156.4	803.3	1,521.9
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	486.8	936.5	769.4	1,495.0	1,204.2	2,331.9	1,797.9	3,488.3	2,601.2	5,010.2

TABLE 25

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

WRITE-ONCE DRIVES: BREAKDOWN BY DISK DIAMETER

	1992 Revenues		Forecast 1993		1994		1995		1996	
	5.25"	4.72"	5.25"	4.72"	5.25"	4.72"	5.25"	4.72"	5.25"	4.72"
U.S. MANUFACTURERS										
PCM/Reseller	2.3	--	1.4	--	1.1	--	.9	--	.6	--
OEM/Integrator	4.0	--	2.7	--	1.9	--	1.5	--	1.1	--
TOTAL U.S. REVENUES	6.3	--	4.1	--	3.0	--	2.4	--	1.7	--
NON-U.S. MANUFACTURERS										
Captive	1.1	5.3	1.1	5.8	1.1	3.7	.7	4.9	.4	7.2
PCM/Reseller	15.7	3.6	13.9	23.8	12.2	30.4	11.4	34.5	10.8	32.0
OEM/Integrator	32.2	14.3	29.5	31.4	25.4	30.4	20.2	32.2	15.7	24.0
TOTAL NON-U.S. REVENUES	49.0	23.2	44.5	61.0	38.7	64.5	32.3	71.6	26.9	63.2
WORLDWIDE RECAP										
Captive	1.1 -97.3%	5.3 -64.7%	1.1 --	5.8 +9.4%	1.1 --	3.7 -36.2%	.7 -36.4%	4.9 +32.4%	.4 -42.9%	7.2 +46.9%
PCM/Reseller	18.0 -28.3%	3.6 --	15.3 -15.0%	23.8 +561.1%	13.3 -13.1%	30.4 +27.7%	12.3 -7.5%	34.5 +13.5%	11.4 -7.3%	32.0 -7.2%
OEM/Integrator	36.2 -10.8%	14.3 +78.8%	32.2 -11.0%	31.4 +119.6%	27.3 -15.2%	30.4 -3.2%	21.7 -20.5%	32.2 +5.9%	16.8 -22.6%	24.0 -25.5%
Total Revenues	55.3 -47.9%	23.2 +.9%	48.6 -12.1%	61.0 +162.9%	41.7 -14.2%	64.5 +5.7%	34.7 -16.8%	71.6 +11.0%	28.6 -17.6%	63.2 -11.7%
ANNUAL SHARE, BY DIAMETER	70.5%	29.5%	44.4%	55.6%	39.4%	60.6%	32.6%	67.4%	31.2%	68.8%

Note: 5.25" drives include 8" drives.

TABLE 26

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

WRITE-ONCE DRIVES: BREAKDOWN BY DISK DIAMETER

	1992 Shipments		Forecast 1993		1994		1995		1996	
	5.25"	4.72"	5.25"	4.72"	5.25"	4.72"	5.25"	4.72"	5.25"	4.72"
U.S. MANUFACTURERS										
PCM/Reseller	.8	--	.5	--	.4	--	.3	--	.2	--
OEM/Integrator	1.1	--	.7	--	.5	--	.4	--	.3	--
TOTAL U.S. SHIPMENTS	1.9	--	1.2	--	.9	--	.7	--	.5	--
NON-U.S. MANUFACTURERS										
Captive	.3	.5	.3	.6	.3	.6	.2	.8	.1	1.2
PCM/Reseller	8.4	1.3	7.3	10.0	6.4	16.0	6.0	23.0	5.7	32.0
OEM/Integrator	18.3	3.1	16.3	8.4	14.1	16.0	11.9	23.0	9.8	30.0
TOTAL NON-U.S. SHIPMENTS	27.0	4.9	23.9	19.0	20.8	32.6	18.1	46.8	15.6	63.2
WORLDWIDE RECAP										
Captive	.3 -97.3%	.5 -44.4%	.3 --	.6 +20.0%	.3 --	.6 --	.2 -33.3%	.8 +33.3%	.1 -50.0%	1.2 +50.0%
PCM/Reseller	9.2 -17.1%	1.3 --	7.8 -15.2%	10.0 +669.2%	6.8 -12.8%	16.0 +60.0%	6.3 -7.4%	23.0 +43.8%	5.9 -6.3%	32.0 +39.1%
OEM/Integrator	19.4 -3.5%	3.1 +416.7%	17.0 -12.4%	8.4 +171.0%	14.6 -14.1%	16.0 +90.5%	12.3 -15.8%	23.0 +43.8%	10.1 -17.9%	30.0 +30.4%
Total Shipments	28.9 -31.7%	4.9 +226.7%	25.1 -13.1%	19.0 +287.8%	21.7 -13.5%	32.6 +71.6%	18.8 -13.4%	46.8 +43.6%	16.1 -14.4%	63.2 +35.0%
ANNUAL SHARE, BY DIAMETER	85.6%	14.4%	57.0%	43.0%	40.1%	59.9%	28.7%	71.3%	20.3%	79.7%

Note: 5.25" drives include 8" drives.

TABLE 27

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

REWRITABLE DRIVES: BREAKDOWN BY DISK DIAMETER

	1992 Revenues		Forecast 1993		1994			1995			1996		
	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS													
Captive	71.3	3.1	102.0	8.4	129.2	12.6	--	136.5	16.9	--	148.5	20.4	--
PCM/Reseller	17.5	--	19.8	.6	34.2	4.4	--	44.4	7.9	--	52.9	10.6	--
OEM/Integrator	46.3	1.6	71.7	3.9	88.0	7.1	--	100.7	10.1	--	109.8	14.3	--
TOTAL U.S. REVENUES	135.1	4.7	193.5	12.9	251.4	24.1	--	281.6	34.9	--	311.2	45.3	--
NON-U.S. MANUFACTURERS													
Captive	63.6	30.6	83.5	55.1	98.3	70.0	--	114.4	80.6	1.5	128.4	88.8	2.0
PCM/Reseller	72.5	67.4	94.2	97.5	107.3	132.5	11.8	118.4	154.7	10.0	126.6	155.9	7.0
OEM/Integrator	129.1	74.9	128.0	99.8	184.8	121.3	3.0	231.4	149.0	13.2	274.8	162.7	24.6
TOTAL NON-U.S. REVENUES	265.2	172.9	305.7	252.4	390.4	323.8	14.8	464.2	384.3	24.7	529.8	407.4	33.6
WORLDWIDE RECAP													
Captive	134.9	33.7	185.5	63.5	227.5	82.6	--	250.9	97.5	1.5	276.9	109.2	2.0
	-29.1%	+121.7%	+37.5%	+88.4%	+22.6%	+30.1%	--	+10.3%	+18.0%	--	+10.4%	+12.0%	+33.3%
PCM/Reseller	90.0	67.4	114.0	98.1	141.5	136.9	11.8	162.8	162.6	10.0	179.5	166.5	7.0
	+28.8%	--	+26.7%	+45.5%	+24.1%	+39.6%	--	+15.1%	+18.8%	-15.3%	+10.3%	+2.4%	-30.0%
OEM/Integrator	175.4	76.5	199.7	103.7	272.8	128.4	3.0	332.1	159.1	13.2	384.6	177.0	24.6
	+4.4%	+548.3%	+13.9%	+35.6%	+36.6%	+23.8%	--	+21.7%	+23.9%	+340.0%	+15.8%	+11.3%	+86.4%
Total Revenues	400.3	177.6	499.2	265.3	641.8	347.9	14.8	745.8	419.2	24.7	841.0	452.7	33.6
	-6.5%	+534.3%	+24.7%	+49.4%	+28.6%	+31.1%	--	+16.2%	+20.5%	+66.9%	+12.8%	+8.0%	+36.0%
ANNUAL SHARE, BY DIAMETER	69.4%	30.6%	65.4%	34.6%	64.0%	34.6%	1.4%	62.8%	35.2%	2.0%	63.5%	34.1%	2.4%

TABLE 28

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

REWRITABLE DRIVES: BREAKDOWN BY DISK DIAMETER

	1992 Shipments		Forecast										
			1993		1994			1995			1996		
	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS													
Captive	18.5	1.9	26.5	6.0	34.0	9.0	--	39.0	13.0	--	45.0	17.0	--
PCM/Reseller	7.1	--	9.0	.8	16.3	7.1	--	22.2	14.2	--	27.8	20.7	--
OEM/Integrator	24.4	2.1	35.8	5.5	44.0	10.1	--	53.0	15.6	--	61.0	23.8	--
TOTAL U.S. SHIPMENTS	50.0	4.0	71.3	12.3	94.3	26.2	--	114.2	42.8	--	133.8	61.5	--
NON-U.S. MANUFACTURERS													
Captive	13.8	8.0	18.7	17.0	23.4	25.0	--	28.6	31.0	5.0	33.8	37.0	10.0
PCM/Reseller	42.4	69.5	57.9	121.0	65.0	165.6	56.0	74.0	214.8	66.0	83.0	243.6	70.0
OEM/Integrator	73.9	84.0	89.2	127.0	132.0	181.1	14.0	178.0	248.4	88.0	229.0	295.9	245.0
TOTAL NON-U.S. SHIPMENTS	130.1	161.5	165.8	265.0	220.4	371.7	70.0	280.6	494.2	159.0	345.8	576.5	325.0
WORLDWIDE RECAP													
Captive	32.3	9.9	45.2	23.0	57.4	34.0	--	67.6	44.0	5.0	78.8	54.0	10.0
	+2.2%	+94.1%	+39.9%	+132.3%	+27.0%	+47.8%	--	+17.8%	+29.4%	--	+16.6%	+22.7%	+100.0%
PCM/Reseller	49.5	69.5	66.9	121.8	81.3	172.7	56.0	96.2	229.0	66.0	110.8	264.3	70.0
	+57.6%	--	+35.2%	+75.3%	+21.5%	+41.8%	--	+18.3%	+32.6%	+17.9%	+15.2%	+15.4%	+6.1%
OEM/Integrator	98.3	86.1	125.0	132.5	176.0	191.2	14.0	231.0	264.0	88.0	290.0	319.7	245.0
	+8.5%	+675.7%	+27.2%	+53.9%	+40.8%	+44.3%	--	+31.3%	+38.1%	+528.6%	+25.5%	+21.1%	+178.4%
Total Shipments	180.1	165.5	237.1	277.3	314.7	397.9	70.0	394.8	537.0	159.0	479.6	638.0	325.0
	+17.3%	+867.8%	+31.6%	+67.6%	+32.7%	+43.5%	--	+25.5%	+35.0%	+127.1%	+21.5%	+18.8%	+104.4%
ANNUAL SHARE, BY DIAMETER	52.2%	47.8%	46.2%	53.8%	40.3%	50.8%	8.9%	36.3%	49.2%	14.5%	33.3%	44.2%	22.5%

TABLE 29

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1992		Forecast							
	--Shipments--		-----1993----		-----1994----		-----1995----		-----1996----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	20.4		32.5		43.0		52.0		62.0	
Erasable	20.4	100.0%	32.5	100.0%	43.0	100.0%	52.0	100.0%	62.0	100.0%
OEM/PCM Total	35.5		52.3		78.4		105.7		133.8	
Write-Once	1.9	5.4%	1.2	2.3%	.9	1.1%	.7	.7%	.5	.4%
Erasable	33.6	94.6%	51.1	97.7%	77.5	98.9%	105.0	99.3%	133.3	99.6%
Total U.S.	55.9		84.8		121.4		157.7		195.8	
Write-Once	1.9	3.4%	1.2	1.4%	.9	.7%	.7	.4%	.5	.3%
Erasable	54.0	96.6%	83.6	98.6%	120.5	99.3%	157.0	99.6%	195.3	99.7%
NON-U.S. MANUFACTURERS										
Captive Total	22.6		36.6		49.3		65.6		82.1	
Write-Once	.8	3.5%	.9	2.5%	.9	1.8%	1.0	1.5%	1.3	1.6%
Erasable	21.8	96.5%	35.7	97.5%	48.4	98.2%	64.6	98.5%	80.8	98.4%
OEM/PCM Total	300.9		437.1		666.2		933.1		1,244.0	
Write-Once	31.1	10.3%	42.0	9.6%	52.5	7.9%	63.9	6.8%	77.5	6.2%
Erasable	269.8	89.7%	395.1	90.4%	613.7	92.1%	869.2	93.2%	1,166.5	93.8%
Total Non-U.S.	323.5		473.7		715.5		998.7		1,326.1	
Write-Once	31.9	9.9%	42.9	9.1%	53.4	7.5%	64.9	6.5%	78.8	5.9%
Erasable	291.6	90.1%	430.8	90.9%	662.1	92.5%	933.8	93.5%	1,247.3	94.1%
WORLDWIDE RECAP										
Total Worldwide Shipments	379.4		558.5		836.9		1,156.4		1,521.9	
	+76.8%		+47.2%		+49.8%		+38.1%		+31.6%	
Write-Once	33.8	8.9%	44.1	7.9%	54.3	6.5%	65.6	5.7%	79.3	5.2%
	-22.8%		+30.4%		+23.1%		+20.8%		+20.8%	
Erasable	345.6	91.1%	514.4	92.1%	782.6	93.5%	1,090.8	94.3%	1,442.6	94.8%
	+102.4%		+48.8%		+52.1%		+39.3%		+32.2%	

Notes: Percentage figures with plus/minus signs refer to year-to-year growth rates.

TABLE 30

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI				
General purpose	5.3	1.4	16.8	1.4
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	42.9	11.3	229.8	19.2
PERSONAL COMPUTERS				
Business and professional, single user	213.2	56.2	439.3	36.7
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	48.6	12.8	187.9	15.7
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	66.8	17.6	232.2	19.4
CONSUMER AND HOBBY COMPUTERS	.4	.1	83.8	7.0
OTHER APPLICATIONS	2.4	.6	7.1	.6
Total	379.4	100.0	1,196.9	100.0

TABLE 31

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1992 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	4.72"	3.5"	Total		5.25"	4.72"	3.5"	Total	
Sony	27.0	1.0	18.0	46.0	28.9	43.0	2.0	54.0	99.0	29.4
Matsushita Electric	20.0	--	15.0	35.0	22.0	39.0	--	39.0	78.0	23.2
Olympus Optical	8.5	--	6.0	14.5	9.1	17.0	--	20.0	37.0	11.0
Ricoh	12.0	--	3.0	15.0	9.4	24.0	--	10.0	34.0	10.1
Other U.S.	20.6	--	.5	21.1	13.3	33.4	--	2.1	35.5	10.6
Other Non-U.S.	12.5	1.8	13.1	27.4	17.3	20.0	2.4	30.5	52.9	15.7
TOTAL	100.6	2.8	55.6	159.0	100.0	176.4	4.4	155.6	336.4	100.0

READ/WRITE OPTICAL DISK DRIVES MORE THAN 1 GIGABYTE

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READ/WRITE OPTICAL DISK DRIVES MORE THAN 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

Eastman Kodak	6800

12" disk diameter

ATG Gigadisc	GD1002, GD6001, GD9001/S
Hitachi	OD 301A-1, OD 321-1
Laser Magnetic Storage Int.	LD 4100
NEC	N7913/N6513-23, N6513-20
Nikon	MO-DD120-1A (Erasable)
Sony	WDD 600, WDD 931

8" disk diameter

Fujitsu	F6443 (Erasable)

High capacity optical disk drives are read/write drives, either write-once or erasable. Most drives in this capacity range are 12" write-once types, although Nikon started shipments of a 12" erasable drive in 1992. Fujitsu has shipped small numbers of a nonremovable 8" erasable drive. Eastman Kodak produces high capacity 14" drives as well. 5.25" drives are expected to enter this product group near the end of the forecast period.

The existing write-once drives are used primarily with large minicomputers and mainframes in specialized imaging, document storage, or archiving applications. They are frequently used with library devices to provide random access mass storage subsystems capable of handling hundreds of gigabytes of storage. Presently, all but two of the available drives in this group use 12" media, and all but one access a single side of a disk. LMSI offers a drive that accesses both sides of the disk simultaneously. 12" optical libraries holding a single drive and fewer than 15 disks are also being used in departmental systems and small work groups.

Market status

For the second year in a row, drive shipments in this group declined. 1992 drive shipments dropped 27.6% to 7,100 units as a result of lower shipments in all distribution channels except for resellers. This decline is believed to be the result of weak worldwide economic conditions that caused postponement of capital equipment purchases (especially in Japan), plus the effect of competition from optical libraries using 5.25" drives with capacities less than 1 gigabyte. Startup production problems for LMSI's new 12" product line were also a contributing factor. 1992 revenues declined 26.4% to $99.8 million. U.S. firms generated 9.3% of total worldwide revenues, although 62.2% of worldwide revenue was generated in the U.S. market, up from 43.3% in 1991.

Almost 98% of units shipped in 1992 were produced by non-U.S. firms, a slightly higher share than in 1991. 45.9% of 1992 unit shipments went to the U.S. market, while 54.1% were sold elsewhere. 1992's leading noncaptive producers were Sony, LMSI and ATG Gigadisc. Hitachi was a strong captive producer.

Japanese firms were the first to enter this drive group because of early emphasis for use on systems capable of storing documents produced in Asian character sets. Of the Japanese firms, Sony and Hitachi have most aggressively pressed forward with improved designs and have benefited by remaining in the market where several other competitors have dropped out.

Government and financial organizations continue to be major markets for high capacity optical disk drives in this group, and some system integrators, including IBM, Unisys and DEC, routinely quote on orders of significant magnitude. IBM now integrates optical drives and libraries with its systems for specific customers. Eastman Kodak's willingness to sell optical drives to replace microfilm equipment for records management has also helped to expand the available market.

Marketing trends

Assuming that the weak economic recovery in the U.S. continues and LMSI shipping capability continues to improve, shipments are expected to recover in 1993 and improve throughout the forecast period. (Because the LMSI model 4100 drive offers unique capabilities, demand for the LMSI drive has substantially

exceeded the firm's production capacity since the drive was introduced, hence the major influence on the forecast.) In 1994 and 1995, shipments are expected to increase dramatically as a new generation of higher capacity 12" drives appears and 5.25" drives with capacity of 1.3 gigabytes per side enter the market. While the 5.25" drives won't have the same capacity per media unit as the 12" drives, their higher performance, lower price, rewritability, and probable multifunctionality and downward compatibility is expected to make them immediately popular. The competition from 5.25" drives will probably halt or reverse the tendency of 12" drive prices to climb each year. It is anticipated that most of the 5.25" drives in this product group will be rewritable or multifunction, but a few write-once drive models may appear as early as 1993. However, they are not expected to have a major impact because customers will be anticipating the arrival of rewritable drives and media. If rewritable drives are delayed beyond 1995, 5.25" write-once drives have an opportunity for modest success.

Because large diameter, high capacity optical disk drives are used mostly in specialized applications, shipment growth rates for drives with more than 1 gigabyte capacity remain smaller than for other optical disk drive groups. Worldwide unit shipments are expected to grow from 7,100 units in 1992 to 34,500 units in 1996, with 60.8% sold in the U.S. market. 58% of 1996 production is expected to be 5.25" drives.

Total revenues in the forecast period are expected to grow from $99.8 million in 1992 (7.6% of the worldwide optical disk drive market) to $269.8 million in 1996 (6.4% of the worldwide optical disk drive market). The U.S. market is expected to generate 63.4% of 1996 worldwide revenues for this product group, with U.S. firms' share of worldwide revenues growing to 19.8%. Most of the U.S. share will come from sales of 5.25" drives. Drive sales should be helped by expanding sales of small optical libraries with a single 12" drive.

Average OEM drive prices are expected to climb through 1993 as the product mix shifts to higher capacity drives and more expensive rewritable drives begin to capture market share, but this trend will be reversed in 1994 as 5.25" drives with capacity over 1 gigabyte per side enter the market. A major acceleration in the rate of price decline is expected in 1996 as 5.25" drive shipments in this group ramp up.

While IBM has an active optical disk drive development program, no early

introduction of internally produced drives over 1 gigabyte from IBM is anticipated. IBM's current policy is to purchase 12" WORM drives and library units, offering them as standard peripheral subsystems with existing system product lines, using appropriate software provided by IBM and other firms. DEC has taken similar action, offering the LMSI 12" drive as the DEC model RV20, and Unisys has purchased 12" drives from Hitachi to run on its 1100 mainframes. IBM's 1991 introduction of a family of 5.25" optical libraries based upon Hewlett-Packard models further suggest IBM has no immediate interest in internal development of 12" optical drives. IBM is expected to produce a 5.25" drive in this product group and is active in the standards effort for 1.3 gigabyte per side media.

Plug compatible hardware vendors, including Data/Ware Development and Comparex, also offer optical drive subsystems for attachment to IBM mainframes, and other firms are also expected to offer such attachments.

Applications

In 1992, the most significant application areas for high capacity optical drives were office systems, multiuser systems, and nonoffice workstations. These three areas accounted for 92% of 1992 unit shipments. In 1996, this pattern will be much the same except with more emphasis on dedicated application office systems, due to growth of demand for document filing systems and integrated information handling systems incorporating document image storage.

Major applications for optical disk drives over 1 gigabyte capacity include records management, medical, geophysical, military or industrial imaging, and storage of transaction documents that must be kept for future reference. Almost all of these applications are archival in nature and favor the use of write-once optical disk technology.

Scientific, industrial and defense oriented users of high capacity drives use them for acquiring high volume digitized data from real time inputs and storing it for subsequent analysis, as well as for administrative uses. Some financial institutions use them for accumulating various types of transaction data in other than image form, reproducing the actual form only upon printing or displaying the document.

Typical usage includes:

Engineering and manufacturing systems

* Centralized drawing/document storage and distribution.
* Document storage for computer integrated manufacturing.
* Document storage and dissemination for construction projects.

Records management

* Personnel records.
* Tax records and tax rolls.
* X-ray and scanner images.
* Law enforcement records.
* Social Security, patent and other government records.
* Large library index files.

Save/restore operations

* Disk backup.
* Archival storage.

Office automation

* Storage and dissemination of office documents.
* Storage of legal documents incorporating signatures and other personal identification.

Transaction audit trails

* Records of reservations, bank and credit card transactions, etc.
* Secure area access records.
* Insurance claim and policy records.

Data acquisition

* Capture of data from scanners, seismic detectors or other imaging devices.

* Capture of data having military or intelligence significance.

The early users of high capacity drives have concentrated on the storage of images, including document filing systems used within government bodies such as taxing agencies, law enforcement, and military/intelligence agencies. Drive library units (jukeboxes) are available for use with high capacity optical disk drives, allowing the creation of on-line mass storage subsystems that are being used by insurance companies, banks, and other large organizations that must have ready recall of large amounts of account related data because they need to service account inquiries in real time. Many of the optical libraries are attached to file servers on networks, which are rapidly increasing their demands for on-line storage.

Approximately 43% of the drives in this group were shipped in automated library subsystems in 1992, and this percentage is expected to increase to 50% in 1993 as shipments of small optical libraries with a single 12" drive begin to increase. By 1996, over 53% of the drives in this group are expected to be installed in jukeboxes upon shipment to the ultimate end user. An automated library system using large capacity drives usually has two or more drives to improve overall response time, although the single drive, five cartridge LMSI library is a notable exception. The number of drives per large library is expected to increase with time, especially for the 5.25" drives, so that at the end of the forecast period the typical library will average between three and four drives installed.

While the records management market is a significant consumer of high capacity optical disk drives, this market tends to experience slow growth due to its conservative nature, reluctance to abandon large investments in existing systems, concern about hidden perils in new technology and, in some organizations, infighting between MIS managers and records managers. In some countries, the legal system discourages the use of optical storage because only original documents are acceptable as legal evidence. Where low cost per stored record is more important than rapid on-line retrieval of a record, microfilm still

competes effectively against optical storage.

However, there has been enough positive experience in the use of optical storage systems so that optical disk drives have entered a period of broad acceptance that will help sustain shipments in the high capacity segment of the optical drive industry. Ample evidence of this trend is available at conferences appealing to managers concerned with records storage: Previously dominated by micrographics oriented speakers and exhibitors, meetings such as the AIIM conference now have such a strong bias towards optical storage that micrographics exhibitors are frustrated with their current low profile.

Large capacity optical disk drives will continue to be employed in dedicated departmental systems that store and manipulate engineering drawings, technical specifications and reference materials. These smaller systems will need smaller library units to meet departmental needs. This segment of the market will have to be defended against smaller diameter drives used with library units of 10-20 disk capacity. The total cost of the drives and library may be well under the price of a single 12" drive, a preferable solution where the longer access time associated with a library is not an objection.

The LMSI drive and library announced in 1990, and Sony's 1992 introduction of a somewhat similar product, attempts to preempt competition from smaller diameter drives in the departmental system market segment. Nevertheless, small diameter drives have begun to eat away at the low capacity end of this product group, a trend which will be accelerated by the arrival of 1.3 gigabytes per side drives and media. 12" drives will be forced to offer increasingly higher capacities in order to remain viable.

Technical trends

Many of the technical issues discussed in the section on optical disk drives under 1 gigabyte capacity also apply to the larger capacity drives in this section. The issues are reviewed here as they pertain specifically to the higher capacity drives.

Performance: Almost all of the released products in this group currently use complex optical head assemblies, resulting in excessive head positioning times. This is of less consequence when the drive is used in a

library subsystem, because of the time required to locate, mount, and spin-up the disk to operating speed. Considerable work is being done by manufacturers to reduce drive complexity and to improve access time. Although it will probably be several years before all head positioning times are below 100 milliseconds, LMSI and ATG Gigadisc have already broken the 100 millisecond barrier.

For a 12" drive operating at 1,800 RPM, a practical data transfer rate limit is about 10 megabits/second, limited by the spot size and power of the laser. As lasers improve, and as RPM increases, the interface and controller will have to cope with significantly higher data transfer rates. A future 12" drive equipped with a green semiconductor laser and spinning at 3,600 RPM could generate a data transfer rate exceeding 37 megabits/second.

The 1.3 gigabytes per side 5.25" drives now under consideration in various standards bodies will probably use zoned recording with pulse width modulated 680 nanometer lasers and the CCS track format. RPM in the 3,000 to 3,600 range is anticipated.

Standards: Standards for 12" high capacity media are finally starting to materialize. Although various manufacturer's product designs are already established and incompatible, the ANSI X3B11 technical subcommittee, which has the U.S. charter to develop such a standard, has obtained agreement on a 17 millimeter height for 12" media cartridges and ISO standard 10885 for 14" media (which affects only the Eastman Kodak drive) has been completed. However, other issues impacting a standard for 12" media may not be resolved for some time to come. In any event, the continuous servo/sampled servo conflict yet remains. IBM could change this situation by announcing a high capacity internally manufactured optical drive and creating a de facto standard, but as already noted, an IBM announcement of a 12" drive is unlikely.

System design: Many large capacity optical disk storage systems will incorporate an automated library. Several firms, including Cygnet, Filenet, Laser Magnetic Storage, Hitachi and others have designed libraries, discovering in the process that it is a major project, requiring substantial time and investment. To be a generally applicable product, the library may have to accommodate several brands of disk drives, an awkward consideration given the lack of product standardization in the industry. The library unit also has to be interfaced to the computer system with which it is to be used, requiring significant development time. The drives themselves must be designed to withstand thousands of cartridge insertions without failure and must accommodate library control and signaling functions.

Software: The software required to integrate a write-once optical disk into the operating system environment of a mainframe computer represents a

major project, requiring many man-years of effort. The integration of erasable disks should be easier, but even these will present some problems. Those aspects of the drive unique to optical storage may be masked by the controller, so that the optical storage subsystem appears as a standard magnetic disk to the operating system. Hierarchical storage management software will be required to make the best use of optical drives and libraries attached to network servers.

Capacity: Capacity per disk is increasing through the use of zoned recording and data compression techniques. Newer 12" drives offer over 5 gigabytes per side, much improved from a typical capacity of 1 gigabyte per side in earlier models. Eastman Kodak's 14" drive also uses disks with over 5 gigabytes per side. Shorter wavelength lasers are expected to bring an additional 30% to 40% improvement in late 1994. The next generation of 12" write-once drives appears likely to offer capacities per side in the 6 to 7 gigabyte region.

Rewritability: In 1992, Nikon started shipments of a rewritable 12" drive and media, but no other firms have yet indicated definite intentions to offer a production drive. Fujitsu's 8" drive incorporates several nonremovable disks, but performance is slow. Media yields for large diameter rewritable media are projected to be low by media suppliers, so media is likely to be scarce and expensive. Consequently, shipments are likely to be modest until media is available and the technology has matured to the point that customers feel confident about the technology.

Nonremovable multiple disks: A multidisk Winchester-like configuration has been considered by various system manufacturers, but probably won't be aggressively marketed until the characteristics of optical drive components have advanced to the point where a drive could closely approach the costs and performance of high capacity magnetic disk drives. The disk diameters employed will probably be 5.25" or 8", and the media will, naturally, be rewritable. Fujitsu has made limited quantities of such a drive with 8" disks, and at least one other firm has a 5.25" development effort aimed at producing a very high capacity, high performance multiple platter drive.

Packaging: The larger capacity optical disk drives typically have a rack mount configuration. Because these drives are often used with library devices, there is a need to define a standardized mechanical interface that will permit any drive to be used with any library load/unload mechanism.

Not all drives in this product group have the drive controller integrated into the drive package yet, but this is expected to become more common in the future as the degree of electronics integration improves. Smaller drives expand disk storage space when drives are used in optical libraries, so embedding the controller in the drive is advantageous.

For the next few years, the 12" form factor will remain the most frequently encountered size in this product group. As areal density improves, 5.25" write-once and rewritable drives are expected to fall into this class of optical drive. There is no expectation of any 3.5" drives in this group within the foreseeable future.

Track following: Pregrooving of the media continues to be the primary method of providing tracking information to the tracking servo for this product group. There has been some interest in using sector servo techniques to improve tracking. ATG Gigadisc has done substantial development work with this technique and has incorporated it into the design of the ATG 12" drive. ATG and other supporters of the sector servo approach believe sector servo improves the ability of the drive to accept write-once, erasable, and read-only media on the same drive and makes the drive less sensitive to variations in groove shape and depth. This approach has been proposed by ATG in the preparation of a standard for 12" optical media. Laser Magnetic Storage also favors a sector servo approach for its future products.

Interface: SCSI is the most commonly encountered interface on the large capacity optical drives. SCSI is likely to remain the preferred choice because of design commitments or until drives with higher performance are technically possible. For many drives, proprietary interfaces are used at the device level, but the desire of manufacturers to sell drive/library combinations attachable to a variety of host systems favors the SCSI interface. For drives to be sold to manufacturers of optical disk libraries, the use of the SCSI interface is a necessity.

Lasers: The larger form factors of the high capacity optical drive favor the use of head assemblies with multiple lasers. The use of multiple lasers can improve drive performance by permitting direct read during write, higher bit densities, use of unusual active layer material, and possibly other benefits. If head designs that separate the laser from the head optics are adopted to reduce mass, it may also be possible to use nonsemiconductor lasers and still achieve reasonable performance.

Because nonsemiconductor lasers can operate at higher frequencies and powers, very high performance may be possible by using them in optical storage systems. GE, for instance, has produced a few specialized systems for the U.S. government using nonsemiconductor lasers. However, cost and reliability will have to be traded for performance in such designs. The short wavelength semiconductor lasers being developed by IBM and others probably have more applicability.

Media: Larger diameter media requires substrates that will not deform at high rotation rates and will maintain consistent optical properties over the usable area of the disk. The latter point is especially significant for magne-

to-optical media in which distortion caused by locked-in or dynamic stresses in the substrate creates signal degradation. These mechanical problems may be a significant obstacle to improving the performance of high capacity optical drives. The considerations for 5.25" media are much the same as in the low capacity drive group.

The current limit on rotational velocity for larger diameter disks is created by available laser write power and the performance of focus and tracking servos, rather than by material failure. 1,800 RPM is considered today's advanced state of the art for high capacity 12" drives, and some currently available drives operate at half this RPM or less. There are expectations of achieving 2,800 to 3,600 RPM in the future through the use of non-mechanical focusing techniques and improved substrate materials.

Substrates: Both plastic and glass are in use for 12" media substrates, and Eastman Kodak is using an aluminum substrate for its 14" drive. Because of the difficulty in molding large diameter plastic substrates with adequately low birefringence, it seems likely that glass will retain a prominent role in the fabrication of readily producible erasable media for large diameter drives.

Producers of glass substrates have demonstrated that glass hardened by ion bombardment has adequate mechanical strength to withstand routine use under projected conditions for future drive designs. However, concern remains as to the effects of small imperfections such as nicks, scratches or chips caused during handling of the disk.

Forecasting assumptions

1. No 12" IBM-produced optical drives are anticipated in this product group through 1996.
2. There will continue to be an adequate supply of write-once media for products in this group.
3. There will be no generally accepted standard for 12" drives and media through 1996.
4. There will be no significant shipments of 5.25" rewritable drives in this product group until 1995.
5. Rewritable 12" drives and media will have only marginal impact through 1993, but are expected to have growing impact on shipments after that.
6. LMSI's dual head drive will stimulate market growth in this category.

TABLE 32

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.6	6.6	6.6	9.9	6.6	13.2	12.3	19.7	18.1	30.7
PCM/Reseller	--	--	--	--	--	--	1.7	2.0	4.2	6.0
OEM/Integrator	2.7	2.7	2.4	2.4	2.7	3.0	4.4	6.4	11.0	17.2
TOTAL U.S. REVENUES	9.3	9.3	9.0	12.3	9.3	16.2	18.4	28.1	33.3	53.9
Non-U.S. Manufacturers										
Captive	--	18.8	--	16.6	--	13.3	.4	12.2	2.2	13.1
PCM/Reseller	3.3	4.4	4.2	7.0	6.0	9.0	6.6	11.2	9.5	15.2
OEM/Integrator	49.5	67.3	63.7	90.2	78.2	115.7	100.9	147.9	128.1	190.5
TOTAL NON-U.S. REVENUES	52.8	90.5	67.9	113.8	84.2	138.0	107.9	171.3	139.8	218.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	62.1	99.8	76.9	126.1	93.5	154.2	126.3	199.4	173.1	272.7
OEM Average Price ($000)		12.7		12.6		12.1		11.1		8.1

TABLE 33

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.2	.2	.2	.3	.2	.4	.9	1.3	2.7	3.8
PCM/Reseller	--	--	--	--	--	--	.5	.6	1.4	2.0
OEM/Integrator	.1	.1	.1	.1	.2	.3	.7	1.3	2.4	4.6
TOTAL U.S. SHIPMENTS	.3	.3	.3	.4	.4	.7	2.1	3.2	6.5	10.4
Non-U.S. Manufacturers										
Captive	--	1.0	--	.9	--	.7	.1	.8	.6	1.5
PCM/Reseller	.3	.4	.3	.5	.4	.6	.5	.8	1.0	1.6
OEM/Integrator	4.0	5.4	5.1	7.2	6.4	9.5	8.3	12.5	12.9	21.0
TOTAL NON-U.S. SHIPMENTS	4.3	6.8	5.4	8.6	6.8	10.8	8.9	14.1	14.5	24.1
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	4.6	7.1	5.7	9.0	7.2	11.5	11.0	17.3	21.0	34.5
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	33.0	73.6	38.7	82.6	45.9	94.1	56.9	111.4	77.9	145.9

TABLE 34

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues	Forecast						
		1993	1994		1995		1996	
	12"	12"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS								
Captive	6.6	9.9	13.2	--	16.5	3.2	19.8	10.9
PCM/Reseller	--	--	--	--	--	2.0	--	6.0
OEM/Integrator	2.7	2.4	2.4	.6	2.4	4.0	4.8	12.4
TOTAL U.S. REVENUES	9.3	12.3	15.6	.6	18.9	9.2	24.6	29.3
NON-U.S. MANUFACTURERS								
Captive	18.8	16.6	13.3	--	11.4	.8	9.5	3.6
PCM/Reseller	4.4	7.0	9.0	--	10.8	.4	12.8	2.4
OEM/Integrator	67.3	90.2	114.3	1.4	142.7	5.2	168.9	21.6
TOTAL NON-U.S. REVENUES	90.5	113.8	136.6	1.4	164.9	6.4	191.2	27.6
WORLDWIDE RECAP								
Captive	25.4 -41.1%	26.5 +4.3%	26.5 --	-- --	27.9 +5.3%	4.0 --	29.3 +5.0%	14.5 +262.5%
PCM/Reseller	4.4 +7.3%	7.0 +59.1%	9.0 +28.6%	-- --	10.8 +20.0%	2.4 --	12.8 +18.5%	8.4 +250.0%
OEM/Integrator	70.0 -20.8%	92.6 +32.3%	116.7 +26.0%	2.0 --	145.1 +24.3%	9.2 +360.0%	173.7 +19.7%	34.0 +269.6%
Total Revenues	99.8 -26.4%	126.1 +26.4%	152.2 +20.7%	2.0 --	183.8 +20.8%	15.6 +680.0%	215.8 +17.4%	56.9 +264.7%
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	98.8%	1.2%	92.3%	7.7%	79.2%	20.8%

Note: 12" drives include 14" drives.

TABLE 35

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments	Forecast						
		1993	1994		1995		1996	
	12"	12"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS								
Captive	.2	.3	.4	--	.5	.8	.6	3.2
PCM/Reseller	--	--	--	--	--	.6	--	2.0
OEM/Integrator	.1	.1	.1	.2	.1	1.2	.2	4.4
TOTAL U.S. SHIPMENTS	.3	.4	.5	.2	.6	2.6	.8	9.6
NON-U.S. MANUFACTURERS								
Captive	1.0	.9	.7	--	.6	.2	.5	1.0
PCM/Reseller	.4	.5	.6	--	.7	.1	.8	.8
OEM/Integrator	5.4	7.2	9.1	.4	10.9	1.6	12.4	8.6
TOTAL NON-U.S. SHIPMENTS	6.8	8.6	10.4	.4	12.2	1.9	13.7	10.4
WORLDWIDE RECAP								
Captive	1.2	1.2	1.1	--	1.1	1.0	1.1	4.2
	-53.8%	--	-8.3%	--	--	--	--	+320.0%
PCM/Reseller	.4	.5	.6	--	.7	.7	.8	2.8
	+33.3%	+25.0%	+20.0%	--	+16.7%	--	+14.3%	+300.0%
OEM/Integrator	5.5	7.3	9.2	.6	11.0	2.8	12.6	13.0
	-20.3%	+32.7%	+26.0%	--	+19.6%	+366.7%	+14.5%	+364.3%
Total Shipments	7.1	9.0	10.9	.6	12.8	4.5	14.5	20.0
	-27.6%	+26.8%	+21.1%	--	+17.4%	+650.0%	+13.3%	+344.4%
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	94.9%	5.1%	74.1%	25.9%	42.0%	58.0%

Note: 12" drives include 14" drives.

TABLE 36

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1992 Estimate Units (000)	1992 Estimate %	1996 Projection Units (000)	1996 Projection %
MAINFRAME/SUPERMINI				
General purpose	.4	6.0	2.8	8.2
MINICOMPUTERS AND MULTIUSER MICROS				
Business and professional, including networks	2.2	31.0	10.8	31.4
PERSONAL COMPUTERS				
Business and professional, single user	.1	1.9	.1	.3
OFFICE SYSTEMS AND WORKSTATIONS				
Dedicated application and electronic typewriters	2.8	38.7	14.3	41.2
NONOFFICE SYSTEMS AND WORKSTATIONS				
Technical, distribution, medical, other specialized	1.6	22.4	6.5	18.9
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	7.0	100.0	34.4	100.0

CD-ROM OPTICAL LIBRARIES

1993 DISK/TREND REPORT

CD-ROM OPTICAL LIBRARIES

Coverage

Examples of optical disk libraries in this group include:

4.72" disk diameter

Borett Automation Technologies	VLC
DSM	CDR-1, CDR-2, CDR-4
Kubik Enterprises	DDC-240, CDR240M
NSM	CDR-100
Pioneer	DRM-600, DRM 604, DRM610

Read-only optical disk libraries currently make use of CD-ROM drives only, and it is unlikely that other read-only disk drive formats will become significant, because multifunction drives will be able to handle read-only media in other formats. For the most part, CD-ROM optical disk libraries are derivatives of designs incorporating audio drives.

Market status

Five manufacturers are shipping CD-ROM library devices, but only Pioneer has significant shipment volume. CD-ROM libraries range from the 549 disk version of DSM to the integrated drive and six unit capacity of Pioneer, which is derived from the design of a multidisk CD audio player. Several U.S. manufacturers of read/write optical disk libraries are currently considering entering the CD-ROM library market segment, but have not indicated they will announce products.

The Kubik library, an unusual rotary mechanism that operates much like a carousel-type slide projector, has entered production status. NSM, a German organization, has shipped a few libraries based upon a previous audio player version. The most elaborate library in this class is produced by Borett Automation Technologies and uses an industrial robot. It is a variant of a design developed to handle other forms of media, and requires the disk to be in a caddy. DSM, also a German company, entered the market in 1992 with a line of larger CD-ROM libraries.

Marketing trends

In 1992, CD-ROM library revenues rose 106.2% to $13.4 million, largely as a result of Pioneer's success with its six disk library, and is expected to reach $53.3 million in 1996. The number of competitors and the complexity of the solutions offered are expected to increase in order to serve network users interested in adding CD-ROM capability to their networks. An increasing number of system manufacturers, such as Compaq, intend to include CD-ROM capability with their file servers, increasing the opportunity for upgrades to a library subsystem.

It is expected that libraries containing a mix of CD-ROM drives and CD-WO drives will begin to appear on servers in 1994.

11,473 units were shipped in 1992, up 49.7% from 1991. 1996 shipments are projected to reach 29,035 units, with the majority of these shipments being low-end libraries holding no more than twenty disks. 80.6% of the total unit shipments in 1992 were to the U.S. market, but this percentage will decline to 74% in 1996. 62.9% of 1992 unit shipments were sold to OEMs or system integrators. The portion sold to OEM/Integrators is expected to increase to 69.1% in 1996.

Applications

The major applications for CD-ROM optical libraries continue to be in file servers on networks and for high-end personal computers and workstations. High-end CD-ROM libraries have found applications in large institutional libraries and in organizations that must provide network access to large amounts of documentation for many users located at diverse sites. Low-end libraries, such as the Pioneer unit, have been used primarily with single-user computers and workstations or with servers in small networks with low transaction rates. Pioneer's high performance version, which rotates at four times the normal speed, is expected to sell strongly to server installations and to multimedia intensive applications because of its quadrupled data transfer rate. Pioneer is expected to improve its already strong position in this segment when it begins producing an 18 cartridge library in late 1993.

Certain users of CD-ROM data bases that span more than one disk find the low-end CD-ROM libraries particularly convenient. Legal case records, citations and regulatory material often fit this pattern, as do CD-ROM records of archival

material such as patent records. Other beneficiaries of low-end libraries could be users of large clip art files or large numbers of maps, and analysts wishing to keep large collections of historical financial data readily available.

Technical trends

Read-only disk library technology is derived from other well established product designs. The Pioneer library is an adaptation of an audio player/changer, but has been shown in a high performance version offering up to four times the standard CD-ROM data transfer rate and rotation rate. Kubik's rotary carousel design is innovative and provides a relatively high storage density. Interfaces are standard RS-232 or SCSI variants.

A potentially troublesome problem is that CD-ROM drives are not engineered to withstand the physical stresses of thousands of disk insertions and ejections in a short period of time. Some current CD-ROM disk load/eject mechanism designs require modification so that the drive can be used in a library.

There is some competition for read-only libraries from configurations of multiple CD-ROM drives usually attached to file servers, that can provide multiple disk availability or offer multiple user access to the same disk with minimal delay. Where only one or a few disks need to be used by a work group, this may be a favored approach.

Forecasting assumptions

1. Read-only library sales will continue to be dominated by low cost, low performance devices.
2. Non-U.S. suppliers will dominate the read-only library market. There will be only minor production by U.S. firms. IBM will not be a producer.
3. There will be no significant changes in library technology impacting read-only libraries over the period of the forecast.
4. Additional competitors will appear in the low-end library market, resulting in price competition that will spur unit shipments.

TABLE 37

OPTICAL LIBRARIES, CD-ROM

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	2.8	2.8	6.3	6.4	9.1	9.8	10.7	12.5	11.4	14.7
TOTAL U.S. REVENUES	2.8	2.8	6.3	6.4	9.1	9.8	10.7	12.5	11.4	14.7
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	3.7	5.6	5.1	8.1	8.5	11.2	9.4	12.4	10.3	13.7
OEM/Integrator	3.9	5.0	8.3	11.6	13.8	19.5	16.3	22.6	18.2	24.9
TOTAL NON-U.S. REVENUES	7.6	10.6	13.4	19.7	22.3	30.7	25.7	35.0	28.5	38.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	10.4	13.4	19.7	26.1	31.4	40.5	36.4	47.5	39.9	53.3
OEM Average Price ($000)		1.1		1.7		2.1		2.0		1.9

TABLE 38

OPTICAL LIBRARIES, CD-ROM

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	185	185	450	460	698	751	892	1,039	1,034	1,336
TOTAL U.S. SHIPMENTS	185	185	450	460	698	751	892	1,039	1,034	1,336
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	3,514	4,187	4,062	5,192	4,706	6,182	5,553	7,324	6,441	8,549
OEM/Integrator	5,552	7,101	7,102	10,014	9,204	13,016	11,651	16,170	14,034	19,150
TOTAL NON-U.S. SHIPMENTS	9,066	11,288	11,164	15,206	13,910	19,198	17,204	23,494	20,475	27,699
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	9,251	11,473	11,614	15,666	14,608	19,949	18,096	24,533	21,509	29,035
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	21	29	32	45	47	65	65	89	87	118

READ/WRITE OPTICAL LIBRARIES, 1-39 CARTRIDGES

1993 DISK/TREND REPORT

READ/WRITE OPTICAL LIBRARIES
1 - 39 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

3.5" disk diameter

IBM	5558-B01
International Data Engineering	TG-8

5.25" disk diameter

Aisin Seiki	JC2000
DSM	4000
Hewlett-Packard	C1710M-105, C1713M, 10LC
Hitachi	OL101-11, OL112-21
IBM	3995-042
International Data Engineering	7000, 7100, 9000, LG5
K&S	Megastore 1000
Mitsubishi Electric	ME-5G2-Z
NEC	N1137-06
Nikkyo	NOL-102
Ricoh	RJ5160
Toshiba	WM-A012

12" disk diameter

Access	ODSR
ATG Gigadisc	GF 6910
Cygnet Systems	1602
DSM	20, 27, 28, 30, 38
Hitachi	OL301
Laser Magnetic Storage Inter.	LF 4500
NEC	N7923
Sony	WDA-E330

In 1993, 5.25" optical libraries remain the predominant type in this product group. The first 3.5" optical libraries in the group were announced by IBM and IDE. Libraries represented in the list above are quite diverse, ranging from the tabletop, single drive, 5 disk unit of IDE to sophisticated multidrive units produced by Hitachi, Hewlett-Packard and DSM.

Also included is the LMSI library, which incorporates the first dual head optical drive, enabling twenty percent of its 28 gigabyte capacity to be on-line at all times. Drives included in libraries of this group are either write-once or re-

writable for 5.25" types, but 12" types are still limited to write-once drives. Although the first 12" rewritable drive (from Nikon) has gone into production, it requires adaptation before it can appear in an optical library. The IBM 3.5" library uses IBM's rewritable 3.5" drive.

Market status

1992 shipments for this product group increased 185.5% to 9,180 units. Revenues grew 88.8% to $82.9 million. 71.8% of 1992 revenues and 89.3% of 1992 shipments were generated by U.S. manufacturers, notably IDE and Hewlett-Packard, which together accounted for nearly 89% of unit shipments. 63.6% of unit shipments were made to U.S. destinations, a slight decrease from 1991.

IDE's strong position in 5.25" low-end tabletop libraries has come under attack from other manufacturers, including Hewlett-Packard, NKK and Nikkyo, although Japanese companies may have some difficulty making immediate inroads into the U.S. market because of the strong yen.

The 3.5" libraries have so far been a disappointment, primarily because the low capacity of the 3.5" drive makes 3.5" libraries less competitive than other possible configurations. 3.5" libraries are expected to become more attractive after 1995 as capacity of 3.5" drives rises above the 300 megabyte level.

Library producers usually install drives before shipping to customers. Frequently, drives are ordered and supplied by the library producer's customer to the library producer for installation. In other cases, library producers (such as Cygnet, Hewlett-Packard and Hitachi) specify, buy, and install drives. This pattern recognizes the wide range of variation in drive performance, reliability and manufacturing tolerances: Not all drives operate equally well in a given library. Business reasons may also dictate the choice of a single drive supplier to reduce development and support costs for captive producers.

Marketing trends

Worldwide unit shipments are forecasted to grow to 35,878 units in 1996, with about 70.1% of the total being sold in the U.S. 1996 revenues will grow to $258.2 million. Both the number of units and the U.S./non-U.S. ratio are being

influenced by shipment growth of inexpensive tabletop libraries sold for use with workstations and high-end personal computers. The increasing proportion of 12" single-drive libraries will cause a temporary increase in the average price within this group during the early portion of the forecast period. However, viewed separately, high-end and low-end price declines will occur gradually throughout the period.

About 49.4% of the 1996 shipments are projected to be made to OEMs and system integrators, while 47.5% will be through PCM/Resellers. 5.25" shipments, which were 89.9% of the 1992 total shipments, are expected to decline to 84.8% in 1996, as a result of the anticipated success of the 12" autochangers in this product group and the gradual growth of 3.5" libraries, which are projected to capture a 1.5% share in 1996.

1996 revenues are projected to grow to $258.2 million, with 64.3% originating from U.S. firms. This is a modest percentage decline from 1992, and reflects the effects of recent small library introductions from non-U.S. manufacturers. About 70.8% of the worldwide library revenues from this product group are expected to be generated in the U.S. market in 1996.

An increase in the number of competitors in this group is anticipated during the forecast period, with many innovative product designs expected. It is anticipated that most of the new entrants will be non-U.S. based firms.

As noted previously, most shipments will be on an OEM basis, with about 49.4% of 1996 unit shipments (mostly low-end) made to OEM/Integrators. High-end libraries in this group will also be shipped as part of complete systems supplied by Hewlett-Packard, Hitachi and other system manufacturers which may elect to produce their own libraries. In most cases, however, system manufacturers will elect to be purchasers of libraries rather than make them, and some existing internally manufactured libraries will tend to be phased out and replaced by purchased models.

Applications

Optical libraries with single drives, regardless of diameter, are being used in stand-alone applications where their relatively low price and limited storage

capacities are appropriate. Multidrive libraries are more likely to be used in multiuser systems where response time to an inquiry is a critical parameter and the cost is shared among a number of system users.

The LMSI, Sony and ATG Gigadisc libraries occupy a middle ground: While relatively low in price, and having only one drive, they provide on-line capacity so large (especially the dual head LMSI design) that throughput may frequently be better than that of multidrive 5.25" units. In cases where rewritable media is not required, the small 12" library may displace some 5.25" libraries in both single user and multiuser systems. The small 12" libraries, the only write-once libraries in this product group, are expected to sustain growth through 1996.

Technical trends

For the time being, libraries in this product group will continue to use 5.25" or 12" drives and media. 3.5" libraries, introduced by IBM and IDE, and under development at several other firms, will capture only a minor market share. Until drives with capacities in the above 300 megabytes appear, 3.5" libraries will offer so much less throughput than 5.25" libraries that they will be relatively unattractive. They may have some appeal as automated disk writers for software duplication where the production requirement is nominal, but specialized equipment for this purpose is already in the market.

Performance, in terms of average media exchange time, is expected to improve somewhat for high-end libraries, but is not a critical issue for stand-alone workstations, where convenience, ease of installation and price are likely to be more important parameters. Again, the unique nature of the LMSI library poses a challenge. It is fast (3 second specified average exchange time) and comparatively inexpensive, and its high data availability and throughput will provide difficult performance criteria for conventional 5.25" library designs to meet. Should direct overwrite rewritable 12" drives and media become readily available, small 12" libraries will become more important competitors in all but the most price sensitive situations.

The use of advanced components such as optical position sensors, optical position encoders and nonvolatile semiconductor memory for controller functions is improving reliability. Some libraries will perform several hundred thousand

cartridge exchanges between failures. It is not unusual for library manufacturers to require drive suppliers to make drives specified to withstand over 300,000 cartridge insertions, in order to achieve adequate system reliability.

Forecasting assumptions

1. There will be additional 3.5" library manufacturers in the market by the end of 1993.
2. The 5.25" format will remain the most commonly used, but it will receive competition from 12" libraries.
3. Erasable drives will be used in more libraries than will write-once drives, which will gradually be supplanted in most applications by multifunction drives.
4. There are no significant changes in technology anticipated affecting libraries over the period of the forecast, but drive capacity improvements will favor the growth of 5.25" libraries over 12" libraries.
5. Single drive 5.25" libraries will be used mostly with stand-alone workstations. Single drive 12" units will be used with workstations and in small multiuser systems. Multidrive libraries will be used in medium to large multiuser systems.
6. The availability of higher capacity optical drives will tend to increase the growth rate of this product group at the expense of the 40 to 69 cartridge product group.

TABLE 39

OPTICAL LIBRARIES, 1-39 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.7	8.8	7.9	10.4	9.5	12.6	11.4	15.1	12.8	17.1
PCM/Reseller	13.3	20.7	32.6	45.6	46.2	63.5	56.1	75.9	62.9	83.8
OEM/Integrator	20.5	30.1	27.8	40.3	34.5	51.9	39.9	59.6	43.2	65.2
TOTAL U.S. REVENUES	40.5	59.6	68.3	96.3	90.2	128.0	107.4	150.6	118.9	166.1
Non-U.S. Manufacturers										
Captive	--	4.6	--	4.6	--	4.8	--	4.9	--	5.1
PCM/Reseller	2.0	2.5	2.2	3.4	2.9	4.5	3.7	5.7	4.3	6.5
OEM/Integrator	11.6	16.2	27.5	42.8	40.8	58.7	53.0	73.2	59.6	80.5
TOTAL NON-U.S. REVENUES	13.6	23.3	29.7	50.8	43.7	68.0	56.7	83.8	63.9	92.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	54.1	82.9	98.0	147.1	133.9	196.0	164.1	234.4	182.8	258.2
OEM Average Price ($000)		8.9		9.5		9.2		8.8		8.1

TABLE 40

OPTICAL LIBRARIES, 1-39 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	273	362	384	509	499	664	630	838	750	1,002
PCM/Reseller	2,152	3,451	4,716	6,746	7,368	10,130	9,908	13,423	12,393	16,535
OEM/Integrator	2,817	4,389	4,384	6,731	6,048	9,166	7,563	11,366	8,761	13,327
TOTAL U.S. SHIPMENTS	5,242	8,202	9,484	13,986	13,915	19,960	18,101	25,627	21,904	30,864
Non-U.S. Manufacturers										
Captive	--	61	--	55	--	57	--	59	--	61
PCM/Reseller	102	127	111	170	150	234	202	310	249	381
OEM/Integrator	503	790	1,229	1,991	1,948	2,868	2,659	3,747	3,317	4,572
TOTAL NON-U.S. SHIPMENTS	605	978	1,340	2,216	2,098	3,159	2,861	4,116	3,566	5,014
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	5,847	9,180	10,824	16,202	16,013	23,119	20,962	29,743	25,470	35,878
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	9	15	20	31	36	54	57	84	82	119

TABLE 41

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues			Forecast											
	1993			1994			1995			1996					
	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"
U.S. MANUFACTURERS															
Captive	.2	8.6	--	.3	10.1	--	.1	12.5	--	.1	15.0	--	.1	17.0	--
PCM/Reseller	--	20.7	--	--	45.6	--	--	63.5	--	--	75.9	--	--	83.8	--
OEM/Integrator	2.0	27.9	.2	2.8	36.7	.8	2.9	47.8	1.2	3.3	54.8	1.5	3.3	60.2	1.7
TOTAL U.S. REVENUES	2.2	57.2	.2	3.1	92.4	.8	3.0	123.8	1.2	3.4	145.7	1.5	3.4	161.0	1.7
NON-U.S. MANUFACTURERS															
Captive	1.3	3.3	--	1.5	3.1	--	1.8	3.0	--	1.9	3.0	--	2.0	3.1	--
PCM/Reseller	1.9	.6	--	2.8	.6	--	4.0	.5	--	5.2	.5	--	6.1	.4	--
OEM/Integrator	14.8	1.4	--	41.4	1.4	--	57.3	1.4	--	71.9	1.3	--	79.3	1.2	--
TOTAL NON-U.S. REVENUES	18.0	5.3	--	45.7	5.1	--	63.1	4.9	--	79.0	4.8	--	87.4	4.7	--
WORLDWIDE RECAP															
Captive	1.5	11.9	--	1.8	13.2	--	1.9	15.5	--	2.0	18.0	--	2.1	20.1	--
	-85.4%	-16.8%	--	+20.0%	+10.9%	--	+5.6%	+17.4%	--	+5.3%	+16.1%	--	+5.0%	+11.7%	--
PCM/Reseller	1.9	21.3	--	2.8	46.2	--	4.0	64.0	--	5.2	76.4	--	6.1	84.2	--
	--	+826.1%	--	+47.4%	+116.9%	--	+42.9%	+38.5%	--	+30.0%	+19.4%	--	+17.3%	+10.2%	--
OEM/Integrator	16.8	29.3	.2	44.2	38.1	.8	60.2	49.2	1.2	75.2	56.1	1.5	82.6	61.4	1.7
	+330.8%	+125.4%	--	+163.1%	+30.0%	+300.0%	+36.2%	+29.1%	+50.0%	+24.9%	+14.0%	+25.0%	+9.8%	+9.4%	+13.3%
Total Revenues	20.2	62.5	.2	48.8	97.5	.8	66.1	128.7	1.2	82.4	150.5	1.5	90.8	165.7	1.7
	+41.3%	+111.1%	--	+141.6%	+56.0%	+300.0%	+35.5%	+32.0%	+50.0%	+24.7%	+16.9%	+25.0%	+10.2%	+10.1%	+13.3%
ANNUAL SHARE, BY DIAMETER	24.4%	75.5%	--	33.2%	66.4%	.4%	33.8%	65.7%	.5%	35.3%	64.2%	.5%	35.3%	64.2%	.5%

TABLE 42

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments			Forecast											
	1993			1994			1995			1996					
	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"
U.S. MANUFACTURERS															
Captive	4	358	--	6	503	--	3	661	--	3	835	--	3	999	--
PCM/Reseller	--	3,451	--	--	6,746	--	--	10,130	--	--	13,423	--	--	16,535	--
OEM/Integrator	50	4,253	86	70	6,435	226	75	8,735	356	85	10,797	484	90	12,636	601
TOTAL U.S. SHIPMENTS	54	8,062	86	76	13,684	226	78	19,526	356	88	25,055	484	93	30,170	601
NON-U.S. MANUFACTURERS															
Captive	28	33	--	32	23	--	36	21	--	40	19	--	44	17	--
PCM/Reseller	97	30	--	140	30	--	207	27	--	286	24	--	360	21	--
OEM/Integrator	670	120	--	1,863	128	--	2,730	138	--	3,596	151	--	4,404	168	--
TOTAL NON-U.S. SHIPMENTS	795	183	--	2,035	181	--	2,973	186	--	3,922	194	--	4,808	206	--
WORLDWIDE RECAP															
Captive	32	391	--	38	526	--	39	682	--	43	854	--	47	1,016	--
	-85.3%	-23.5%	--	+18.8%	+34.5%	--	+2.6%	+29.7%	--	+10.3%	+25.2%	--	+9.3%	+19.0%	--
PCM/Reseller	97	3,481	--	140	6,776	--	207	10,157	--	286	13,447	--	360	16,556	--
	--	+594.8%	--	+44.3%	+94.7%	--	+47.9%	+49.9%	--	+38.2%	+32.4%	--	+25.9%	+23.1%	--
OEM/Integrator	720	4,373	86	1,933	6,563	226	2,805	8,873	356	3,681	10,948	484	4,494	12,804	601
	+326.0%	+141.1%	--	+168.5%	+50.1%	+162.8%	+45.1%	+35.2%	+57.5%	+31.2%	+23.4%	+36.0%	+22.1%	+17.0%	+24.2%
Total Shipments	849	8,245	86	2,111	13,865	226	3,051	19,712	356	4,010	25,249	484	4,901	30,376	601
	+118.3%	+191.8%	--	+148.6%	+68.2%	+162.8%	+44.5%	+42.2%	+57.5%	+31.4%	+28.1%	+36.0%	+22.2%	+20.3%	+24.2%
ANNUAL SHARE, BY DIAMETER	9.2%	89.9%	.9%	13.0%	85.7%	1.3%	13.2%	85.4%	1.4%	13.5%	85.0%	1.5%	13.7%	84.8%	1.5%

TABLE 43

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1992 --Shipments--		Forecast							
			1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	362.0		509.0		664.0		838.0		1,002.0	
Write-Once	4.0	1.1%	6.0	1.2%	3.0	.5%	3.0	.4%	3.0	.3%
Erasable	358.0	98.9%	503.0	98.8%	661.0	99.5%	835.0	99.6%	999.0	99.7%
OEM/PCM Total	7,840.0		13,477.0		19,296.0		24,789.0		29,862.0	
Write-Once	570.0	7.3%	650.0	4.8%	717.0	3.7%	799.0	3.2%	871.0	2.9%
Erasable	7,270.0	92.7%	12,827.0	95.2%	18,579.0	96.3%	23,990.0	96.8%	28,991.0	97.1%
Total U.S.	8,202.0		13,986.0		19,960.0		25,627.0		30,864.0	
Write-Once	574.0	7.0%	656.0	4.7%	720.0	3.6%	802.0	3.1%	874.0	2.8%
Erasable	7,628.0	93.0%	13,330.0	95.3%	19,240.0	96.4%	24,825.0	96.9%	29,990.0	97.2%
NON-U.S. MANUFACTURERS										
Captive Total	61.0		55.0		57.0		59.0		61.0	
Write-Once	43.0	70.6%	45.0	81.9%	47.0	82.6%	49.0	83.2%	51.0	83.7%
Erasable	18.0	29.4%	10.0	18.1%	10.0	17.4%	10.0	16.8%	10.0	16.3%
OEM/PCM Total	917.0		2,161.0		3,102.0		4,057.0		4,953.0	
Write-Once	888.0	96.9%	2,123.0	98.3%	3,058.0	98.7%	4,006.0	98.8%	4,895.0	98.9%
Erasable	29.0	3.1%	38.0	1.7%	44.0	1.3%	51.0	1.2%	58.0	1.1%
Total Non-U.S.	978.0		2,216.0		3,159.0		4,116.0		5,014.0	
Write-Once	931.0	95.3%	2,168.0	97.9%	3,105.0	98.4%	4,055.0	98.6%	4,946.0	98.7%
Erasable	47.0	4.7%	48.0	2.1%	54.0	1.6%	61.0	1.4%	68.0	1.3%
WORLDWIDE RECAP										
Total Worldwide Shipments	9,180.0		16,202.0		23,119.0		29,743.0		35,878.0	
	+185.5%		+76.4%		+42.6%		+28.6%		+20.6%	
Write-Once	1,505.0	16.4%	2,824.0	17.4%	3,825.0	16.5%	4,857.0	16.3%	5,820.0	16.2%
	+8.1%		+87.6%		+35.4%		+26.9%		+19.8%	
Erasable	7,675.0	83.6%	13,378.0	82.6%	19,294.0	83.5%	24,886.0	83.7%	30,058.0	83.8%
	+321.0%		+74.3%		+44.2%		+28.9%		+20.7%	

Notes: Percentage figures with plus/minus signs refer to year-to-year growth rates.

READ/WRITE OPTICAL LIBRARIES, 40-69 CARTRIDGES

1993 DISK/TREND REPORT

READ/WRITE OPTICAL LIBRARIES
40 - 69 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Amber Technology	Rotostar 252
Eastman Kodak	560E
Hitachi	OL101-12, OL112-12, OL114-12
Matsushita Electric Industry	LF-J5000A, LF-J7000A
Mitsubishi Electric	ME-5G2-A
NEC	N7925-81, ND3605-19, N5817-31
Nikkyo	NOL-642
NKK	N-556E, N-556ET, N-556W, N-556MP
Ricoh	RJ5330E

12" disk diameter

Cygnet Systems	1802
DSM	48
Hitachi	OL321-22/32
NEC	N7921
Sony	WDA 610

The libraries in this group are mainstream products for classical library uses in imaging and archiving systems. The 12" models are frequently used in multi-user systems because of their high storage capacities. The 5.25" libraries are often found in multiuser systems also, but many are being used in freestanding document image filing systems used for general office purposes and for technical documentation.

Market status

In 1992, shipments of optical libraries in this product group increased moderately to 2,651 units, a 13.2% increase from 1991. Revenues increased 1.1% to $64.7 million. Shipments of 5.25" units again exceeded shipments of 12" units, capturing 89.2% of worldwide shipments, up slightly from 1991.

19.5% of worldwide revenues were generated by 12" libraries as a result of higher average prices compared to 5.25" libraries, down slightly from 1991. With

the increase of 5.25" drive capacities this year, sales of drives in this product group are being siphoned away into the 1-39 cartridge group, and 5.25" libraries are displacing 12" libraries within this product group.

Marketing trends

In 1996, forecasted unit shipments are projected to grow to over 5,900 optical disk libraries for this product group. The 1996 balance between 12" and 5.25" drive usage will tilt ever more heavily in favor of 5.25" as high capacity 5.25" drive shipments ramp up.

The number of manufacturers of 12" libraries in this group will probably decline with time, but the number of 5.25" participants is expected to increase somewhat. It is also possible that there may be some 3.5" libraries in this product group within a few years, but the timing is too uncertain to forecast.

The larger customers for archival applications now appear to desire systems with larger on-line capacity, so interest in 12" write-once drive based libraries is shifting out of this group into libraries with capacities of 70 cartridges or more. Organizations which have lower interest in archival storage are expected to shift to 5.25" based systems with multifunction drives.

Only 29% of the 1992 shipments of libraries in this group involved write-once drives, and in 1996 only 13.1% of the units are projected to be equipped exclusively with write-once drives.

Applications

Archival storage and on-line retrieval of document images are the two primary application areas for these midrange libraries. Large financial institutions and government organizations are believed to be the most significant applications, followed by aerospace companies, large construction firms and geophysical exploration and production firms.

Dedicated office systems were the most significant 1992 application, followed by general purpose multiuser systems. Non-office and technical applications were third in importance. This pattern is expected to be maintained throughout the forecast period. A considerable percentage of the 5.25" libraries in this

category are used in technical design environments where they serve an engineering design team. Few libraries in this category will be used with personal computers because they are too expensive for most installations and the amount of data stored is more than a single user could reasonably use.

Technical trends

The most significant changes are expected in several areas: An increasing number of drives per library to increase on-line data availability, an increased capacity per drive, and increased availability of dual cartridge elevator pickers on libraries in this class. Libraries that can mix media types within one library, with the picker mechanism adaptable enough to route media to and from the appropriate drives are anticipated in the future. The Borett library, which appears in the DISK/TREND product group for libraries with over 70 disks, may be a precursor of similar capabilities in this product group.

Specialized internal controllers will be increasingly replaced by personal computer processors packaged for the application. The basic electronic modules of a personal computer are fast enough and powerful enough to perform the necessary functions, costs are low, and excellent software tools are available.

Forecasting assumptions

1. Archival applications will continue to favor write-once drives and media. Other applications will favor 5.25" rewritable or multifunction drive based optical libraries.
2. There are no immediate expectations in this product group for libraries using formats other than 12" and 5.25" format.
3. There will be no fundamental changes in technology affecting this group of libraries over the period of the forecast, although pickers capable of handling several types of media within one library are anticipated.
4. There will be continued erosion of growth in this product group by optical libraries with fewer or greater numbers of cartridges, although not enough to create negative growth.

TABLE 44

OPTICAL LIBRARIES, 40-69 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast							
	1993		1994		1995		1996			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	4.6	5.4	6.5	9.2	9.0	13.6	10.3	16.2	11.1	17.5
TOTAL U.S. REVENUES	4.6	5.4	6.5	9.2	9.0	13.6	10.3	16.2	11.1	17.5
Non-U.S. Manufacturers										
Captive	1.3	12.4	1.8	13.3	1.6	13.8	1.4	13.6	1.2	13.0
PCM/Reseller	4.6	5.9	5.2	6.8	5.5	7.6	5.9	8.2	6.2	8.7
OEM/Integrator	27.8	41.0	31.7	45.6	34.3	51.3	36.9	55.1	37.9	56.4
TOTAL NON-U.S. REVENUES	33.7	59.3	38.7	65.7	41.4	72.7	44.2	76.9	45.3	78.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	38.3	64.7	45.2	74.9	50.4	86.3	54.5	93.1	56.4	95.6
OEM Average Price ($000)		22.2		19.4		18.1		16.3		14.6

TABLE 45

OPTICAL LIBRARIES, 40-69 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992 Shipments		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	387	450	567	798	754	1,136	938	1,478	1,106	1,742
TOTAL U.S. NONCAPTIVE	387	450	567	798	754	1,136	938	1,478	1,106	1,742
TOTAL U.S. SHIPMENTS	387	450	567	798	754	1,136	938	1,478	1,106	1,742
Non-U.S. Manufacturers										
Captive	30	303	40	310	40	315	36	317	32	318
PCM/Reseller	174	254	217	320	267	395	317	472	361	542
OEM/Integrator	1,078	1,644	1,345	2,023	1,630	2,451	1,918	2,883	2,206	3,311
TOTAL NON-U.S. SHIPMENTS	1,282	2,201	1,602	2,653	1,937	3,161	2,271	3,672	2,599	4,171
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,669	2,651	2,169	3,451	2,691	4,297	3,209	5,150	3,705	5,913
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	3	6	5	10	8	14	11	19	15	25

TABLE 46

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues		Forecast							
			1993		1994		1995		1996	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
OEM/Integrator	--	5.4	--	9.2	--	13.6	--	16.2	--	17.5
TOTAL U.S. REVENUES	--	5.4	--	9.2	--	13.6	--	16.2	--	17.5
NON-U.S. MANUFACTURERS										
Captive	3.6	8.8	3.6	9.7	3.5	10.3	3.2	10.4	3.0	10.0
PCM/Reseller	--	5.9	--	6.8	--	7.6	--	8.2	--	8.7
OEM/Integrator	9.0	32.0	3.5	42.1	2.1	49.2	1.7	53.4	1.4	55.0
TOTAL NON-U.S. REVENUES	12.6	46.7	7.1	58.6	5.6	67.1	4.9	72.0	4.4	73.7
WORLDWIDE RECAP										
Captive	3.6	8.8	3.6	9.7	3.5	10.3	3.2	10.4	3.0	10.0
	--	-72.0%	--	+10.2%	-2.8%	+6.2%	-8.6%	+1.0%	-6.2%	-3.8%
PCM/Reseller	--	5.9	--	6.8	--	7.6	--	8.2	--	8.7
	--	+181.0%	--	+15.3%	--	+11.8%	--	+7.9%	--	+6.1%
OEM/Integrator	9.0	37.4	3.5	51.3	2.1	62.8	1.7	69.6	1.4	72.5
	-34.3%	+125.3%	-61.1%	+37.2%	-40.0%	+22.4%	-19.0%	+10.8%	-17.6%	+4.2%
Total Revenues	12.6	52.1	7.1	67.8	5.6	80.7	4.9	88.2	4.4	91.2
	-9.4%	+4.0%	-43.7%	+30.1%	-21.1%	+19.0%	-12.5%	+9.3%	-10.2%	+3.4%
ANNUAL SHARE, BY DIAMETER	19.5%	80.5%	9.5%	90.5%	6.5%	93.5%	5.3%	94.7%	4.6%	95.4%

Note: 12" libraries includes 14" libraries.

TABLE 47

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments		Forecast							
			1993		1994		1995		1996	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
OEM/Integrator	--	450	--	798	--	1,136	--	1,478	--	1,742
TOTAL U.S. SHIPMENTS	--	450	--	798	--	1,136	--	1,478	--	1,742
NON-U.S. MANUFACTURERS										
Captive	60	243	60	250	58	257	56	261	54	264
PCM/Reseller	--	254	--	320	--	395	--	472	--	542
OEM/Integrator	225	1,419	87	1,936	54	2,397	41	2,842	32	3,279
TOTAL NON-U.S. SHIPMENTS	285	1,916	147	2,506	112	3,049	97	3,575	86	4,085
WORLDWIDE RECAP										
Captive	60	243	60	250	58	257	56	261	54	264
	--	-77.0%	--	+2.9%	-3.3%	+2.8%	-3.4%	+1.6%	-3.6%	+1.1%
PCM/Reseller	--	254	--	320	--	395	--	472	--	542
	--	+108.2%	--	+26.0%	--	+23.4%	--	+19.5%	--	+14.8%
OEM/Integrator	225	1,869	87	2,734	54	3,533	41	4,320	32	5,021
	-24.5%	+117.3%	-61.3%	+46.3%	-37.9%	+29.2%	-24.1%	+22.3%	-22.0%	+16.2%
Total Shipments	285	2,366	147	3,304	112	4,185	97	5,053	86	5,827
	-5.9%	+16.1%	-48.4%	+39.6%	-23.8%	+26.7%	-13.4%	+20.7%	-11.3%	+15.3%
ANNUAL SHARE, BY DIAMETER	10.8%	89.2%	4.3%	95.7%	2.6%	97.4%	1.9%	98.1%	1.5%	98.5%

Note: 12" libraries includes 14" libraries.

TABLE 48

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1992 --Shipments--		Forecast							
			1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	--		--		--		--		--	
OEM/PCM Total	450.0		798.0		1,136.0		1,478.0		1,742.0	
Write-Once	--	--	--	--	--	--	--	--	--	--
Erasable	450.0	100.0%	798.0	100.0%	1,136.0	100.0%	1,478.0	100.0%	1,742.0	100.0%
Total U.S.	450.0		798.0		1,136.0		1,478.0		1,742.0	
Write-Once	--	--	--	--	--	--	--	--	--	--
Erasable	450.0	100.0%	798.0	100.0%	1,136.0	100.0%	1,478.0	100.0%	1,742.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	303.0		310.0		315.0		317.0		318.0	
Write-Once	128.0	42.2%	125.0	40.3%	120.0	38.1%	110.0	34.7%	100.0	31.4%
Erasable	175.0	57.8%	185.0	59.7%	195.0	61.9%	207.0	65.3%	218.0	68.6%
OEM/PCM Total	1,898.0		2,343.0		2,846.0		3,355.0		3,853.0	
Write-Once	640.0	33.7%	585.0	25.0%	610.0	21.4%	653.0	19.5%	674.0	17.5%
Erasable	1,258.0	66.3%	1,758.0	75.0%	2,236.0	78.6%	2,702.0	80.5%	3,179.0	82.5%
Total Non-U.S.	2,201.0		2,653.0		3,161.0		3,672.0		4,171.0	
Write-Once	768.0	34.9%	710.0	26.8%	730.0	23.1%	763.0	20.8%	774.0	18.6%
Erasable	1,433.0	65.1%	1,943.0	73.2%	2,431.0	76.9%	2,909.0	79.2%	3,397.0	81.4%
WORLDWIDE RECAP										
Total Worldwide Shipments	2,651.0		3,451.0		4,297.0		5,150.0		5,913.0	
	+13.2%		+30.1%		+24.5%		+19.8%		+14.8%	
Write-Once	768.0	29.0%	710.0	20.6%	730.0	17.0%	763.0	14.8%	774.0	13.1%
	-19.7%		-7.5%		+2.8%		+4.5%		+1.4%	
Erasable	1,883.0	71.0%	2,741.0	79.4%	3,567.0	83.0%	4,387.0	85.2%	5,139.0	86.9%
	+36.0%		+45.5%		+30.1%		+22.9%		+17.1%	

Notes: Percentage figures with plus/minus signs refer to year-to-year growth rates.

READ/WRITE OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

1993 DISK/TREND REPORT

READ/WRITE OPTICAL LIBRARIES
70 OR MORE CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Asaca	ADL-450
Borett Automation Technology	VLC
Document Imaging Systems	D75-1, D255-1, D510-2, D1050-2
Docupoint	DP 520
DSM	100, 2000, 5100, 5200, 5500, 6300
Fujitsu	F6445/A1, F6445/A2, F6445/A2X2
Hewlett-Packard	C1714M, C1715M
IBM	3995-023, 3995-132
Mitsubishi Electric	ME-5G2-B
NKK	N-5160ET, N-5160MP, N-5160MS

12" and 14" disk diameter

Borett Automation Technology	VLC
Cygnet Systems	1800
Eastman Kodak	6800 ADL
Filenet	OSAR models GTX, 144, 288, 340
Sony	WDA-E930

This group was pioneered by manufacturers of 12" libraries, which are typically used in large systems that manage image files for a complete business or major government department. Filenet started the 12" activity in this product group in 1985, and now battles with Cygnet for dominance. Sony entered the fray in 1992. 5.25" libraries are appearing in increasing numbers, and the number of competitors in this corner of the 5.25" arena is expected to continue to increase during the forecast period.

Market status

1992 unit shipments increased 141.4% to 1,318 units, the first time more than 1,000 units per year in this product group have been shipped. As in 1991, the majority of the increase was in 5.25" models, which accounted for over 71% of shipments. Shipments of 5.25" units grew almost 275%, while shipments of 12" units rose almost 28%. 1992 worldwide revenues gained 78.4% to reach the

$88.3 million mark. 78.5% of this product group's revenues were generated from sales in the U.S., and 91.2% of worldwide revenues were generated by U.S. manufacturers, the highest U.S. manufacturer revenue percentage among the library product groups, but down slightly from 1991.

Hewlett-Packard was the shipment leader for the group in 1992, followed by Cygnet and NKK. IBM, which uses Hewlett-Packard mechanisms in its library products was also a substantial market presence. Had IBM been manufacturing its own library mechanisms, it would have been the leading manufacturer. IBM's use of 5.25" technology for AS/400, RS/6000 and mainframe computers will influence the choices made by other system manufacturers and their customers and is expected to stimulate sales of 5.25" systems. Filenet and Cygnet dominate the 12"/14" segment, accounting together for more than three quarters of the large diameter library shipments.

70.3% of 1992 shipments went through the OEM/Integrator channel, up slightly from 1991. Captive shipments accounted for 18.9%. There is a low level of PCM/Reseller activity for the libraries in this group because the system integration and support requirements are very complex and the costs of the 12" libraries are a burden for the typical reseller. Reseller activity tends to concentrate in Europe where the typical reseller is more likely to be technically sophisticated and in the 5.25" subsystem area, regardless of location, where complexity is less and carrying costs are lower.

Non-U.S. manufacturers have increased their participation in this product group, but gaining share against the aggressive U.S. competitors will be difficult. The strongest challenge from non-U.S. firms is expected to be in the 5.25" optical library segment, where competition from NKK began in 1992.

It is also likely that the number of competitors in this product group will increase. The new entrants are most likely to specialize in libraries handling 5.25" disk cartridges.

Marketing trends

4,591 units are forecasted for 1996 shipment, with most of the growth being 5.25" units and most being consumed in the U.S. market. U.S. suppliers are

expected to remain predominant because of their very strong system support capabilities for larger computing systems. No 3.5" libraries in this product group are anticipated through 1996.

1996 revenue is expected to exceed $216 million, 70.3% of which is forecasted to be generated in the U.S. System size, in terms of the number of stored cartridges, is expected to increase, but the average price per system will decline throughout the forecast period, reflecting the increasing presence of the less expensive 5.25" systems in the product group. The availability of 1.3 gigabytes per side drives in 1995 will accelerate this trend.

12" libraries should be able to retain 19% of the unit shipments in 1996, but will account for 38.7% of 1996 revenue. The lower prices of the 5.25" libraries will produce a much stronger growth rate for 5.25" libraries than for 12" libraries throughout the forecast period.

Most 12" libraries will use write-once media. The 5.25" libraries are more likely to use erasable or multifunction drives. The emphasis on archival storage applications on large systems in this product group, the desire to retain compatibility with the installed base, and the desire of the archivist to minimize the number of media units all tend to favor the continued use of 12" write-once drives.

Libraries using rewritable disk drives are expected to increase their share of the market from 71.2% in 1992 to 80.3% in 1996. Most of the rewritable drives will be 5.25" diameter drives, but after 1993 the availability of rewritable 12" drives that have been designed for use in optical libraries is anticipated.

Slightly less than half of the libraries in this product group will be attached to multiuser micro or minicomputers and about a quarter will be attached to mainframes used as servers in 1996.

Applications

Financial and government institutions are, and will remain, the major users of optical libraries in this product group. It is possible that towards the end of the forecast period, optical library based mass storage systems designed to replace tape libraries for mainframe applications may appear in the market.

The IBM 3995 optical library introduced in 1991 (based on the Hewlett-Packard library) represents a near term response to customer pressures for a library and the competitive pressure of Storage Technology's model 4400 tape-based library system. The 3995 library is not the expected replacement for tape libraries, but IBM's 1992 announcement of support for the 3995 as a virtual 3390 disk subsystem under System Managed Storage is expected to significantly increase the appeal of the 3995 optical library. IBM has steadily increased the number of models available within the 3995 family and now offers them with interfaces to its mainframes as well as the AS/400, RS/6000 and local area networks.

Technical trends

The large libraries that have appeared so far have used X-Y positioners accessing multiple bays of disk cartridge storage cells. Some of the new 5.25" models (those of Document Image Storage and DSM, for instance) offer the buyer the ability to configure the library with almost any combination of drives and storage cells. These same systems also offer multiple independently actuated positioner mechanisms. Some library designers are attempting a silo design similar in concept to the tape cartridge library developed by Storage Technology. In Borett's unusual design, the use of an industrial robot permits mixing of various types of media within the library. The robotic mechanism serves a mix of optical and tape drives, and is capable of exchanging its picking mechanism on the fly, as necessary, to handle the selected type of cartridge.

5.25" drives with capacities of 2.6 gigabytes (1.3 gigabytes per side) are expected to appear within the forecast period, probably in 1995. As they appear, they will help 5.25" based optical libraries to compete more strongly against 12" drives, because fewer disk swaps will be required to support a given amount of stored data. 12" drive storage capabilities are also expected to increase, but by a lesser percentage and probably will be an advantage only in archival applications or in systems where multiple accesses for the same mounted data are likely to occur.

Modular systems are becoming increasingly prominent in this product class. Manufacturers including DISC, Docupoint, DSM and others offer a semi-custom configuration permitting a mix of drives and media that balance the need for

capacity and library performance. Customers can specify the number and location of drives and cartridge storage modules to optimize performance for their application.

Forecasting assumptions

1. Governments, financial institutions and other large users will continue to be the primary market for libraries in this product group.
2. 5.25", having become the dominant format, will retain that status. 12" is the only other format expected to be significant in the forecast period.
3. U.S. suppliers will continue to dominate this segment of the library market due to their experience and strength in system integration skills.
4. There will be no significant changes in basic technology affecting these libraries over the period of the forecast.
5. IBM's adoption of 5.25" library technology will continue to promote a shift from 12" to 5.25" technology in this product group. The appearance of higher capacity 5.25" drives will also contribute to this shift.
6. IBM support of the 3995 as a virtual 3390 is expected to increase demand for the 3995 and for other libraries in this product class if similar capabilities are provided for them.

TABLE 49

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1992 Revenues		Forecast 1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	27.2	32.1	30.9	37.4	32.7	40.9	35.1	44.7	36.1	46.9
PCM/Reseller	5.5	7.3	11.0	15.0	17.1	22.3	22.1	30.5	26.8	38.2
OEM/Integrator	31.8	41.1	42.2	55.7	51.2	68.6	58.2	78.8	62.9	85.7
TOTAL U.S. NONCAPTIVE	37.3	48.4	53.2	70.7	68.3	90.9	80.3	109.3	89.7	123.9
TOTAL U.S. REVENUES	64.5	80.5	84.1	108.1	101.0	131.8	115.4	154.0	125.8	170.8
Non-U.S. Manufacturers										
Captive	--	.4	--	.4	--	.4	--	.5	--	.5
PCM/Reseller	.2	.3	.4	.7	.5	.9	.6	1.1	.7	1.3
OEM/Integrator	4.6	7.1	9.4	15.9	14.3	25.5	19.4	34.6	25.9	43.9
TOTAL NON-U.S. REVENUES	4.8	7.8	9.8	17.0	14.8	26.8	20.0	36.2	26.6	45.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	69.3	88.3	93.9	125.1	115.8	158.6	135.4	190.2	152.4	216.5
OEM Average Price ($000)		52.1		48.9		46.8		44.0		40.9

TABLE 50

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1992		Forecast							
	Shipments		1993		1994		1995		1996	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	193	240	233	293	265	341	298	391	327	438
PCM/Reseller	101	135	219	298	364	475	502	694	653	930
OEM/Integrator	619	808	921	1,225	1,215	1,630	1,526	2,064	1,832	2,495
TOTAL U.S. SHIPMENTS	913	1,183	1,373	1,816	1,844	2,446	2,326	3,149	2,812	3,863
Non-U.S. Manufacturers										
Captive	--	10	--	10	--	11	--	12	--	13
PCM/Reseller	5	7	9	15	13	23	17	31	21	39
OEM/Integrator	65	118	131	240	200	379	274	516	376	676
TOTAL NON-U.S. SHIPMENTS	70	135	140	265	213	413	291	559	397	728
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	983	1,318	1,513	2,081	2,057	2,859	2,617	3,708	3,209	4,591
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	1	2	3	4	5	7	8	11	11	15

TABLE 51

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1992 Revenues		Forecast							
	1993		1994		1995		1996			
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	24.4	7.7	26.3	11.1	27.4	13.5	28.2	16.5	28.1	18.8
PCM/Reseller	--	7.3	--	15.0	--	22.3	--	30.5	--	38.2
OEM/Integrator	13.0	28.1	14.0	41.7	15.1	53.5	17.1	61.7	19.3	66.4
TOTAL U.S. REVENUES	37.4	43.1	40.3	67.8	42.5	89.3	45.3	108.7	47.4	123.4
NON-U.S. MANUFACTURERS										
Captive	--	.4	--	.4	--	.4	--	.5	--	.5
PCM/Reseller	--	.3	--	.7	--	.9	--	1.1	--	1.3
OEM/Integrator	3.8	3.3	11.1	4.8	19.4	6.1	27.6	7.0	36.3	7.6
TOTAL NON-U.S. REVENUES	3.8	4.0	11.1	5.9	19.4	7.4	27.6	8.6	36.3	9.4
WORLDWIDE RECAP										
Captive	24.4 -6.5%	8.1 +305.0%	26.3 +7.8%	11.5 +42.0%	27.4 +4.2%	13.9 +20.9%	28.2 +2.9%	17.0 +22.3%	28.1 -.4%	19.3 +13.5%
PCM/Reseller	-- --	7.6 --	-- --	15.7 +106.6%	-- --	23.2 +47.8%	-- --	31.6 +36.2%	-- --	39.5 +25.0%
OEM/Integrator	16.8 +66.3%	31.4 +190.7%	25.1 +49.4%	46.5 +48.1%	34.5 +37.5%	59.6 +28.2%	44.7 +29.6%	68.7 +15.3%	55.6 +24.4%	74.0 +7.7%
Total Revenues	41.2 +12.6%	47.1 +265.1%	51.4 +24.8%	73.7 +56.5%	61.9 +20.4%	96.7 +31.2%	72.9 +17.8%	117.3 +21.3%	83.7 +14.8%	132.8 +13.2%
ANNUAL SHARE, BY DIAMETER	46.7%	53.3%	41.1%	58.9%	39.0%	61.0%	38.3%	61.7%	38.7%	61.3%

Note: 12" libraries include 14" libraries.

TABLE 52

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1992 Shipments		Forecast							
			1993		1994		1995		1996	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	145	95	146	147	148	193	149	242	148	290
PCM/Reseller	--	135	--	298	--	475	--	694	--	930
OEM/Integrator	192	616	208	1,017	228	1,402	263	1,801	302	2,193
TOTAL U.S. SHIPMENTS	337	846	354	1,462	376	2,070	412	2,737	450	3,413
NON-U.S. MANUFACTURERS										
Captive	--	10	--	10	--	11	--	12	--	13
PCM/Reseller	--	7	--	15	--	23	--	31	--	39
OEM/Integrator	40	78	120	120	214	165	310	206	423	253
TOTAL NON-U.S. SHIPMENTS	40	95	120	145	214	199	310	249	423	305
WORLDWIDE RECAP										
Captive	145	105	146	157	148	204	149	254	148	303
	+2.8%	+262.1%	+.7%	+49.5%	+1.4%	+29.9%	+.7%	+24.5%	-.7%	+19.3%
PCM/Reseller	--	142	--	313	--	498	--	725	--	969
	--	--	--	+120.4%	--	+59.1%	--	+45.6%	--	+33.7%
OEM/Integrator	232	694	328	1,137	442	1,567	573	2,007	725	2,446
	+54.7%	+218.3%	+41.4%	+63.8%	+34.8%	+37.8%	+29.6%	+28.1%	+26.5%	+21.9%
Total Shipments	377	941	474	1,607	590	2,269	722	2,986	873	3,718
	+27.8%	+274.9%	+25.7%	+70.8%	+24.5%	+41.2%	+22.4%	+31.6%	+20.9%	+24.5%
ANNUAL SHARE, BY DIAMETER	28.6%	71.4%	22.8%	77.2%	20.6%	79.4%	19.5%	80.5%	19.0%	81.0%

Note: 12" libraries include 14" libraries.

TABLE 53

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1992 --Shipments--		Forecast							
			1993		1994		1995		1996	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	240.0		293.0		341.0		391.0		438.0	
Write-Once	145.0	60.5%	146.0	49.8%	148.0	43.4%	149.0	38.1%	148.0	33.8%
Erasable	95.0	39.5%	147.0	50.2%	193.0	56.6%	242.0	61.9%	290.0	66.2%
OEM/PCM Total	943.0		1,523.0		2,105.0		2,758.0		3,425.0	
Write-Once	194.0	20.6%	226.0	14.8%	250.0	11.9%	289.0	10.5%	332.0	9.7%
Erasable	749.0	79.4%	1,297.0	85.2%	1,855.0	88.1%	2,469.0	89.5%	3,093.0	90.3%
Total U.S.	1,183.0		1,816.0		2,446.0		3,149.0		3,863.0	
Write-Once	339.0	28.7%	372.0	20.5%	398.0	16.3%	438.0	13.9%	480.0	12.4%
Erasable	844.0	71.3%	1,444.0	79.5%	2,048.0	83.7%	2,711.0	86.1%	3,383.0	87.6%
NON-U.S. MANUFACTURERS										
Captive Total	10.0		10.0		11.0		12.0		13.0	
Write-Once	--	--	--	--	--	--	--	--	--	--
Erasable	10.0	100.0%	10.0	100.0%	11.0	100.0%	12.0	100.0%	13.0	100.0%
OEM/PCM Total	125.0		255.0		402.0		547.0		715.0	
Write-Once	40.0	32.0%	120.0	47.1%	214.0	53.3%	310.0	56.8%	423.0	59.3%
Erasable	85.0	68.0%	135.0	52.9%	188.0	46.7%	237.0	43.2%	292.0	40.7%
Total Non-U.S.	135.0		265.0		413.0		559.0		728.0	
Write-Once	40.0	29.6%	120.0	45.3%	214.0	51.9%	310.0	55.6%	423.0	58.2%
Erasable	95.0	70.4%	145.0	54.7%	199.0	48.1%	249.0	44.4%	305.0	41.8%
WORLDWIDE RECAP										
Total Worldwide Shipments	1,318.0		2,081.0		2,859.0		3,708.0		4,591.0	
	+141.3%		+57.8%		+37.3%		+29.7%		+23.8%	
Write-Once	379.0	28.8%	492.0	23.6%	612.0	21.4%	748.0	20.2%	903.0	19.7%
	+16.2%		+29.8%		+24.3%		+22.2%		+20.7%	
Erasable	939.0	71.2%	1,589.0	76.4%	2,247.0	78.6%	2,960.0	79.8%	3,688.0	80.3%
	+326.8%		+69.2%		+41.4%		+31.7%		+24.5%	

Notes: Percentage figures with plus/minus signs refer to year-to-year growth rates.

OPTICAL DISK DRIVE SPECIFICATIONS

1993 DISK/TREND REPORT

OPTICAL DISK DRIVE SPECIFICATIONS

Coverage: The following pages list optical disk drives intended for computer data storage which are now announced or in new production. In a few cases, products are listed for which only preliminary announcements have been made because they are judged to be significant indicators of industry direction in the production period shown.

Recording medium: The composition of the active layer of optical media is the one described by the drive manufacturer. Formulations of other manufacturers may not operate properly. Recording formats also differ, and for many products announced to date, recorded media is generally not interchangeable between systems. Where manufacturers specify that more than one type of media is usable, media type is indicated as "Various".

Operating mode: Rewritable (erasable) drives are indicated on the line describing the operating mode, with the technology type in parentheses. For multifunction drives, an abbreviated form is used: e.g. "Wr. Once,Rewrit". Where the drive is a magneto-optic type and supports multifunctionality using MO-WORM media, the designation "Rewritable-(MF)" is used.

Interface: Specific interfaces are listed for most of the drives. The abbreviation "PC" means the IBM PC/XT or PC/AT interface.

Speed control: Two abbreviations are used:

CAV = constant angular velocity.
CLV = constant linear velocity.

Capacities: Capacities are listed as "U" for unformatted and "F" for formatted. For optical drives that can access only one side of the media, the capacity given is in terms of one side, even if the drive uses two-sided media. As optical media is preformatted, the capacity given is the formatted capacity. Track capacity in CLV drives is variable, so this parameter is given only for CAV drives. For CD-ROM drives, the capacity given is the mode 1 capacity.

Servo type: Optical drive servo types are noted as:

Continuous: Continuous composite servo format
Sampled: Sampled servo format

Positioner type: Many optical disk drives have multistage head positioning systems. A coarse movement positions the head in the vicinity of the track to be located. A fine, or vernier, actuator then moves the head to the desired track. Where appropriate, the abbreviation "Crs" is used for "coarse".

Average access time: The average access time is the sum of average positioning time plus rotational latency. Optical drive manufacturers, and especially CD-ROM manufacturers are inconsistent in the use of this definition, so while the values given for these specifications are believed to be accurate, they should be accepted with caution and the drive manufacturer contacted for details.

Data transfer rate: The data transfer rate given is the rate from the disk during reading. If more than one rate is given:

If separated by a hyphen, the figures represent the drive's minimum and maximum transfer rates.

If separated by a slash, the figures represent the rates obtained when the drive operates at more than one RPM or offers more than one capacity.

Figures followed by the abbreviations "asynch." or "synch." are transfer rates between the drive and the host computer.

CD-ROM drives may have rates specified for multiple operating modes.

Accuracy: All of the information in this section has been checked for accuracy. Due to rapid changes in the industry, report users may need to make verbal inquiries of manufacturers for updates. Where data is not specified or otherwise unavailable, the abbreviation "NS" is used. Where a specification is not applicable, the abbreviation "N/A" appears.

1993 DISK/TREND optical disk product groups

For the 1993 report, products are classified in six groups.

Optical drives:

Group 10: CD-ROM optical disk drives.
Group 11: Read/write disk drives, less than 1 gigabyte.
Group 12: Read/write disk drives, more than 1 gigabyte.

Optical libraries:

Group 50: CD-ROM optical libraries.
Group 51: Optical libraries with 1 to 39 cartridge capacity.
Group 52: Optical libraries with 40 to 69 cartridge capacity.
Group 53: Optical libraries with 70 or over cartridge capacity.

See the following specification section for optical library data.

MANUFACTURER	ASACA	ATG GIGADISC	ATG GIGADISC	ATG GIGADISC	ATG GIGADISC
DRIVE	AMD-1340NS	GD 1002	GD 6000	GD 6001	GD 9001
DISK/TREND GROUP	11	12	12	12	12
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	300 mm	300 mm	300 mm	300 mm
Recording medium	Tb-Fe-Co	Au-Cr-Polymer	Au-Cr-Polymer	Au-Cr-Polymer	Au-Cr-Polymer
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Write Once	Write Once	Write Once
Interface	SCSI-2	SCSI	SCSI	SCSI	SCSI, SCSI-2
Speed control	CAV	CAV	CAV	CAV	MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 598	F: 1,000	F: 3,200	F: 3,200	F: 4,500
Capacity per track (Bytes)	F: N/A	F: 25,600	F: 52,428	F: 52,428	*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10400	40000	62500	62500	82000
Track density (TPI)	16925	15200	25400	25400	25400
Maximum linear density (BPI)	36000	14514	28200	28200	25400
Rotational speed (RPM)	3000	1121.5	1143	1143	914
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Dual Lens Actuator	Crs: Voice Coil Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.
Servo type	Continuous	Sampled	Sampled	Sampled	Sampled
Average positioning time (msec)	120	110	90	90	90
Within fine band (msec)	20	8	0.8	0.8	NS
Fine band capacity (Mbytes)	25 tracks	78	16	16	NS
Average rotational delay (msec)	10	26.7	26.2	26.2	33
Average access time (msec)	130	136.7	116.2	116.2	123
Data transfer rate (KBytes/sec)	12240	480	1000	1000	1000
FIRST CUSTOMER SHIPMENT	3/93	2Q88	3Q89	4Q90	1991
COMMENTS	Proprietary format			Differs from GD 6000 in the cartridge (single operation loading)	*Varies by zone Can read GD 6000 disks

MANUFACTURER	ATG GIGADISC	CANON	CANON	CD-ROM, Inc.	CD-ROM, Inc.
DRIVE	GD 9001/S	MO-5001S	OM-500D	CRI 1000e	CRI 1000i
DISK/TREND GROUP	12	11	11	10	10
MARKET	OEM	Captive, OEM	Captive, OEM	PCM	PCM
MEDIA: Nominal disk diameter	300 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	Au-Cr-Polymer	Tb-Fe-Co	Bilayer RE-TM	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Rewritable-(MO)	Rewritable-(MO)	Read Only	Read Only
Interface	SCSI, SCSI-2	SCSI	Modified ESDI	SCSI	SCSI
Speed control	MCAV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 5,100	F: 256	F: 256	F: 540	F: 540
Capacity per track (Bytes)	*	F: 16,384	F: 16,384	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	82000	15728	15728	20750	20750
Track density (TPI)	25400	15875	15875	15875	15875
Maximum linear density (BPI)	25400	21082	21082	27600	27600
Rotational speed (RPM)	914	3000	3000	550-200	550-200
PERFORMANCE					
Positioner type	Crs: Linear Motor Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Lead Screw Fine: Lens Actuator	Crs: Lead Screw Fine: Lens Actuator
Servo type	Sampled	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	90	80	80	365	365
Within fine band (msec)	NS	18	18	--	--
Fine band capacity (Mbytes)	NS	1	1	--	--
Average rotational delay (msec)	33	10	10	110	110
Average access time (msec)	123	90	90	475	475
Data transfer rate (KBytes/sec)	1000	1138	1138	153.6 Mode 1 175.2 Mode 2	153.6 Mode 1 175.2 Mode 2
FIRST CUSTOMER SHIPMENT	2Q92	3/90	4Q88		
COMMENTS	*Varies by zone Can read GD 6000 disks and read/write GD 9001	SCSI controller available. Exchange coupled MO media. External mount	SCSI controller available Exchange coupled MO media	41.3 mm high 64 KB buffer External mount	41.3 mm high 64 KB buffer

MANUFACTURER	CD-ROM, Inc.	CD-ROM, Inc.	CHINON	CHINON	CHINON
DRIVE	CRI 1010e	CRI 1010i	CDA-431 CDC-431 CDN-431 CDS-431 CDX-431	CDA-435 CDC-435 CDS-435 CDX-435	CDA-535 CDC-535 CDS-535 CDX-535
DISK/TREND GROUP	10	10	10	10	10
MARKET	PCM	PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	SCSI	SCSI	SCSI	SCSI	SCSI-2
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 650	F: 650	F: 650
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	550-200	550-200	200-530	200-530	400-1060
PERFORMANCE					
Positioner type	Crs: Lead Screw Fine: Lens Actuator	Crs: Lead Screw Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	365	365	350	260	230
Within fine band (msec)	--	--	N/A	N/A	N/A
Fine band capacity (Mbytes)	--	--	N/A	N/A	N/A
Average rotational delay (msec)	110	110	110	110	55
Average access time (msec)	475	475	460	370	285
Data transfer rate (KBytes/sec)	153.6 Mode 1 175.2 Mode 2	153.6 Mode 1 175.2 Mode 2	153.6	153.6	307.2
FIRST CUSTOMER SHIPMENT			1Q90	1Q92	1Q93
COMMENTS	External mount Soft audio	41.3 mm high 64 KB buffer Soft audio	41.3 mm high. External mount, except CDS-431. Audio output. Motorized loading.	41.3 mm high 64 KB buffer Motorized loading	41.3 mm high CDA is for Mac. CDX is external mount. 256 KB buffer. Multisession.

MANUFACTURER	CHINON	CHINON	CHINON	CHINON	EASTMAN KODAK
DRIVE	CDS-355 CDX-355	CDS-525	MO100	MO300	6800
DISK/TREND GROUP	10	10	11	11	12
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Nominal disk diameter	80 mm	120 mm	86 mm	86 mm	14"
Recording medium	Aluminum	Aluminum	RE-TM Alloy	RE-TM Alloy	Phase Change
Track format	Spiral	Spiral	Spiral	Spiral	Spiral (Zone)
DRIVE: Operating mode	Read Only	Read Only	Rewritable-(MO)	Rewritable-(MO)	Write Once
Interface	SCSI-2	IDE	SCSI-2	SCSI-2	SCSI
Speed control	CLV	CLV	CAV	CAV	MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 200	F: 650	F: 128	F: 128	F: 5,100
Capacity per track (Bytes)	F: N/A	F: N/A	F:	F:	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	10000	10000	87354
Track density (TPI)	15875	15875	15875	15875	21160
Maximum linear density (BPI)	27600	27600	24440	24440	21000
Rotational speed (RPM)	200-320	200-1060	1800	3000	786-1632
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Sampled
Average positioning time (msec)	1390	435	60	45	500
Within fine band (msec)	--	N/A			100
Fine band capacity (Mbytes)	--	N/A			N/A
Average rotational delay (msec)	110	55	16.6	10	27
Average access time (msec)	1500	490	76.6	55	527
Data transfer rate (KBytes/sec)	153.6	307.2	384	625	1000
FIRST CUSTOMER SHIPMENT	1993	4Q93	1Q93	1Q93	4Q88
COMMENTS	41.3 mm high CDX is external mount 32 KB buffer	41.3 mm high 64 KB buffer	41.3 mm high 64 KB buffer	41.3 mm high 256 KB buffer	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.
DRIVE	M2507B	M2511A DynaMO	F6443	GCD-R300B	GCD-R300S
DISK/TREND GROUP	11	11	12	10	10
MARKET	Captive, OEM	Captive, OEM	Captive	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	86 mm	200 mm	120 mm	120 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	Tb-Fe-Co	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Read Only	Read Only
Interface	SCSI-2	SCSI-2	Modified SMD	SCSI-2	SCSI-2
Speed control	CAV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 326.4	F: 128	F: 8,900	F: 690	F: 690
Capacity per track (Bytes)	F: 17,408	F: 12,800	F: 24,576	F: N/A	F: N/A
Data surfaces per spindle	1	1	16	1	1
Tracks per surface	18751	10000	23640	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	24923	24400	19098	27600	27600
Rotational speed (RPM)	5400	3600	1800	535-200	535-200
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: Fine:	Crs: Fine:
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35	30	200*	320	320
Within fine band (msec)	NS	1	NS	N/A	N/A
Fine band capacity (Mbytes)	NS	1.208	NS	N/A	N/A
Average rotational delay (msec)	5.6	8.3	16.6	110	110
Average access time (msec)	40.6	38.3	216.6	440	440
Data transfer rate (KBytes/sec)	2080 4100 synch.	1090 4000 synch.	979	153.6	153.6
FIRST CUSTOMER SHIPMENT	6/92	1992	6/89	5/93	5/93
COMMENTS	82 mm high Direct overwrite, 3 beam head. Sold in Japan	25.4 mm high DynaMO is external subsystem. 246 read cache	8 fixed disks per spindle. 2 actuators, 4 heads/spindle. *Media to media seek is 5 sec.	Internal mount	External mount

MANUFACTURER	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	GCD-R400B	GDI-11	C1300T	C1716A/M	C1716C
DISK/TREND GROUP	10	10	11	11	11
MARKET	OEM	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	130 mm
Recording medium	Aluminum	Aluminum	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Interface	PC AT	Serial	SCSI-2	SCSI	SCSI-2
Speed control	CLV	CLV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 690	F: 540	F: 650	F: 325	F: 325
Capacity per track (Bytes)	F: N/A	F: N/A	F: 17,408	F: 17,408	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	21600*	18751	18751
Track density (TPI)	15875	15875	18273	15875	15875
Maximum linear density (BPI)	27600	27600	29540	24902	24902
Rotational speed (RPM)	535-200	500-200	2400	2400	3600
PERFORMANCE					
Positioner type	Crs: Fine:	Crs: Rotary Galvonometer Fine:	Crs: Linear, Voice Coil Fine: NS	Crs: Linear, Voice Coil Fine: NS	Crs: Linear, Voice Coil Fine: NS
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	340	800	23.5	95	27
Within fine band (msec)	N/A	N/A	4	22	8
Fine band capacity (Mbytes)	N/A	N/A	2.2	2.2	2.2
Average rotational delay (msec)	110	110	12.5	12.5	8.3
Average access time (msec)	450	910	36	107.5	35.3
Data transfer rate (KBytes/sec)	153.6	153.6 Mode 1 175.2 Mode 2	5000 synch. 1600 asynch.	680	1000
FIRST CUSTOMER SHIPMENT	3Q93		2Q93	2Q89	1Q92
COMMENTS		CDI player Preliminary specification	External version of C1716T *37600 logical tracks	MO WORM Single-ended interface	MO WORM DSP Servo

MANUFACTURER	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	C1716T	CDR 1700S	CDR 1750S	CDR 1800S	CDR 1850S
DISK/TREND GROUP	11	10	10	10	10
MARKET	Captive,OEM,PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Wr.Once,Rewrit.	Read Only	Read Only	Read Only	Read Only
Interface	SCSI-2	Proprietary	SCSI	Proprietary	SCSI-2
Speed control	CAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 682	F: 682	F: 682	F: 682
Capacity per track (Bytes)	F: 17,408	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	20750	20750	20750	20750
Track density (TPI)	18273	15875	15875	15875	15875
Maximum linear density (BPI)	29540	27600	27600	27600	27600
Rotational speed (RPM)	2400	530-200	530-200	530-200	530-200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: NS	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	23.5	320	320	170	170
Within fine band (msec)	4	NS	N/A	N/A	N/A
Fine band capacity (Mbytes)	2.2	NS	N/A	N/A	N/A
Average rotational delay (msec)	12.5	110	110	130	130
Average access time (msec)	36	430	430	300	300
Data transfer rate (KBytes/sec)	5000 synch. 1600 asynch.	153.6	153.6	153.6	153.6
FIRST CUSTOMER SHIPMENT	2Q93	2Q91	10/91		
COMMENTS	MO WORM. DSP servo. Backward compat *37600 logical tracks. 512 KB buffer.	72 mm high External mount	72 mm high External mount		

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	CDR 1900S	CDR 3700	CDR 3750	CDR 5150	CDR 6700
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	Proprietary	Proprietary	SCSI-2	SCSI-2	Proprietary
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 682	F: 682	F: 682	F: 682
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	530-200	530-200	530-200	1060-400
PERFORMANCE					
Positioner type	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	190	300	300	300	190
Within fine band (msec)	N/A	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	N/A	N/A	N/A	N/A	N/A
Average rotational delay (msec)	70	110	110	110	70
Average access time (msec)	260	410	410	410	260
Data transfer rate (KBytes/sec)	307.2	153.6	153.6	153.6	307.2
FIRST CUSTOMER SHIPMENT		2Q92	2Q92	3Q92	
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high Can expand compressed data Internal Kanji ROM	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HONEYWELL
DRIVE	OD 101-1	OD 112-1	OD 301A-1	OD 321-1 OD 321-2	AN/MU-928
DISK/TREND GROUP	11	11	12	12	11
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	300 mm	300 mm	130 mm
Recording medium	Te Alloy	Tb-Fe-Co	Te Alloy	Te Alloy	Te Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Concentric
DRIVE: Operating mode	Write Once	Rewritable-(MO)	Write Once	Write Once	Write Once
Interface	SCSI	SCSI	SCSI, GPIB, SMD	SCSI	Modified SCSI
Speed control	CAV	CAV	CAV	MCAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 300	F: 322	F: 1,310	F: 3,500	F: 260
Capacity per track (Bytes)	F: 16,400	F: 17,408	F: 31,700	F: N/A	F: 20,480
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18624	18751	41300	48035	12695
Track density (TPI)	16000	16000	16000	17000	NS
Maximum linear density (BPI)	24000	24000	19500	33200	NS
Rotational speed (RPM)	1800	2400	600	1000	1800
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Stepping Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Sector
Average positioning time (msec)	93	62.5	200	120	125
Within fine band (msec)	NS	NS	NS		NS
Fine band capacity (Mbytes)	NS	NS	NS		NS
Average rotational delay (msec)	16.7	12.5	50	30	17
Average access time (msec)	109.7	75	250	150	142
Data transfer rate (KBytes/sec)	690	925	440	1160-2220	562
FIRST CUSTOMER SHIPMENT	2Q87	7/89	3Q85	1Q91	2Q89
COMMENTS		ISO standard		Pit edge recording. Glass substrate 321-2 used in libraries	Embedded controller Militarized

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	1295	MD 3125B	3431	0632-C1X	0632-C2X
DISK/TREND GROUP	11	11	11	11	11
MARKET	Captive	OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	86 mm	86 mm	130 mm	130 mm	130 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Banded spiral
DRIVE: Operating mode	Rd.Only,Rewrit.	Rd.Only,Rewrit.	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
Speed control	CAV	CAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 127/122	F: 127/122	F: 595/650*	F: 297.5/325	F: 595/650*
Capacity per track (Bytes)	F:12,700/12,200	F:12,700/12,200	F: 17,408	F: 17,408	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	10000	18751	18751	21600**
Track density (TPI)	15900	15900	15900	15900	18273
Maximum linear density (BPI)	24400	24400	24900	24900	29540
Rotational speed (RPM)	1800	3000	2400	2400	2400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	40	40	70	70	55
Within fine band (msec)	--	--			
Fine band capacity (Mbytes)	--	--			
Average rotational delay (msec)	10	10	12.5	12.5	12.5
Average access time (msec)	50	50	82.5	82.5	67.5
Data transfer rate (KBytes/sec)	625 4000 synch.	625 4000 synch.	620/680* 4000 synch.	620/680* 4000 synch.	1160/1272* 4000 synch.
FIRST CUSTOMER SHIPMENT	3Q92	3Q92	1Q93	3Q92	2Q93
COMMENTS	41.3 mm high 122 MB with read only media PS/2 series. P-ROM support.	41.3 mm high 122 MB with read only media P-ROM support	*512/1024 bytes per sector For Micro-channel systems	*512/1024 bytes per sector	*512/1024 bytes per sector **37600 logical tracks

MANUFACTURER	IBM	JVC	KAWASAKI STEEL	KYOCERA	LASER MAGNETIC STORAGE
DRIVE	7209	XR-W1001	KL1200S	DI-J43000	CM 205 CM 225
DISK/TREND GROUP	11	11	11	10	10
MARKET	Captive, OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	130 mm	120 mm	130 mm	120 mm	120 mm
Recording medium	RE-TM Alloy	Organic Dye	Te Alloy	Aluminum	Aluminum
Track format	Spiral	Spiral	Concentric	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Write Once	Read Only	Read Only
Interface	SCSI	SCSI	SCSI, PC	Proprietary	PC AT, Prop.
Speed control	CAV	CLV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 595	F: 580	F: 630	F: 680	F: 553
Capacity per track (Bytes)	F: 17,408	F: N/A	F: 20,480	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18751	20750	31500	20750	20750
Track density (TPI)	15900	15875	36000 max.	15875	15875
Maximum linear density (BPI)	24900	27600	27000 max.	27600	27600
Rotational speed (RPM)	2400	530-200	1800	500-200	500-200
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine:	Crs: Stepping Motor Fine: Galvonom.	Crs: DC Motor Fine: Lens Actuator	Crs: Fine:
Servo type	Continuous	Continuous	Sampled	Continuous	Continuous
Average positioning time (msec)	70	300	90	2000	265
Within fine band (msec)		NS	8	NA	--
Fine band capacity (Mbytes)		NS	4	NA	--
Average rotational delay (msec)	12.5	110	16.7	110	110
Average access time (msec)	82.5	410	106.7	2110	375
Data transfer rate (KBytes/sec)	620 4000 synch.	153.6	600	172	153.6
FIRST CUSTOMER SHIPMENT	4Q92	4/92	3Q89	7/93	1992
COMMENTS	For RS6000	41.3 mm high Embedded SCSI	Grooveless tracking system	CD-I player For business market only	41.3 mm high CM 225 is external mount Audio output

MANUFACTURER	LASER MAGNETIC STORAGE	LASER MAGNETIC STORAGE	LASER MAGNETIC STORAGE	LASER MAGNETIC STORAGE	LASER MAGNETIC STORAGE
DRIVE	CM 206	CM 214 CM 234	CM 215	510	LD 4100
DISK/TREND GROUP	10	10	10	11	12
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	12"
Recording medium	Aluminum	Aluminum	Aluminum	Te Alloy	Te Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Write Once	Write Once
Interface	SCSI-2	PC AT, Prop.	PC AT	SCSI	SCSI-2
Speed control	CLV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 553 Mode 1 F: 635 Mode 2	F: 553	F: 553 Mode 1 F: 635 Mode 2	F: 326.5	F: 5,600
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 16,384	F: 49,808
Data surfaces per spindle	1	1	1	1	2
Tracks per surface	20750	20750	20750	19928	57301
Track density (TPI)	15875	15875	15875	NS	16925-23132
Maximum linear density (BPI)	27600	27600	27600	NS	NS
Rotational speed (RPM)	500-200	500-200	1000-400	2160	855
PERFORMANCE					
Positioner type	Crs: Fine:	Crs: Fine:	Crs: Fine:	Linear, Voice Coil	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Sampled	Sampled
Average positioning time (msec)	350	265	360	61.3	80
Within fine band (msec)	NS	--	NS	N/A	NS
Fine band capacity (Mbytes)	NS	--	NS	N/A	NS
Average rotational delay (msec)	110	110	55	13.7	35
Average access time (msec)	460	375	410	75	130*
Data transfer rate (KBytes/sec)	307.2 Mode 1 352.8 Mode 2	153.6	153.6 Mode 1 176.4 Mode 2	590	700
FIRST CUSTOMER SHIPMENT	1993	1992	1992	4Q88	2Q90
COMMENTS	41.3 mm high. Tray loading. 64 KB buffer. Multisession, XA support.	41.3 mm high CM 234 is external mount	41.3 mm high. Tray loading. 64 KB buffer. Multisession, XA support.		*Includes command latency Has Direct Read During Write

MANUFACTURER	LASERBYTE	LITERAL	LITERAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LB3128	525 GB+ 525 GBX2+	I-525 MF S-525 MF	CR-501B CR-501S	CR-503
DISK/TREND GROUP	11	11	11	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	86 mm	130 mm	130 mm	120 mm	120 mm/80 mm
Recording medium	RE-TM Alloy	Te Alloy	TeX/Tb-Fe-Co	Aluminum	Aluminum
Track format	Spiral	Concentric	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Wr.Once/Rewrit.	Read Only	Read Only
Interface	SCSI, SCSI-2	SCSI-2	SCSI	SCSI	SCSI-2
Speed control	CAV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 640	F: 326.4	F: 682	F: 682
Capacity per track (Bytes)	F: 12,800	F: 20,000	F: 17,920	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	32000	20000	20750	20750
Track density (TPI)	15900	35000	16900	15875	15875
Maximum linear density (BPI)	24400	32000	17662	27600	27600
Rotational speed (RPM)	3600	1800	1800	530-200	1060-400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Galvonom.	Crs: DC Motor, Rack & Pinion Fine: Lens Actuator	Crs: DC Motor Lead Screw Fine: Lens Actuator
Servo type	Continuous	Sector	Sampled	Continuous	Continuous
Average positioning time (msec)	28	90	53	390	265
Within fine band (msec)	NS	8	NS	N/A	--
Fine band capacity (Mbytes)	NS	4	NS	N/A	--
Average rotational delay (msec)	8.3	16.7	16.7	110	55
Average access time (msec)	36.3	106.7	69.7	500	320
Data transfer rate (KBytes/sec)	768	812.5	475	153.6	307.2
FIRST CUSTOMER SHIPMENT	4Q93	4/88	2Q91	1Q90	2Q90
COMMENTS	41.3 mm high 256K-1MB buffer P-ROM and CD-ROM support	525 GBX2+ is external mount; dual drive available	Pioneer mechanism	41.3 mm high S is external mount Embedded SCSI	41.3 mm high 256 KB buffer. Tray loading. PCD, MPC, XA, multisession

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	CR-521B CR-521S	CR-532	CR-533	CR-563	LK-MC501B LK-MC501S
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm/80 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	PC AT	SCSI, SCSI-2	SCSI, SCSI-2	PC AT	SCSI
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 682	F: 682	F: 682	F: 682
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	530-200	530-200	1060-400	1060-400	530-200
PERFORMANCE					
Positioner type	Crs: DC Motor, Rack & Pinion Fine: Lens Actuator	Crs: DC Motor Rack & Pinion Fine: Lens Actuator	Crs: DC Motor Rack & Pinion Fine: Lens Actuator	Crs: DC Motor Lead Screw Fine: Lens Actuator	Crs: DC Motor, Rack & Pinion Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	390	290	310	265	390
Within fine band (msec)	N/A	--	--	--	N/A
Fine band capacity (Mbytes)	N/A		--	--	N/A
Average rotational delay (msec)	110	110	55	55	110
Average access time (msec)	500	400	365	320	500
Data transfer rate (KBytes/sec)	153.6	153.6	307.2	307.2	153.6
FIRST CUSTOMER SHIPMENT	1989	2Q93	2Q93	2Q93	6/91
COMMENTS	41.3 mm high S is external mount Embedded AT	41.3 mm high 128 KB buffer 256 KB option	41.3 mm high 128 KB buffer 256 KB option	41.3 mm high 64 KB buffer. Tray loading. PCD, MPC, XA, multisession	41.3 mm high S is external mount Embedded SCSI

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LK-MC521B LK-MC521S	LF-3000E LF-3002 LF-3004 LF-3090	LF-3100 LF-3104	LF-5010 LF-5012 LF-5014 LF-5110 LF-5210	LF-7010 LF-7014 LF-7110
DISK/TREND GROUP	10	11	11	11	11
MARKET	Captive, OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	86 mm	86 mm	130 mm	130 mm
Recording medium	Aluminum	Tb-Fe-Co	Tb-Fe-Co	Te-Ox	Ge-Tb-Se
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Rewritable-(MO)	Rewritable-(MO)	Write Once-(PC)	Rewritable-(PC)
Interface	PC AT	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	CLV	CAV	CAV	MCAV	MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 128	F: 128	F: 470	F: 500/470*
Capacity per track (Bytes)	F: N/A	F: 12,800	F: 12,800	F: 25,600 avg.	F: NS
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	10000	18360	19968/18360*
Track density (TPI)	15875	15875	15875	16925	16925
Maximum linear density (BPI)	27600	24440	24440	NS	30480
Rotational speed (RPM)	530-200	3000	3000	1200	1800
PERFORMANCE					
Positioner type	Crs: DC Motor Rack & Pinion Fine: Lens Actuator	Crs: Linear, Voice Coil Fine:	Crs: Linear, Voice Coil Fine:	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	390	40	40	90	90
Within fine band (msec)	N/A	--	--	45	45
Fine band capacity (Mbytes)	N/A	--	--	NS	NS
Average rotational delay (msec)	110	10	10	25	16.7
Average access time (msec)	500	50	50	115	106.7
Data transfer rate (KBytes/sec)	153.6	937.5	906 1500 avg.	861.25	990
FIRST CUSTOMER SHIPMENT	6/91	4Q91	3Q91	3Q89	4Q90
COMMENTS	41.3 mm high S is external mount Embedded AT	41.3 mm high LF-3090 is external mount	41.3 mm high LF-3100 is external mount Sold in Japan	LF-5010 is external mount. LF-51XX series sold in Japan. LF-52XX series sold in Europe.	*Will operate with WORM media: 470 MB capacity. LF-7110 sold in Japan.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS
DRIVE	LF-7012 LF-7090	LF-7012X	LF-9000 LF-9004 LF-9100	EBP-103	EBP-201
DISK/TREND GROUP	11	11	11	10	10
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	Ge-Tb-Se		Tb-Fe-Co	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(PC)	Rewritable-(PC)	Rewritable-(MO)	Read Only	Read Only
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI, PC	Centronics
Speed control	MCAV	MCAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 500/470*	F: 750	F: 326	F: 540	F: 540
Capacity per track (Bytes)	F: NS	F:	F: 17,408	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	19968/18360*		18727	20750	20750
Track density (TPI)	16925		15875	15875	15875
Maximum linear density (BPI)	30480		24937	27600	27600
Rotational speed (RPM)	1800	2400	2400	530-200	530-200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: DC Motor Rack & Pinion Fine: Lens Actuator	Crs: DC Motor Lead Screw Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	90	45	62.5	1590	1590
Within fine band (msec)	45		13	N/A	N/A
Fine band capacity (Mbytes)	NS		1.6	N/A	N/A
Average rotational delay (msec)	16.7	12.5	12.5	110	110
Average access time (msec)	106.7	57.5	75	1700	1700
Data transfer rate (KBytes/sec)	752 avg. 983 max.	1000-2000	925	153.6	153.6
FIRST CUSTOMER SHIPMENT	1991	4Q93	1Q91	1Q89	1Q89
COMMENTS	*Will operate with WORM media: 470 MB capacity. LF-7090 is external mount.	41.3 mm high Preliminary specification	Glass substrate LF-9000 is external mount. LF-9100 sold only in Japan.	50 mm high Pop up loading model	55 mm high Stand-alone model

MANUFACTURER	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS
DRIVE	EBP-401	EBP-501	EBP-502	EBP-503	EBP-601
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	Proprietary	Proprietary	Proprietary	Proprietary	Proprietary
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	530-200	530-200	530-200	530-200	530-200
PERFORMANCE					
Positioner type	Crs: DC Motor, Lead Screw Fine: Lens Actuator	Crs: DC Motor, Lead Screw Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: DC Motor Lead Screw Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	1590	1590	890	390	1890
Within fine band (msec)	N/A	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	N/A	N/A	N/A	N/A	N/A
Average rotational delay (msec)	110	110	110	110	110
Average access time (msec)	1700	1700	1000	500	2000
Data transfer rate (KBytes/sec)	153.6	153.6	153.6	153.6	153.6
FIRST CUSTOMER SHIPMENT	2Q91	3Q91	3Q92	3Q92	1Q93
COMMENTS	52 mm high For automobile use	50 mm high Drawer loading model	29 mm high Drawer loading model	29 mm high Drawer loading model	50 mm high

MANUFACTURER	MAXIMUM STORAGE	MAXIMUM STORAGE	MAXOPTIX	MAXOPTIX	MAXOPTIX
DRIVE	APX-3200	APX-5100 APX-5200	T3-1300	Tahiti II Tahiti II SD	Tahiti IIM
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Te Alloy	Te Alloy	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy
Track format	Concentric	Concentric	Spiral (Zone)	Spiral (Zone)	Spiral (Zone)
DRIVE: Operating mode	Write Once	Write Once	Wr.Once,Rewrit.	Rewritable-(MO)	Wr.Once,Rewrit.
Interface	Mod. ESDI, PC	Modified ESDI	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV	CAV	CAV	CAV, MCAV	CAV, MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 122	F: 501.8	F: 650/512/326	F: 512/326.4	F: 512/326.4
Capacity per track (Bytes)	F: 8,192	F: 16,384	F:	F:25,000/17,408	F:25,000/17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	14901	30626	37600/25000	25000	25000
Track density (TPI)	14100	26458	18273/16933	16933	16933
Maximum linear density (BPI)	11400	17665	29540*	25000*	25000*
Rotational speed (RPM)	1800	1800	3375/4000/4800	2200	2200
PERFORMANCE					
Positioner type	Crs: Stepping Motor Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Sector	Sector	Continuous	Continuous	Continuous
Average positioning time (msec)	118	NS	19	35	35
Within fine band (msec)	20	NS	--	3	3
Fine band capacity (Mbytes)	1.31	NS	--	2	2
Average rotational delay (msec)	16.7	16.7	6.25/7.5/8.9	13.6	13.6
Average access time (msec)	134.7	NS	25.25	48.6	48.6
Data transfer rate (KBytes/sec)	312.5	625	2200/1100	1200/840	1200/840
FIRST CUSTOMER SHIPMENT	3Q87	10/89	5/93	1/91	5/92
COMMENTS		APX-5200 is external mount Rack & Pinion coarse positioner	*2,7 RLL Code	SD version is for library use *2,7 RLL Code	CCW WORM media per DIS 11560 *2,7 RLL Code

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	ME-5E1 ME-5U1	MW-5E3 MW-5U3	CRMC-FX	CRMC-FX-D	CRMC-LUO
DISK/TREND GROUP	11	11	10	10	10
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co	Te-Se	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Read Only	Read Only	Read Only
Interface	ESDI, SCSI	SCSI	PC XT	PC XT	PC XT
Speed control	CAV	CAV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 297/326	F: 297/326	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F:15,872/17,408	F:15,872/17,408	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18750	18750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	25000	25000	27600	27600	27600
Rotational speed (RPM)	2400	2400	500-200	1000-200	500-200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Motor, Lead Screw Fine: Lens Positioner	Crs: Motor, Lead Screw Fine: Lens Positioner	Crs: Motor, Lead Screw Fine: Lens Positioner
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35.5	35.5	280	250	385
Within fine band (msec)	1.5	1.5	N/A	N/A	N/A
Fine band capacity (Mbytes)	.317	.317	N/A	N/A	N/A
Average rotational delay (msec)	12.5	12.5	110	55/110	110
Average access time (msec)	48	48	390	305/390	490
Data transfer rate (KBytes/sec)	925	925	150	300	153.6
FIRST CUSTOMER SHIPMENT	2Q90	4Q91	6/93	8/93	2/91
COMMENTS	ME-5U1 is external mount	MW-5U3 is external mount	Auto-front tray loading	Auto-front tray loading	41.3 mm high Top loading

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MOST	MOUNTAINGATE DATA SYSTEMS
DRIVE	CRMC-LU005S	CRS-UF	CRS-XP	RMD 5200-S	CR6000 CR6120 CR6221/22 CR6300
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	86 mm	130 mm
Recording medium	Aluminum	Aluminum	Aluminum	RE-TM Alloy	Te-Ox
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Proprietary	Read Only	Read Only	Rewritable-(MO)	Write Once
Interface	PC XT	PC XT	PC XT	SCSI-1/2	SCSI
Speed control	CLV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 630 Mode 2 F: 540 Mode 1	F: 540	F: 540	F: 127.3/254*	F: 320
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 12,800/**	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	10000	18750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	15875/39625	24924
Rotational speed (RPM)	500-200	500-200	500-200	2400	1800
PERFORMANCE					
Positioner type	Crs: Motor, Lead Screw Fine: Lens Positioner	Crs: Motor, Lead Screw Fine: Lens Positioner	Crs: Motor, Lead Screw Fine: Lens Positioner	Crs: Voice Coil Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	350	540	900	35.2	112
Within fine band (msec)	N/A	N/A	N/A	12	50
Fine band capacity (Mbytes)	N/A	N/A	N/A	1.63/**	1.7
Average rotational delay (msec)	110	110	110	12.5	16.5
Average access time (msec)	460	650	1010	47.7	128.5
Data transfer rate (KBytes/sec)	153.6 Mode 1 175 Mode 2	153.6	153.6	512/820-1228	522
FIRST CUSTOMER SHIPMENT	2/91	8/91	9/91	2Q92	3/89
COMMENTS	41.3 mm high Top loading MPC compliant	External model Front loading	Portable model Top loading	41.3 mm high. *Zoned record. **Varies by zone. OROM support. 128 KB buffer.	

MANUFACTURER	MOUNTAINGATE DATA SYSTEMS	MOUNTAINGATE DATA SYSTEMS	MOUNTAINGATE DATA SYSTEMS	MOUNTAIN OPTECH	MOUNTAIN OPTECH
DRIVE	CR6800 CR6822 CR6835/36 CR6841/42/44 CR6880	CR7800	CR7900	SI-250 R/W	CS-1000 M/F SE-1000 M/F SS-1000 M/F ST-1000 M/F
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	86 mm	130 mm
Recording medium	Te-Ox	Te-Ox	Te-Ox	RE-TM Alloy	RE-TM Alloy
Track format	Concentric	Concentric	Concentric	Spiral	Spiral (Zone)
DRIVE: Operating mode	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
Speed control	CAV	CAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 320	F: 325/500	F: 325	F: 128	F: 512/326.4
Capacity per track (Bytes)	F: 17,408	F: 17,408	F: 17,408	F: 12,800	F:25,000/17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18750	18750/20000	18750	10000	25000
Track density (TPI)	15875	15875	15875	15900	16933
Maximum linear density (BPI)	24924	24924	24924	24400	25000
Rotational speed (RPM)	1800	2400	2400	1800	2200
PERFORMANCE					
Positioner type	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: NS Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	112	35	35	60	35
Within fine band (msec)	50			NS	20.5/16
Fine band capacity (Mbytes)	1.7			1.0	2
Average rotational delay (msec)	16.5	12.5	12.5	16.6	13.6
Average access time (msec)	128.5	47.5	47.5	76.6	48.6
Data transfer rate (KBytes/sec)	522	696/1024	696	543.8	1250/880
FIRST CUSTOMER SHIPMENT	1989	10/92	10/92	4Q92	2Q91
COMMENTS	For use in harsh environments	For use in harsh environments	For use in military environments	Ruggedized Preliminary specification	Ruggedized version of Maxtor Tahiti SE-1000 is for military use

MANUFACTURER	MOUNTAIN OPTECH	MOUNTAIN OPTECH	MOUNTAIN OPTECH	NEC	NEC
DRIVE	CS-400	SEL-2C SEL-2-SAMS	RM-2000 M/F	CDR-25	CDR-38 MultiSpin
DISK/TREND GROUP	11	11	11	10	10
MARKET	OEM	OEM	OEM	OEM, PCM	PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	Te Alloy	Te Alloy	RE-TM Alloy	Aluminum	Aluminum
Track format	Concentric	Concentric	Spiral (Zone)	Spiral	Spiral
DRIVE: Operating mode	Write Once	Write Once	Rewritable-(MO)	Read Only	Read Only
Interface	SCSI, PC AT	SCSI, PC AT	SCSI	SCSI	SCSI, SCSI-2
Speed control	CAV	CAV	ZCAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 202	F: 202	F: 512/326.4	F: 680	F: 680
Capacity per track (Bytes)	F: 10,752	F: 10,752	F:25,000/17,408	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18826	18826	25000	20750	20750
Track density (TPI)	15625	15625	16933	15875	15875
Maximum linear density (BPI)	14620	14620	25000	27600	27600
Rotational speed (RPM)	1200	1200	2200	530-200	1060-400
PERFORMANCE					
Positioner type	Crs: Stepping Motor Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	170	170	35	540	290
Within fine band (msec)	15	15	20.5/16	N/A	NS
Fine band capacity (Mbytes)	.32	.32	2	N/A	NS
Average rotational delay (msec)	25	25	13.6	110	110
Average access time (msec)	195	195	48.6	650	400
Data transfer rate (KBytes/sec)	275	275	1250/880	153.6	307.2
FIRST CUSTOMER SHIPMENT	1986	1987	1993	3Q92	1993
COMMENTS		Ruggedized CS-400 MicroVax interface available	2 ruggedized drives in 19" rack	Portable model	41.3 mm high Portable 64 KB buffer. Top loading

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	CDR-55	CDR-74-1 MultiSpin	CDR-84-1 MultiSpin	PC-CD160	PC-CD160F
DISK/TREND GROUP	10	10	10	10	10
MARKET	Captive	OEM, PCM	OEM	Captive	Captive
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	SCSI	SCSI, SCSI-2	SCSI, SCSI-2	SCSI	SCSI
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680	F: 680	F: 680	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	1060-400	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	295	225	225	225	225
Within fine band (msec)	NS	NS	NS	N/A	N/A
Fine band capacity (Mbytes)	NS	NS	NS	N/A	N/A
Average rotational delay (msec)	55	55	55	55	55
Average access time (msec)	350	280	280	280	280
Data transfer rate (KBytes/sec)	307.2	307.2 4000 synch.	307.2 4000 synch.	307.2	307.2
FIRST CUSTOMER SHIPMENT	1992	1993	1993	3Q92	1993
COMMENTS	41.3 mm high Internal	41.3 mm high External 256 KB buffer	41.3 mm high 256 KB buffer		Internal for PC 98XX Tray loading

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	PC-CD50	N1137-04 N7915-11 N7915-84 PC-0D102	N5267-37 N7915	ND-3605-13	0DD-155
DISK/TREND GROUP	10	11	11	11	11
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Aluminum	Tb-Fe-Co	Tb-Fe-Co	Te Alloy	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Rewritable-(MO)	Rewritable-(MO)	Write Once	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
Speed control	CLV	CAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680	F: 305	F: 305	F: 305	F: 680/325
Capacity per track (Bytes)	F: N/A	F: 17,408	F: 17,408	F: 17,408	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	18751	18751	18751	21600*
Track density (TPI)	15875	15375	15875	15375	18273
Maximum linear density (BPI)	27600	25000	25000	25000	29540
Rotational speed (RPM)	530-200	3000	1800	1800	3000/4200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	1590	60	68	85	32
Within fine band (msec)	NS	NS	NS	NS	NS
Fine band capacity (Mbytes)	NS	NS	NS	NS	NS
Average rotational delay (msec)	110	10	16.7	16.6	10/7
Average access time (msec)	1700	70	84.7	101.6	42/39
Data transfer rate (KBytes/sec)	153.6	1500	1500	1500	1940
FIRST CUSTOMER SHIPMENT	1992	1Q91	8/89	7/90	3Q93
COMMENTS	External model for PC 9800 series				41.3 mm high *37600 logical tracks

MANUFACTURER	NEC	NEC	NEC	NIKON	OLYMPUS
DRIVE	PC-0D301	N6513-20	N6513-23 N7913	MO-DD120-1A	MOS300E MOS300S
DISK/TREND GROUP	11	12	12	12	11
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Nominal disk diameter	86 mm	12"	12"	12"	86 mm
Recording medium	Tb-Fe-Co	Te Alloy	Te Alloy	Tb-Fe,Gd-Fe-Co	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Write Once	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI	SCSI, Prop.	Prop., SCSI	SCSI	SCSI-2
Speed control	CAV	Zone CLV	MCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 1,800	F: 2,500	F: 1,750/2,000*	F: 128
Capacity per track (Bytes)	F: 12,800	F:29,500-56,500	F: NS	F: 51721/59111*	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	41000	49000	33755	10000
Track density (TPI)	15375	15875	16940	15875	15875
Maximum linear density (BPI)	24500	20000	25000	30600	24440
Rotational speed (RPM)	3000	600-330	600	1500	3600
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	40	650	150	69	38
Within fine band (msec)	NS	NS	NS	5	8
Fine band capacity (Mbytes)	NS	NS	NS	1.12	.320
Average rotational delay (msec)	10	70	50	20	8.3
Average access time (msec)	50	720	200	89	46.3
Data transfer rate (KBytes/sec)	1500	452	900	1430	3000 synch. 768
FIRST CUSTOMER SHIPMENT	1992	1Q87	6/90	1/92	10/92
COMMENTS				*Sector size 512B/1024B	41.3 mm high

MANUFACTURER	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS
DRIVE	CDD 462	CDD 462BK CDD 462RS	CDF 100	CDF 200	CDI 220
DISK/TREND GROUP	10	10	10	10	10
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	Serial	SCSI-2	Video/audio	RF, video/audio	Serial
Speed control	CLV	CLV			CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 645	F: 645	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-200	500-200	500-200	500-200	500-200
PERFORMANCE					
Positioner type	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	400	400	1000	1000	1000
Within fine band (msec)	N/A	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	N/A	N/A	N/A	N/A	N/A
Average rotational delay (msec)	110	110	110	110	110
Average access time (msec)	510	510	1110	1110	1110
Data transfer rate (KBytes/sec)	153.6	153.6	153.6/175.2	153.6/175.2	153.6/175.2
FIRST CUSTOMER SHIPMENT	4/93	2Q93			
COMMENTS	Desktop. Multisession. Tray load. Audio control on front.	462RS includes external speakers. Tray load. MPC, photo CD compatible	Portable Multisession Photo CD player	Desktop Multisession Photo CD player	Desktop CDI player "Thumbstick" remote control

MANUFACTURER	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS
DRIVE	CDI 350	CDI 360	CDI 601 CDI 602 CDI 605	CM 405ABK CM 425ABK	CDD 521
DISK/TREND GROUP	10	10	10	10	11
MARKET	OEM, PCM	OEM, PCM	Captive	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Dye Polymer
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Write Once
Interface	Serial	Serial	Serial	SCSI-2	SCSI-2
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 645	F: 540/645
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-200	500-200	500-200	1000-400	1000-400*
PERFORMANCE					
Positioner type	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:	Crs: Fine:	Crs: Linear Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	800	800	800	265	1000
Within fine band (msec)	N/A	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	N/A	N/A	N/A	N/A	N/A
Average rotational delay (msec)	110	110	110	55	110
Average access time (msec)	910	910	910	320	1110
Data transfer rate (KBytes/sec)	153.6/175.2	153.6/175.2	153.6/175.2	307.2	307.2/153.6
FIRST CUSTOMER SHIPMENT	4/93	3Q93	1990	2Q93	3/92
COMMENTS	Portable CDI player with LCD screen	Portable CDI player with LCD screen	External mount CDI602 includes floppy disk drive CDI player	425ABK is external mount 64 KB buffer. Photo CD multisession	External mount. Tray load. *500-200 with 153.6 KB data rate

MANUFACTURER	PINNACLE MICRO	PIONEER	PIONEER	PIONEER	PIONEER
DRIVE	PMO-650	DRM-1804	DRM-600/610	DRM-602X	DRM-604X
DISK/TREND GROUP	11	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	RE-TM Alloy	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Read Only	Read Only	Read Only	Read Only
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
Speed control	CAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 326.4	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: 17,408	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18751	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	24902	27600	27600	27600	27600
Rotational speed (RPM)	3600	2120-200	530-200	1060-200	2120-200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NA	300	600	300	300
Within fine band (msec)	NS	NS	NS	NS	NS
Fine band capacity (Mbytes)	NS	NS	NS	NS	NS
Average rotational delay (msec)	8.3	28	110	55	28
Average access time (msec)	NA	328	710	355	328
Data transfer rate (KBytes/sec)	1400 4200 synch.	614.4	153.6	307.2	614.4
FIRST CUSTOMER SHIPMENT	1992	1994	4Q89	3Q93	3Q92
COMMENTS	Purchased mechanism	Integral with 18 disk changer	Integral with 6 disk changer. Disk change time is 7 sec. Includes audio output.	Integral with 6 disk changer	Includes 6 disk changer Multisession compatible

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
DRIVE	DD-M5101	DD-S5101 DD-U5101 DDJ-U5101	DDJ-U5101	DE-S7001 DE-U7001	DE-SH7101 DE-UH7101
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Cyanine Dye	Cyanine Dye	Cyanine Dye	Tb-Fe-Co/Dye	Tb-Fe-Co/Dye
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Write Once	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Interface	Proprietary	SCSI, Prop.	SCSI, Prop.	SCSI	SCSI
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 327	F: 327	F: 327	F: 327	F: 327
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 16,384	F: 16,384	F: 16,384
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	19958	19958	19958	19958	19958
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	15875	15875	15875	15875	15875
Rotational speed (RPM)	1800	1800	1800	1800	1800
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Sampled	Sampled	Sampled	Sampled	Sampled
Average positioning time (msec)	60	60	60	53.3	53.3
Within fine band (msec)	NS	NS	NS	27	27
Fine band capacity (Mbytes)	NS	NS	NS	.819	.819
Average rotational delay (msec)	16.7	16.7	16.7	16.7	16.7
Average access time (msec)	76.7	76.7	76.7	70	70
Data transfer rate (KBytes/sec)	742.5	742.5	491	491	635
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	4/91	6/90	2Q93
COMMENTS	41.3 mm high Mechanism only. External SCSI controller board available	DD-S5101 is external mount DDJ for use with optical libraries	For use with optical libraries	DE-S7001 is external mount Multifunction	41.3 mm high Multifunction

MANUFACTURER	PIONEER	RICOH	RICOH	RICOH	RICOH
DRIVE	DEJ-U7001	RO-3010E RS-3100E	RO-3011 Transporter 1	RO-3012E RS-3102E Transporter 2	RO-5030E RO-5030E-II RS-9200E-II
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM	OEM, PCM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	86 mm	86 mm	86 mm	130 mm
Recording medium	Tb-Fe-Co/Dye	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	RE-TM(Tb-Fe-Co)
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Wr.Once,Rewrit.	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI	SCSI-2	SCSI, SCSI-2	SCSI-2	SCSI
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 327	F: 127.4	F: 127.4	F: 127.4	F: 297/326
Capacity per track (Bytes)	F: 16,384	F: 12,740	F: 12,740	F: 12,740	F:15,872/17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	19958	10000	10000	10000	18750
Track density (TPI)	15875	15875	15875	15875	18875
Maximum linear density (BPI)	15875	24440	24440	24440	24902
Rotational speed (RPM)	1800	3000	1800	3000	1800
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Voice Coil
Servo type	Sampled	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	53.3	35	60	45	50
Within fine band (msec)	27	--	--		NS
Fine band capacity (Mbytes)	.819	--	--		NS
Average rotational delay (msec)	16.7	10	16.7	10	16.7
Average access time (msec)	70	45	76.7	55	66.7
Data transfer rate (KBytes/sec)	491	640	384	640	625
FIRST CUSTOMER SHIPMENT	4/91	12/91	5/93	3/93	1Q90
COMMENTS	For use with optical libraries Multifunction	41.3 mm high RS-3100E is external version. 128 KB buffer.	41.3 mm high Internal mount 64 KB buffer	41.3 mm high RS-3102E is external version. 256 KB buffer.	Embedded SCSI controller. E-II supports ISO and E form. RS-9200E-II is external vers.

MANUFACTURER	RICOH	RICOH	RICOH	SAMSUNG ELECTRONICS	SANYO
DRIVE	RO-5031E RS-9200EX	RO-5043 RS-8200 RS-9100H	RS-9200CD	SCDR-300	ROM-3000U ROM-3000US
DISK/TREND GROUP	11	11	11	10	10
MARKET	OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co	Cyanine Dye	Dye Polymer	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Write Once	Read Only	Read Only
Interface	SCSI	SCSI	SCSI-2	SCSI	Proprietary
Speed control	CAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 297/326	F: 393	F: 650	F: 540	F: 540
Capacity per track (Bytes)	F:15,872/17,408	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18750	18750	20750	20750	20750
Track density (TPI)	15875	15900	15875	15875	15875
Maximum linear density (BPI)	24923	32200	27600	27600	27600
Rotational speed (RPM)	3600	668-334	530-200	500-200	530-200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Crs: Voice Coil Fine: Voice Coil	Crs: Fine:	Crs: Fine:	Crs: Linear Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	29	108	390	340	500
Within fine band (msec)	NS	NS	--	--	N/A
Fine band capacity (Mbytes)	NS	N/A	--	--	N/A
Average rotational delay (msec)	8.3	60	110	110	108
Average access time (msec)	37.3	168	500	450	608
Data transfer rate (KBytes/sec)	1250	312.5	150	153.6	153.6
FIRST CUSTOMER SHIPMENT	4Q91	2Q90	1Q93	3Q93	2/88
COMMENTS	Embedded SCSI controller. Split optics RS-9200EX is external vers. 480 KB buffer.	41.3 mm high. SCSI controller included. RS-8200 & 9100H are external versions.	41.3 mm high Multisession CD format		S model has audio output External mount

MANUFACTURER	SANYO	SANYO	SANYO	SEIKO EPSON	SEIKO EPSON
DRIVE	ROM-4015U	ROM-4026U	ROM-PD1	OMD 5010	OMF 5000
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM	OEM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm/180 mm	86 mm	86 mm
Recording medium	Aluminum	Aluminum	Aluminum	RE-TM Alloy	RE-TM Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Rewritable-(MO)	Rewritable-(MO)
Interface	Proprietary	SCSI	PC AT/Centronic	SCSI, SCSI-2	SCSI, SCSI-2
Speed control	CLV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540/180	F: 128	F: 128
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 12,800	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	10000	10000
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	24440	24440
Rotational speed (RPM)	530-200	530-200	530-200	3600	3600
PERFORMANCE					
Positioner type	Crs: Linear Fine: Lens Actuator	Crs: Linear Fine: Lens Actuator	Crs: Fine:	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	500	500	900	38	38
Within fine band (msec)	N/A	N/A	--	--	--
Fine band capacity (Mbytes)	N/A	N/A	--	--	--
Average rotational delay (msec)	108	108	110	8.3	8.3
Average access time (msec)	608	608	1010	46.3	46.3
Data transfer rate (KBytes/sec)	153.6	153.6	153.6	768	768
FIRST CUSTOMER SHIPMENT	5/89	8/89	6/91	2Q92	2Q93
COMMENTS	41.3 mm high Internal mount Includes audio output	41.3 mm high Internal mount Includes audio output	Has audio output External mount Top loading	41.3 mm high	Subsystem

MANUFACTURER	SHARP	SHARP	SHARP	SONY	SONY
DRIVE	PU-CDI	JY-700 JY-7000	JY-750 JY-7500	CDU-31A	CDU-535
DISK/TREND GROUP	10	11	11	10	10
MARKET	PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	80 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	Aluminum	RE-TM(Tb-Fe-Co)	RE-TM(Tb-Fe-Co)	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Rewritable-(MO)	Rewritable(MO)*	Read Only	Read Only
Interface	Proprietary	SCSI	SCSI, SCSI-2	Proprietary	Proprietary
Speed control	CLV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 200	F: 326	F: 326	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: 17,408	F: 17,408	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	8750	18751	18751	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	33200*	33200**	27600	27600
Rotational speed (RPM)	500-300	2400	3000	530-230	500-200
PERFORMANCE					
Positioner type	Crs: NS Fine: NS	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: DC Motor, Gear Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	60	40	380	230
Within fine band (msec)	NS	NS	NS	N/A	N/A
Fine band capacity (Mbytes)	NS	NS	NS	N/A	N/A
Average rotational delay (msec)	NS	12.5	10	110	110
Average access time (msec)	NS	72.5	50	490	340
Data transfer rate (KBytes/sec)	NS	793	870 4000 synch.	150	150
FIRST CUSTOMER SHIPMENT	1993	1/90	10/92	1992	1990
COMMENTS	Sold only in Japan for Electronic Organizer	*2,7 RLL Code JY-7000 is external mount	41.3 mm high *CCW compatible **2,7 RLL Code JY-7500 is external mount		Has audio output

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	CDU-541	CDU-561	CDU-6205	CDU-6211 CDU-7211	CDU-6251A
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	SCSI	SCSI	Proprietary	SCSI	Proprietary
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-200	*	500-200	530-200	530-230
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	270	240	230	270	380
Within fine band (msec)	N/A	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	N/A	N/A	N/A	N/A	N/A
Average rotational delay (msec)	110	55/110	110	110	110
Average access time (msec)	380	295/350	340	380	490
Data transfer rate (KBytes/sec)	150	307.2/153.6	150	150	150
FIRST CUSTOMER SHIPMENT	1989	1992	1990	1989	1993
COMMENTS	Has audio output	*2 speed ranges: 1160-460 530-230	External mount Has audio output	External mount Has audio output	External mount 2 drives in a single mount

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	DD-10BZ Data Discman	DD-1EX DD-10X Data Discman	DD-8 Data Discman	DD-DR1 Data Discman	MMCD
DISK/TREND GROUP	10	10	10	10	10
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Nominal disk diameter	80 mm	80 mm	80 mm	80 mm	120 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Read Only
Interface	Proprietary	Proprietary	Proprietary	RS232C	Proprietary
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 184	F: 184	F: 184	F: 184	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	9062	9062	9062	9062	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-300	500-300	500-300	500-300	530-230
PERFORMANCE					
Positioner type	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor, Gear Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	NS	NS	NS	N/A
Within fine band (msec)	N/A	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	N/A	N/A	N/A	N/A	N/A
Average rotational delay (msec)	65	65	65	65	110
Average access time (msec)	NS	NS	NS	NS	N/A
Data transfer rate (KBytes/sec)	9.4	9.4	9.4	9.4	153.6
FIRST CUSTOMER SHIPMENT		7/90	1993		1992
COMMENTS					CD-I player External mount

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	CDW-900E	RMO-S350 RMO-S360 SMO-S301	RMO-S501A RMO-S550 SMO-S501A	SMO-E301 SMO-E301F	SMO-E501 SMO-S501A
DISK/TREND GROUP	11	11	11	11	11
MARKET	Captive	OEM, PCM	Captive,OEM,PCM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	86 mm	130 mm	86 mm	130 mm
Recording medium	Dye Polymer	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI	SCSI, SCSI-2	SCSI
Speed control	CLV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 128	F: 326.4	F: 128	F: 325
Capacity per track (Bytes)	F: N/A	F: 12,800	F: 17,408	F: 12,800	F: 17,332
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	18751	10000	18751
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	24440	24902	24440	24902
Rotational speed (RPM)	1000-200	3000	2400	3000	2400
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Acuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	40	70	38	70
Within fine band (msec)	NS	20	20	20	22
Fine band capacity (Mbytes)	N/A	1.64	22	1.64	2.22
Average rotational delay (msec)	NS	10	12.5	10	12.5
Average access time (msec)	NS	50	92.5	48	82.5
Data transfer rate (KBytes/sec)	150-300	625	680	625	680
FIRST CUSTOMER SHIPMENT	1992	6/91	2Q88	8/93	3Q90
COMMENTS	Sold only with mastering system	External subsystems	ISO standard RMO-S550 is external subsystem	41.3 mm high Embedded SCSI controller. Internal fan on E301F.	Embedded SCSI controller SMO-S501A is external subsystem

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	SMO-E502	SMO-E511	SMO-F521	SMO-P301	SMO-S303
DISK/TREND GROUP	11	11	11	11	11
MARKET	Captive, OEM	Captive, OEM	OEM, PCM	OEM	PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	86 mm	86 mm
Recording medium	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co
Track format	Spiral	Spiral	Banded Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Wr.Once,Rewrit.	Rewritable-(MF)	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI, SCSI-2	SCSI	SCSI, SCSI-2	SCSI	SCSI
Speed control	CAV	CAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 325	F: 325	F: 650	F: 128	F: 128
Capacity per track (Bytes)	F: 17,332	F: 17,332	F: N/A	F: 12,800	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18751	18751	21600*	10000	10000
Track density (TPI)	15875	15875	18273	15875	15875
Maximum linear density (BPI)	24902	24902	29540	24440	24440
Rotational speed (RPM)	2400	2400	3000	3000	3000
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine:
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	60	70	40	40	40
Within fine band (msec)	20	22	NS	20	20
Fine band capacity (Mbytes)	2.22	2.22	NS	1.64	1.64
Average rotational delay (msec)	12.5	12.5	10	10	10
Average access time (msec)	72.5	82.5	50	50	50
Data transfer rate (KBytes/sec)	680	680	2000	625	625 4000 synch.
FIRST CUSTOMER SHIPMENT	1Q92	1991	3Q93	1991	1993
COMMENTS	Embedded SCSI controller	Embedded SCSI controller	41.3 mm high *37600 logical tracks	41.3 mm high Integrated controller	External mount

MANUFACTURER	SONY	SONY	SONY	TEAC	TEAC
DRIVE	SMO-S501A	WDD-600	WDD-930-01 WDD-931	CD-50	OD-3000
DISK/TREND GROUP	11	12	12	10	11
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	12"	12"	120 mm	86 mm
Recording medium	Tb-Fe-Co	Sb25e3-B12Te3	Sb25e3-B12Te3	Aluminum	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Write Once	Read Only	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI-2	SCSI-1	SCSI-2
Speed control	CAV	CAV, CLV	CAV, CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 326.4	F: 2,182/3,276	F: 2,182/3,276	F: 540	F: 128
Capacity per track (Bytes)	F: 17,408	F: NS	F: NS	F: N/A	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18751	43750	43750	20750	10000
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	24902	49874	49874	27600	24440
Rotational speed (RPM)	2400	360-1440	540-2160	400-1060	3000
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine:
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	70	180/600	180/600	270	42
Within fine band (msec)	22	10	10	N/A	
Fine band capacity (Mbytes)	2.22	3.2/6.4	3.2/6.4	N/A	
Average rotational delay (msec)	12.5	41/55	27/36.7	55	10
Average access time (msec)	82.5	221/455	207/637	375	52
Data transfer rate (KBytes/sec)	680	600	900	300	640
FIRST CUSTOMER SHIPMENT	2Q88	3Q89	2Q92		4Q91
COMMENTS	ISO standard External mount	Downward compatible with WDD 3000	Downward compatible with WDD-600 & WDD-3000	41.3 mm high 64 KB buffer XA compatible	41.3 mm high 128 KB buffer

MANUFACTURER	TEAC	TEXEL (SHINANO KENSHI)	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	OD-5000	DM-3028 DM-5028	TXM-3301A1 TXM-3301E1 TXM-3301P1	XM-3301B XM-3301BC	XM-3401B
DISK/TREND GROUP	11	10	10	10	10
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	86 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	RE-TM Alloy	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Read Only	Read Only	Read Only	Read Only
Interface	SCSI, SCSI-2	SCSI	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 127.4	F: 599	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: 12,740	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	20750	21250	21250	21250
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	24440	25400	25400	25400	25400
Rotational speed (RPM)	3000	1060-400	530-200	530-200	1170-200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator
Servo type	Continuous		Continuous	Continuous	Continuous
Average positioning time (msec)	42	185	207	207	145
Within fine band (msec)	NS	N/A	N/A	N/A	N/A
Fine band capacity (Mbytes)	NS	N/A	N/A	N/A	N/A
Average rotational delay (msec)	10	55	118	118	55
Average access time (msec)	52	240	325	325	200
Data transfer rate (KBytes/sec)	5300 synch.	335	150	150	330
FIRST CUSTOMER SHIPMENT		3Q93	1Q91	1Q91	4Q92
COMMENTS	41.3 mm high P-ROM, O-ROM compatible. Mounts in 5.25" form factor	41.3 mm high DM-5028 is external mount	External drive MPC compliant	41.3 mm high MPC compliant	41.3 mm high. 256 KB buffer. External drive. Photo-CD compliant. MPC compliant.

MANUFACTURER	TOSHIBA	TOSHIBA	YAMAHA		
DRIVE	XM-8100B	OD-D300B OD-S370A	YPR-102		
DISK/TREND GROUP	10	11	11		
MARKET	OEM	OEM	Captive		
MEDIA: Nominal disk diameter	80 mm	86 mm	120 mm		
Recording medium	Aluminum	RE-TM	Dye Polymer		
Track format	Spiral	Spiral	Spiral		
DRIVE: Operating mode	Read Only	Rewritable-(MO)	Write Once		
Interface	SCSI-2	SCSI, SCSI-2	SCSI, Prop.		
Speed control	CLV	CAV	CLV		
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 180	F: 128	F: 620		
Capacity per track (Bytes)	F: N/A	F: 12,800	F: N/A		
Data surfaces per spindle	1	1	1		
Tracks per surface	8750	10000	20750		
Track density (TPI)	15875	15875	15875		
Maximum linear density (BPI)	25400	24440	29870		
Rotational speed (RPM)	530-300	3600	460-200		
PERFORMANCE					
Positioner type	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Linear, Voice Coil Fine:	Crs: Linear, Voice Coil Fine: Lens Actuator		
Servo type	Continuous	Continuous	Continuous		
Average positioning time (msec)	206	25	NS		
Within fine band (msec)	N/A	25	N/A		
Fine band capacity (Mbytes)	N/A	N/A	N/A		
Average rotational delay (msec)	84	8.3	110		
Average access time (msec)	290	33.3	NS		
Data transfer rate (KBytes/sec)	150	768	153.6		
FIRST CUSTOMER SHIPMENT	2Q92	2Q92	1991		
COMMENTS	41.3 mm high	41.3 mm high. OD-S370A is external mount. Sold only in Japan. 256 KB buffer.	Sold only as part of PDS system		

1993 DISK/TREND REPORT

OPTICAL LIBRARY SPECIFICATIONS

Coverage: The following pages list optical libraries intended for computer data storage which are now announced or in new production. In a few cases, products are listed for which preliminary announcements have been made because they are considered indicators of future industry direction.

Interface: Two interface specifications are given: One for the channel used to control the library and one for the channel(s) used to control the optical disk drives.

Import/export module: The number of disks which can be physically loaded into a library at once. Some libraries have a magazine containing multiple disks, allowing several disks to be inserted into the library at once.

Positioner type: The robotic positioner may be a single axis positioner, a two axis X-Y positioner, a rotary positioner or a carousel.

Pickers per positioner: Some positioning mechanisms can hold more than one disk at a time, permitting an exchange of disks without the need to immediately store the old disk.

Average media exchange: The average time needed for a library to remove a disk, store it, pick a new disk, and load it into a drive. It does not include spin-up or spin-down time. If the positioner has multiple pickers, only the disk fetch and exchange-at-drive times are included.

Nonqueued access time: The average time required for a library to locate a cartridge, load it, spin-up the drive and be ready to read or write.

Drive data transfer rate: The data rate on the host drive interface channel. Throughput will be lower due to write verify or other delays and latencies.

Number of data paths: There may be a common I/O channel for the drives in a library or each may have its own connection to the host computer, depending upon the library design.

Accuracy: All of the information in this section has been checked for accuracy. Due to rapid changes in the industry, report users may need to make verbal inquiries of the manufacturers for updates. Where data is not specified or otherwise available, the abbreviation "NS" is used. Where a specification is not applicable, the abbreviation "N/A" appears.

1993 DISK/TREND optical disk product groups

For the 1993 report, products are classified in six groups.

Optical drives:

Group 10: CD-ROM optical disk drives.
Group 11: Read/write disk drives, less than 1 gigabyte.
Group 12: Read/write disk drives, more than 1 gigabyte.

Optical libraries:

Group 50: CD-ROM optical libraries.
Group 51: Optical libraries with 1 to 39 cartridge capacity.
Group 52: Optical libraries with 40 to 69 cartridge capacity.
Group 53: Optical libraries with 70 or over cartridge capacity.

See the previous specification section for optical disk drive data.

MANUFACTURER	ACCESS	AISIN SEIKI	AMBER TECHNOLOGY	ASACA	ATG GIGADISC
LIBRARY	ODSR	JC2000	Rotostar 252	ADL-450	GF 6910
DISK/TREND GROUP	51	51	52	53	51
MARKET	Captive	OEM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	12"	130 mm	130 mm	130 mm	300 mm
Nominal disk capacity (MB)	2,000	600-650	650/1,000	598	10,200
Cartridge type	LMSI	ANSI/ISO	ISO	ANSI/ISO	Proprietary
DRIVE: Type	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Rewritable-(MO)	Write Once
Drive models	LMSI LD 1250E	Various	Pioneer, Sony, Maxoptix, other	AMD-1340NS	GD 6001 GD 9001 GD 9001S
LIBRARY MECHANISM					
Minimum disk capacity (units)	16*	20	52	450	6
Maximum disk capacity (units)	20	20	52	450	6
Number of drives: Maximum	2	2	2	4	1
Interface: Library Drive	RS232C SCSI	SCSI, RS232C Drive dependent	RS232 SCSI	RS-232C SCSI-2	SCSI SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	40	12-13	33.8/52	540	30.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Rotary	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	9	5	10	7.5	2.5
Spin-up + drive ready time (sec)	3	Drive dependent	Drive dependent	6*	3
Spin-down time (sec)	3	Drive dependent	Drive dependent	3	2
Average drive access time (msec)	212.5	Drive dependent	Drive dependent	130	Drive dependent
Non-queued access time (sec)	12	Drive dependent	Drive dependent		5.5
Drive data transfer rate (KB/s)	1500	Drive dependent	Drive dependent	12240	1000
Number of drive data paths: Max.	2	1 or 2	2	4	1
FIRST CUSTOMER SHIPMENT	--	2Q88	1993	--	1992
COMMENTS	*With 2 drives		Mini silo Can be expanded to 104 disks CD ROM version available	*With glass media	

MANUFACTURER	ATG GIGADISC	BORETT AUTOMATION TECHNOLOGIES	BORETT AUTOMATION TECHNOLOGIES	BORETT AUTOMATION TECHNOLOGIES	CYGNET SYSTEMS
LIBRARY	Gigastore	VLC (CD)	VLC (12")	VLC (5.25")	1602
DISK/TREND GROUP	51	50	53	53	51
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	300 mm	120 mm	12"	130 mm	12"
Nominal disk capacity (MB)	10,200	600	Drive dependent	Drive dependent	Drive dependent
Cartridge type	Proprietary	Caddy	Any	Any	Drive dependent
DRIVE: Type	Write Once	Read Only	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Write Once
Drive models	GD 6001 GD 9001 GD 9001S	Various	Various	Various	ATG LMS Sony
LIBRARY MECHANISM					
Minimum disk capacity (units)	25	NS	NS	NS	29
Maximum disk capacity (units)	31	4620*	756	1540	29
Number of drives: Maximum	2	48	10	24	2
Interface: Library Drive	SCSI-2, RS232 SCSI-2	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	316.2	3000	7560	1540	295*
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Rotary Industrial Robot	Rotary Industrial Robot	Rotary Industrial Robot	Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)	8.2	10	10	10	6.5
Spin-up + drive ready time (sec)	3	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	2	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	11.2	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	1000	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	2	NS	NS	NS	2
FIRST CUSTOMER SHIPMENT	5/93	--	--	--	10/91
COMMENTS	Mechanism from Access	Can mix media types *1540 with caddy	Can mix media types	Can mix media types	*With ATG drive

MANUFACTURER	CYGNET SYSTEMS	CYGNET SYSTEMS	CYGNET SYSTEMS	CYGNET SYSTEMS	CYGNET SYSTEMS
LIBRARY	1800/A2	1800/H1	1800/L2	1800/S	1800/S2
DISK/TREND GROUP	53	53	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	10,200	7,000	5,600	6,550	6,550
Cartridge type	ATG	Hitachi	LMSI	Sony	Sony
DRIVE: Type	Write Once	Write Once	Write Once	Write Once	Write Once
Drive models	ATG GD 9001S	Hitachi OD 321	LMSI 4100	Sony WDD 600	Sony WDD 930
LIBRARY MECHANISM					
Minimum disk capacity (units)	61	61	61	61	61
Maximum disk capacity (units)	141	141	141	141	141
Number of drives: Maximum	5	5	5	5	5
Interface: Library Drive	RS232C, SCSI-2 SCSI	RS232C SCSI-2	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1438	987	789.6	923.55	923
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7.2	8	7.2	8	8
Spin-up + drive ready time (sec)	2.6	3.5	3.5	3.8	2.4
Spin-down time (sec)	2.0	3.5	1.5	2.1	1.2
Average drive access time (msec)	116	150	115	221	207
Non-queued access time (sec)	7.1	7.5	7.1	9	6.4
Drive data transfer rate (KB/s)	1500	1116-2220	1000	1000	900
Number of drive data paths: Max.	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)
FIRST CUSTOMER SHIPMENT	10/91	3Q93	7/91	2Q89	3Q93
COMMENTS	Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies

MANUFACTURER	CYGNET SYSTEMS	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.
LIBRARY	1800/T	D75-1	D255-1	D510-2	D1050-2
DISK/TREND GROUP	53	53	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	5,000	650-1300	650-1300	650-1300	650-1300
Cartridge type	Toshiba WM7500	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVE: Type	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Toshiba WMS500A	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	53	47	90	90	240
Maximum disk capacity (units)	124	77	257	514	1054
Number of drives: Maximum	5	4	12	24	36
Interface: Library Drive	RS232C, SCSI SCSI	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	620	61-100	117-334	117-668	312-1370
Import/export module (disks)	1	1	1	2	2
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	8.7	7	7	7	7
Spin-up + drive ready time (sec)	5 max.	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	5 max.	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	160	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	11	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	1250	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	5 (1 per drive)	1	1-8	1-8	1-8
FIRST CUSTOMER SHIPMENT	1Q90	12/91	12/91	5/92	5/92
COMMENTS	Includes model 1802 and 1803 assemblies Shipped only in Japan	Depopulated versions available	Depopulated versions available	Depopulated versions available	Depopulated versions available

MANUFACTURER	DOCUPOINT	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	DP 520	CDR-1	CDR-2	CDR-3	CDR-4
DISK/TREND GROUP	53	50	50	50	50
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650/1,300	600 (Mode 1)	600 (Mode 1)	600 (Mode 1)	600 (Mode 1)
Cartridge type	ISO	Caddy	Caddy	Caddy	Caddy
DRIVE: Type	Wr.Once,Rewrit.	Read Only	Read Only	Read Only	Read Only
Drive models	Various	NEC CDR 83	NEC CDR 83	NEC CDR 83	NEC CDR 83
LIBRARY MECHANISM					
Minimum disk capacity (units)	100	85	151	411	549
Maximum disk capacity (units)	288	105	191	480	687
Number of drives: Maximum	10	6	14	28	42
Interface: Library Drive	RS232 SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	187/374	63	114.6	288	412.2
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	4*	9	10	11	12
Spin-up + drive ready time (sec)	Drive dependent	4.0	4.0	4.0	4.0
Spin-down time (sec)	Drive dependent	2.7	2.7	2.7	2.7
Average drive access time (msec)	Drive dependent	280	280	280	280
Non-queued access time (sec)	Drive dependent	6.5	7	7.5	8
Drive data transfer rate (KB/s)	Drive dependent	307.2	307.2	307.2	307.2
Number of drive data paths: Max.	4	1	2	4	6
FIRST CUSTOMER SHIPMENT	3Q93	4Q92	4Q92	4Q92	4Q92
COMMENTS	*With 2 drives installed	2 drives minimum	6 drives minimum	14 drives minimum	14 drives minimum

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	20/27/30	28/38	4000	48	100-2000
DISK/TREND GROUP	51	51	51	52	53
MARKET	Captive, OEM	Captive, OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	12"	12"	130 mm	12"	12"
Nominal disk capacity (MB)	2,000	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Cartridge type	Proprietary	Proprietary	ANSI/ISO	Proprietary	Proprietary
DRIVE: Type	Write Once	Write Once	Wr.Once,Rewrit.	Write Once	Write Once
Drive models	LMSI 1200	ATG, Optimem Sony, Toshiba, LMSI 4100	Various	ATG Gigadisc, Optim.,LMSI4100 Sony WDD600	ATG, Optimem, Sony, Hitachi, LMSI, Toshiba
LIBRARY MECHANISM					
Minimum disk capacity (units)	20	28	20	48	54
Maximum disk capacity (units)	30 (2 drives)	38	20	48	2380
Number of drives: Maximum	2	2	2	2	120
Interface: Library Drive	RS232C SCSI	RS232C SCSI	RS232C SCSI	RS232C SCSI	RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	60	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Import/export module (disks)	1	1	1	1	Up to 119*
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	6	6	6	7	8-12
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	4.5 + spin-up	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	2	2	1-2	2	Variable
FIRST CUSTOMER SHIPMENT	4/90	11/89	4/92	11/89	9/87
COMMENTS	Model 27 has 1 drive, 27 disks	Model 38 has 1 drive, 38 disks			*Custom configured

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	EASTMAN KODAK	EASTMAN KODAK	FILENET
LIBRARY	5100 5200 5300 5400 5500	6300 6400	560E	6800 ADL	Model 0140 OSAR GTX
DISK/TREND GROUP	53	53	52	53	53
MARKET	Captive, OEM	OEM	Captive,OEM,PCM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	14"	12"
Nominal disk capacity (MB)	Drive dependent	Drive dependent	654/1,280	10,200	7,000
Cartridge type	ANSI/ISO	ANSI/ISO	Various	Proprietary	Hitachi
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Write Once	Write Once
Drive models	Various	Various	Various	Kodak 6800	Hitachi OD 301
LIBRARY MECHANISM					
Minimum disk capacity (units)	24 (5100)	274 (6300)	36	50	96
Maximum disk capacity (units)	134 (5500)	458 (6400)	60	100	125
Number of drives: Maximum	8 (5300-5500)	16	5	2	6
Interface: Library Drive	RS232C SCSI	RS232C SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232, RS422 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	39/78*	1020	875
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	6-7	8	5	6.5	4.0
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	2.4	3.0
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	1.4	2.5
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	570	150
Non-queued access time (sec)	Drive dependent	Drive dependent	Drive dependent	7.0	6.0
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	1000	4000
Number of drive data paths: Max.	2 to 8	Various	5	2	6
FIRST CUSTOMER SHIPMENT	11/89	6/92	3Q92	4Q88	6/91
COMMENTS			*With 654 and 1280 MB media	Expandable in modules of 50 disks	Maximum capacity with 2 drives

MANUFACTURER	FILENET	FILENET	FILENET	FILENET	FILENET
LIBRARY	Model 0150 OSAR 107/144 GT	Model 0161 OSAR 288 X	OSAR 151	OSAR 170	OSAR 171
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	5,600	7,000	5,600	10,200	10,200
Cartridge type	LMSI	Hitachi	LMSI	Proprietary	Proprietary
DRIVE: Type	Write Once	Write Once	Write Once	Write Once	Write Once
Drive models	LMSI LD 4100	Hitachi OD 321	LMSI LD 4100	ATG 9001/S	ATG 9001/S
LIBRARY MECHANISM					
Minimum disk capacity (units)	107	288	340	100	288
Maximum disk capacity (units)	144	288	340	130	288
Number of drives: Maximum	6	4	4	6	4
Interface: Library Drive	RS232, RS422 SCSI	RS232, RS422 SCSI	RS232, RS422 SCSI	RS252, RS422 SCSI	RS252, RS422 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	806	2016	1904	1326	2909
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	4.0	8.3	7.8	4.0	4.0
Spin-up + drive ready time (sec)	3.0	3.0	3.0	3.0	3.0
Spin-down time (sec)	1.5	2.5	4.5	1.5	1.5
Average drive access time (msec)	130	150	130	123	123
Non-queued access time (sec)	6.0	9.5	9.3	6.0	6.0
Drive data transfer rate (KB/s)	4000	4000	4000	4000	4000
Number of drive data paths: Max.	6	4	4	6	4
FIRST CUSTOMER SHIPMENT	3/91	7/91	--	1993	1993
COMMENTS	Maximum capacity with 2 drives		Special order	Maximum capacity with 2 drives	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	F6445/A1 M255X/A1	F6445/A2 M255X/A2	F6445/A2X2 M255X/A2X2	C1700 C1713C Mod. 10C C1713M Mod. 10C Model 10GB/A Model 10GB/M	C1703M C1710 Mod. 20C C1710C Mod. 20C Model 20GB/A Model 20GB/M
DISK/TREND GROUP	53	53	53	51	51
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	644	644	644	650	650
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	M2507L	M2507L	M2507L	H-P C1716C Sony SMO-D501 Sony SMO-E511	H-P C1716C Sony SMO-D501 Sony SMO-E511
LIBRARY MECHANISM					
Minimum disk capacity (units)	390	780	1560	16	32
Maximum disk capacity (units)	390	780	1560	16	32
Number of drives: Maximum	6	11	10	1	2
Interface: Library Drive	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2 SCSI	SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	251.2	502.3	10046	10.4	20.8
Import/export module (disks)	10/10	10/10	10/10	1	1
PERFORMANCE					
Positioner type	Rotary Drum Y Axis Picker	Rotary Drum (2) 2 Y Axis Picker	Rotary Drum (4) 4 Y Axis Picker	X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	10	10	10	7	7
Spin-up + drive ready time (sec)	5.5	5.5	5.5	2.5	2.5
Spin-down time (sec)	4.5	4.5	4.5	2.0	2.0
Average drive access time (msec)	40.6	40.6	40.6	27	27
Non-queued access time (sec)	10.5	10.5	10.5	6.0	6.0
Drive data transfer rate (KB/s)	2080	2080	2080	1000	1000
Number of drive data paths: Max.	2	2	2	1	2
FIRST CUSTOMER SHIPMENT	4Q91	4Q91	4Q91	1Q91	11/89
COMMENTS	Single pass write *With DIR (M109X/F1785)	Single pass write *With DIR (M109X/F1785)	Single pass write *With DIR (M109X/F1785)	Specifications with H-P drive	Specifications with H-P drive

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
LIBRARY	C1708C C1718C 10LC	C1704 C1714C Mod. 60C C1714M Mod.60	C1705 C1715C Mod.100C C1715M Mod.100	OL101-11 OL101-21	OL112-11 OL112-21
DISK/TREND GROUP	51	53	53	51	51
MARKET	Captive, OEM	Captive,OEM,PCM	Captive,OEM,PCM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	650	650	600	644
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MO)	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Write Once	Rewritable-(MO)
Drive models	HP C1716C	H-P C1716C Sony SMO-D501 Sony SMO-E511	H-P C1716C Sony SMO-D501 Sony SMO-E511	Hitachi OD101	Hitachi OD112-1
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	88	144	24	24
Maximum disk capacity (units)	16	88	144	24	24
Number of drives: Maximum	1	4	4	2	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI	SCSI-2 SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	10.4	57.2	93.6	14.4	15
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	8	8	7.7	7.7
Spin-up + drive ready time (sec)	2.5	2.5	2.5	2.5	4.0
Spin-down time (sec)	2.0	2.0	2.0	2.5	3.5
Average drive access time (msec)	35.3	2.5	27	110	70
Non-queued access time (sec)	6.5	6.5	6.5	7.8	7.8
Drive data transfer rate (KB/s)	1000	1000	1000	1500	1500
Number of drive data paths: Max.	1	4	4	1	1
FIRST CUSTOMER SHIPMENT	3Q92	1Q91	1Q91	1987	1989
COMMENTS	Multifunction drive	Specifications with H-P drives Single-ended or differential SCSI	Specifications with H-P drives Single-ended or differential SCSI	-11 has single ended interface -21 has differential interface	-11 has single ended interface -21 has differential interface

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
LIBRARY	OL301-11 OL301-21	OL301-12 OL301-22	OL101-12 OL101-22	OL112-12 OL112-22	OL114-12 OL114-22
DISK/TREND GROUP	51	51	52	52	52
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	12"	12"	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2,620	2,620	600	644	644
Cartridge type	Proprietary	Proprietary	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Write Once	Write Once	Write Once	Rewritable-(MO)	Wr.Once,Rewrit.
Drive models	Hitachi OD301A1	Hitachi OD301A1	Hitachi OD101	Hitachi OD112-1	Hitachi
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	32	48	48	48
Maximum disk capacity (units)	16	32	48	48	48
Number of drives: Maximum	2	2	4	4	4
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	42	83.9	28.8	30	30
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8.7	8.7	7.7	7.7	7.7
Spin-up + drive ready time (sec)	4.3	4.3	2.5	3.7	4.0
Spin-down time (sec)	3.5	3.5	2.5	2.7	3.5
Average drive access time (msec)	250	250	110	70	70
Non-queued access time (sec)	8.8	8.8	7.8	7.8	7.8
Drive data transfer rate (KB/s)	1500	1500	1500	1500	1500
Number of drive data paths: Max.	1	1	2	1	4
FIRST CUSTOMER SHIPMENT	1985	1985	1987	1989	1991
COMMENTS	-11 has single ended interface -21 has differential interface. IEEE-488 interface avail	-12 has single ended interface -22 has differential interface. IEEE-488 interface avail	-12 has single ended interface -22 has differential interface	-12 has single ended interface -22 has differential interface	-12 is single-ended SCSI -22 is differential SCSI Sold only in Japan

MANUFACTURER	HITACHI	HITACHI	IBM	IBM	IBM
LIBRARY	OL321-22	OL321-32	3995-021	3995-022	3995-042
DISK/TREND GROUP	52	52	51	51	51
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive
MEDIA: Nominal disk diameter	12"	12"	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	7000	7000	650	650	650
Cartridge type	Proprietary	Proprietary	ISO	ISO	ISO
DRIVE: Type	Write Once	Write Once	Rewritable-(MO)	Write Once	Write Once
Drive models	Hitachi OD321	Hitachi OD321	IBM 0632-C1X	NS	NS
LIBRARY MECHANISM					
Minimum disk capacity (units)	47	64	32	32	32
Maximum disk capacity (units)	47/127*	64/144*	32	32	32
Number of drives: Maximum	4	2	2	2	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	LAN SCSI	LAN SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	329/889*	448/1008*	20.8	20.8	20.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	1	1	1
Average media exchange time (sec)	6.5	6.5	7	7	7
Spin-up + drive ready time (sec)	3	3	3.1	2.5	2.5
Spin-down time (sec)	3	3	1.3	1.3	1.3
Average drive access time (msec)	150	150	82.5	62	62
Non-queued access time (sec)	8.5	8.5	6.5	6.1	6.1
Drive data transfer rate (KB/s)	1500/4000	1500/4000	680	680	680
Number of drive data paths: Max.	2	2	2	2	2
FIRST CUSTOMER SHIPMENT	1Q91	1Q91	4Q92	2Q92	2Q92
COMMENTS	Dual picker *With expansion unit	Dual picker *With expansion unit	For LAN Hewlett-Packard mechanism	For LAN Hewlett-Packard mechanism	For AS/400 Hewlett-Packard mechanism

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	5558-B01	3995-023	3995-063	3995-111	3995-112
DISK/TREND GROUP	51	53	53	53	53
MARKET	Captive	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	86 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	128	1300	1300	650	650
Cartridge type	ISO	ISO	ISO	ISO	ISO
DRIVE: Type	Rewritable	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Write Once
Drive models	IBM 3125B	IBM 0632-C2X	IBM 0632-C2X	IBM 0632-C1X	NS
LIBRARY MECHANISM					
Minimum disk capacity (units)	32	32	32	144	144
Maximum disk capacity (units)	32	32	32	144	144
Number of drives: Maximum	1	2	2	4	4
Interface: Library Drive	Microchannel SCSI	LAN SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	4.1	40	40	93.6	93.6
Import/export module (disks)	32	1	1	1	1
PERFORMANCE					
Positioner type	Rotary Carousel	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	--	7	7	8	8
Spin-up + drive ready time (sec)	--	3.1	3.1	8.1	2.5
Spin-down time (sec)	--	1.3	1.3	1.3	1.3
Average drive access time (msec)	50	67.5	67.5	82.5	62
Non-queued access time (sec)	--	6.5	6.5	6.5	6.1
Drive data transfer rate (KB/s)	640	1272	1272	680	680
Number of drive data paths: Max.	1	2	2	4	4
FIRST CUSTOMER SHIPMENT	3Q92	3Q93	3Q93	4Q92	4Q91
COMMENTS		For LAN Hewlett-Packard mechanism	For RS/6000 Hewlett-Packard mechanism	Expansion unit for Rewritable libraries Hewlett-Packard mechanism	Expansion unit for Write Once libraries Hewlett-Packard mechanism

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-113	3995-121	3995-122	3995-123	3995-131
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	650	650	1300	650
Cartridge type	ISO	ISO	ISO	ISO	ISO
DRIVE: Type	Rewritable-(MO)	Rewritable-(MO)	Write Once	Rewritable-(MO)	Rewritable-(MO)
Drive models	IBM 0632-C2X	IBM 0632-C1X	NS	IBM 0632-C2X	IBM 0632-C1X
LIBRARY MECHANISM					
Minimum disk capacity (units)	144	144	144	144	144
Maximum disk capacity (units)	144	144	144	144	144
Number of drives: Maximum	4	5	5	5	5
Interface: Library Drive	SCSI SCSI	LAN SCSI	LAN SCSI	LAN SCSI	S/370* SCSI
Library capacity (Gbytes) (with maximum disk capacity)	178	93.6	93.6	188	93.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	8	1	1	8	1
Average media exchange time (sec)	8	8	8	8	8
Spin-up + drive ready time (sec)	3.1	3.1	2.5	3.1	8.1
Spin-down time (sec)	1.3	1.3	1.3	1.3	1.3
Average drive access time (msec)	67.5	82.6	62	67.5	82.5
Non-queued access time (sec)	7.5	6.5	6.1	7.5	6.5
Drive data transfer rate (KB/s)	1272	680	680	1272	680
Number of drive data paths: Max.	4	5	5	4	5
FIRST CUSTOMER SHIPMENT	3Q93	4Q92	2Q92	3Q93	4Q92
COMMENTS	Expansion unit for Rewritable libraries Hewlett-Packard mechanism	For LAN Hewlett-Packard mechanism	For LAN Hewlett-Packard mechanism	For LAN Hewlett-Packard mechanism	*OEMI channel Hewlett-Packard mechanism

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-132	3995-142	3995-151	3995-153	3995-163
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive, OEM	Captive	Captive, OEM	Captive	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	650	650	1300	1300
Cartridge type	ISO	ISO	ISO	ISO	ISO
DRIVE: Type	Write Once	Write Once	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Drive models	NS	NS	IBM 0632-C1X	IBM 0632-C2X	IBM 0632-C2X
LIBRARY MECHANISM					
Minimum disk capacity (units)	144	144	144	144	144
Maximum disk capacity (units)	144	144	144	144	144
Number of drives: Maximum	5	4	5	5	5
Interface: Library Drive	S/370* SCSI	SCSI SCSI	S/370* SCSI	S/370* SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	93.6	93.6	93.6	178	178
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	8	8	8	8
Spin-up + drive ready time (sec)	2.5	2.5	3.1	3.1	3.1
Spin-down time (sec)	1.3	1.3	1.3	1.3	1.3
Average drive access time (msec)	62	62	82.5	67.5	67.5
Non-queued access time (sec)	6.1	6.1	6.5	7.5	7.5
Drive data transfer rate (KB/s)	680	680	680	1272	1272
Number of drive data paths: Max.	5	4	4	5	5
FIRST CUSTOMER SHIPMENT	4Q91	4Q92	4Q92	3Q93	3Q93
COMMENTS	*OEMI channel Hewlett-Packard mechanism	For AS/400 Hewlett-Packard mechanism	*ECKD emulation *OEMI channel Hewlett-Packard mechanism	*OEMI channel Hewlett-Packard mechanism	RS/6000 Hewlett-Packard mechanism

MANUFACTURER	INTERNATIONAL DATA ENGINEERING	INTERNATIONAL DATA ENGINEERING	INTERNATIONAL DATA ENGINEERING	INTERNATIONAL DATA ENGINEERING	INTERNATIONAL DATA ENGINEERING
LIBRARY	7100	7200	9000	LG-5	TG-8
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	86 mm
Nominal disk capacity (MB)	654	654	654	650	128
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Rewritable-(MO)
Drive models	Various	Various	Various	Maxoptix Ricoh Sony	Sony E301F Ricoh Panasonic
LIBRARY MECHANISM					
Minimum disk capacity (units)	10	20	20	5	8
Maximum disk capacity (units)	10*	20	20	5	8
Number of drives: Maximum	1	1	2	1	1
Interface: Library Drive	SCSI-2 SCSI	SCSI-2 SCSI	SCSI-2 SCSI	SCSI-2 SCSI	SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	6.5/10.3	18.8	13.1/20*	3.25/5*	1
Import/export module (disks)	1	1	1	5	8
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X axis	X axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	5.5	7	7	4.5
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	1/90	4Q93	3Q91	1Q92	1Q93
COMMENTS	*11 with Panasonic drive Ruggedized version		105 MB Winchester buffer is optional. *With 1GB media and Maxoptix drive.	Microlibrary includes host adaptor	

MANUFACTURER	K&S	KUBIK ENTERPRISES	KUBIK ENTERPRISES	LASER MAGNETIC STORAGE	LASER MAGNETIC STORAGE
LIBRARY	Megastore 1000	CDR240M	DDC-240	LF 4500 RapidChanger	LF 4502
DISK/TREND GROUP	51	50	50	51	51
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	12"	12"
Nominal disk capacity (MB)	654/1024*	550	550	5,600	5,600
Cartridge type	ISO, ZCAV*	N/A	N/A	LMSI	LMSI
DRIVE: Type	Rewritable-(MO)	Read Only	Read Only	Write Once	Write Once
Drive models	Various	Toshiba	LMSI, Sony	LMSI LD 4100	LMSI LD 4100
LIBRARY MECHANISM					
Minimum disk capacity (units)	1	240	240	5	10
Maximum disk capacity (units)	10	240	240	5	10
Number of drives: Maximum	1	4	1	1	2
Interface: Library Drive	SCSI SCSI	RS232C SCSI	RS232C SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	6.5/10.2*	132	132	28	56
Import/export module (disks)	1	1	1	5	5
PERFORMANCE					
Positioner type	Y axis	Rotary	Rotary	Moving Magazine	Moving Magazine
Pickers per positioner	1	1	1	N/A	1
Average media exchange time (sec)	11	7	7	3	3
Spin-up + drive ready time (sec)	Drive dependent	1	1	2.5	3
Spin-down time (sec)	Drive dependent	1	1	1.5	1.5
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	130*	130
Non-queued access time (sec)	Drive dependent	NS	NS	5.5	5.5
Drive data transfer rate (KB/s)	Drive dependent	153.6	153.6	1800**	700
Number of drive data paths: Max.	1	4	1	1	2
FIRST CUSTOMER SHIPMENT	9/91	1992	1990	2Q90	1992
COMMENTS	*With Maxoptix drive			*Includes command overhead **Asynchronous mode	2 LF 4500 in single cabinet

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
LIBRARY	LF-J5000A	LF-J7000A	ME-5G2-Z	ME-5G2-A	ME-5G2-B
DISK/TREND GROUP	52	52	51	52	53
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	940	1,000	594/652	594/652	594/652
Cartridge type	ANSI/ISO	ANSI/ISO	Proprietary	Proprietary	Proprietary
DRIVE: Type	Write Once	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Drive models	MEI LF-5012Z	MEI LF-7012Z	Mitsub. ME-5E1	Mitsub. ME-5E1	Mitsub. ME-5E1
LIBRARY MECHANISM					
Minimum disk capacity (units)	50	50	24	54	150
Maximum disk capacity (units)	50	50	24	54	150
Number of drives: Maximum	2	2	2	2	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	47	50	14	32	90
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	13	8	5.5	6.5	8.5
Spin-up + drive ready time (sec)	5	4	3.5	3.5	3.5
Spin-down time (sec)	5	2.5	3.0	3.0	3.0
Average drive access time (msec)	115	107	58	58	58
Non-queued access time (sec)	12	8	6	7	8
Drive data transfer rate (KB/s)	1500/4000*	1500/4000*	620	620	620
Number of drive data paths: Max.	1	1/2	2	2	2
FIRST CUSTOMER SHIPMENT	1/90	7/91	2Q91	2Q91	2Q91
COMMENTS	*SCSI synchronous mode	*SCSI synchronous mode	Sold only in Japan	Sold only in Japan	Sold only in Japan

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
LIBRARY	N1137-06	N7923	N5817-31/32 N7925-82	N7925-81	ND3605-19
DISK/TREND GROUP	51	51	52	52	52
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Nominal disk diameter	130 mm	12"	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	610	5,000	610	610	610
Cartridge type	ANSI/ISO	Proprietary	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MO)	Write Once	Rewritable-(MO)	Rewritable-(MO)	Write Once
Drive models	NEC N1137-04	NEC N7913	NEC N7915 NEC N5817-11	NEC N7915-81	NEC ND3605-13
LIBRARY MECHANISM					
Minimum disk capacity (units)	4	36	46	46	46
Maximum disk capacity (units)	4	36	67	67	60
Number of drives: Maximum	1	2	4	4	4
Interface: Library Drive	SCSI SCSI	NEC Proprietary	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	2.4	180	40	40	36.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	2	1	2	2
Average media exchange time (sec)	10	14	10	10	10
Spin-up + drive ready time (sec)	4	8	4	3.5	3.5
Spin-down time (sec)	4	8	4	3.5	3.5
Average drive access time (msec)	60	200	60	84.7	84.7
Non-queued access time (sec)	8	15	9	9	9
Drive data transfer rate (KB/s)	1500	900	1500	1500	1500
Number of drive data paths: Max.	1	2	1	1	1
FIRST CUSTOMER SHIPMENT	1991	6/90	1992	1990	9/90
COMMENTS					

MANUFACTURER	NIKKYO	NIKKYO	NIKKYO	NKK	NKK
LIBRARY	NOL-102	NOL-161	NOL-642	N-520	N-556ET
DISK/TREND GROUP	51	51	52	51	52
MARKET	OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	654	654	654	650/1000/1300	650/1000*
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO	ANSI/ISO*
DRIVE: Type	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MF)	Rewritable-(MF)
Drive models	Sony SMO-E501, SMO-E502, SMO-E511	Sony SMO-E501, SMO-E502, SMO-E511	Sony SMO-E501, SMO-E502, SMO-E511	Sony, Pioneer, Maxoptix, IBM	Maxoptix-Tahiti SD, Tahiti IIm
LIBRARY MECHANISM					
Minimum disk capacity (units)	10	16	64	20	56
Maximum disk capacity (units)	10	16	64	20	56
Number of drives: Maximum	2	1	2	2	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI, SCSI-2	SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	6.5	10.4	41.8	13/20/26	36.4/56*
Import/export module (disks)	1	1	1/16	1	16
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	5	5	7	4
Spin-up + drive ready time (sec)	7	7	7	Drive dependent	4/4.5*
Spin-down time (sec)	4	4	4	Drive dependent	1.5/1.6*
Average drive access time (msec)	100	100	100	Drive dependent	35
Non-queued access time (sec)	9.5	9.5	9.5	Drive dependent	6/6.5*
Drive data transfer rate (KB/s)	1200	1200	1200	Drive dependent	1500
Number of drive data paths: Max.	1	1	1	1/2	1/2
FIRST CUSTOMER SHIPMENT	4Q92	3Q93	4Q93	4Q93	2Q92
COMMENTS	Sold under Alaya brand	Sold under Alaya brand	Sold under Alaya brand		*Maxoptix ZCAV media Non-ANSI non-ISO standard

MANUFACTURER	NKK	NKK	NKK	NKK	NKK
LIBRARY	N-556MP	N-556MS	N-5160ET	N-5160MP	N-5160MS
DISK/TREND GROUP	52	52	53	53	53
MARKET	OEM	OEM, PCM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	654	650	650/1000*	654	650
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO*	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MF)	Wr.Once,Rewrit.	Rewritable-(MF)
Drive models	Pioneer DEJ-U7001	Sony SMO-E501, E502, E511	Maxoptix-Tahiti SD, Tahiti IIM	Pioneer DEJ-U7001	Sony E501, E502, E511
LIBRARY MECHANISM					
Minimum disk capacity (units)	56	56	144	144	144
Maximum disk capacity (units)	56	56	160	160	160
Number of drives: Maximum	2	2	4	4	4
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI	SCSI	SCSI	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	36.6	36.4	160	104.6	104
Import/export module (disks)	16	16	16	16	16
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	4	4	4	4	4
Spin-up + drive ready time (sec)	6	7	4	6	7
Spin-down time (sec)	3	4	1.5	3	4
Average drive access time (msec)	70	67	35	70	67
Non-queued access time (sec)	8.0	9.0	6.5	8.5	9.0
Drive data transfer rate (KB/s)	1500	1200	1500	1500	1200
Number of drive data paths: Max.	1/2	1/2	1	1	1
FIRST CUSTOMER SHIPMENT	3Q91	3Q91	4Q92	3Q92	3Q92
COMMENTS			*1000 MB in non-ISO format		

MANUFACTURER	NSM	PIONEER	PIONEER	PIONEER	RICOH
LIBRARY	CDR-100/S	DRM-1804	DRM-600 DRM-600A DRM-610	DRM-604X	RJ5100EX
DISK/TREND GROUP	50	50	50	50	51
MARKET	OEM	OEM, PCM	OEM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (MB)	600	540	540	540	652
Cartridge type	NSM	N/A	N/A	N/A	ANSI/ISO
DRIVE: Type	Read Only	Read Only	Read Only	Read Only	Rewritable-(MF)
Drive models	Philips	Pioneer (integrated with drive)	Pioneer (integrated with drive)	Pioneer (integrated with drive)	Ricoh RO-5031
LIBRARY MECHANISM					
Minimum disk capacity (units)	100	18	6	6	16
Maximum disk capacity (units)	100	18	6	6	16
Number of drives: Maximum	1	1	1	1	1
Interface: Library Drive	SCSI, RS422 SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	60	9.72	3.24	3.24	10.4
Import/export module (disks)	50/1	18	6	6	1
PERFORMANCE					
Positioner type	X-Y axis	NS	NS	NS	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	5.5	5	7	5	5
Spin-up + drive ready time (sec)	1.5	NS	NS	NS	
Spin-down time (sec)	1.0	NS	NS	NS	
Average drive access time (msec)	500	300	600	300	45.3
Non-queued access time (sec)	9	NS	NS	NS	
Drive data transfer rate (KB/s)	153.6	614.4/153.6	153	614.4/153.6	1200
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	7/91	4Q93	4Q89	3Q92	1993
COMMENTS		Preliminary specification			

MANUFACTURER	RICOH	RICOH	SONY	SONY	SONY
LIBRARY	RJ5160	RJ5330E	WDA-E330	WDA-610	WDA-E930
DISK/TREND GROUP	51	52	51	52	53
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	12"	12"	12"
Nominal disk capacity (MB)	800	646	6,552	6,552	6,552
Cartridge type	Proprietary	ANSI/ISO	Proprietary	Proprietary	Proprietary
DRIVE: Type	Write Once	Rewritable	Write Once	Write Once	Write Once
Drive models	Ricoh RO-5040WL	Ricoh RO-5030EII	Sony WDD 930-01	Sony WDD 600-01	Sony WDD 930-01
LIBRARY MECHANISM					
Minimum disk capacity (units)	20	56	12	50	47
Maximum disk capacity (units)	20	56	12	50	77
Number of drives: Maximum	2	2	1	2	4
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	16	36.2	78.6	327.6	504.5
Import/export module (disks)	1	16	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	7	5	3.0	5	5
Spin-up + drive ready time (sec)	.5	9.0	2.4	2.4	2.4
Spin-down time (sec)	.5	5.0	2.5	1.1	1.2
Average drive access time (msec)	168	67	208/637	221/455	208/637
Non-queued access time (sec)	8.2	11.5	4	5	5
Drive data transfer rate (KB/s)	1400	1400	900	600	900
Number of drive data paths: Max.	1/2	1/2	1	1	1
FIRST CUSTOMER SHIPMENT	2Q88	4Q89	3Q92	9/89	4Q92
COMMENTS				Can attach 7 units to 1 SCSI port	

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1993 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing optical disk drives or optical disk libraries, or those which are expected to eventually enter the market, are listed in this section. DISK/TREND normally estimates the annual volume of disk drive sales by manufacturers. Because few companies had a high level of optical library or disk drive sales in 1992, this figure is reported explicitly only for firms with major 1992 sales. "1992 total net sales" covers the fiscal year ending in 1992 for each firm unless noted otherwise, or for the parent company if the disk drive or library manufacturer is a subsidiary. The fiscal year of listed firms ends on December 31, 1992, unless otherwise noted.

Manufacturers located in the United States that have majority owners headquartered in other countries are grouped in the geographical area in which the owner's home office is located.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars are given below. The average exchange rate for 1992 is used, as cited by the Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
France	French franc	5.29
Japan	Yen	127.0
Netherlands	Guilder	1.87
South Korea	Won	785.0
Germany	Deutschmark	1.56
United Kingdom	Pound	.568

Use caution in making year to year comparisons of revenue and income figures, as they are significantly impacted by exchange rate changes.

U.S. Manufacturers

ACCESS CORPORATION
1101 Glendale-Milford Road
Cincinnati, Ohio 45215

Access is a manufacturer of digital and micrographic image management and distribution systems. The company was founded in 1963. As an adjunct to its engineering document image systems business, Access, in conjunction with Laser Magnetic Storage, designed a 12" optical library unit which it supplied exclusively to LMSI for a few years. Access now supplies the library to its own end users and for resale through ATG Gigadisc.

ADVANCED DIGITAL INFORMATION CORPORATION (ADIC)
14737 NE 87th Street
Redmond, WA

ADIC is a supplier of backup subsystems and controller boards for personal computers. The firm is also developing a tabletop library for 3.5" drives and is expected to formally announce the product in late 1993. Several manufacturers of 3.5" drives were actively evaluating the library as of mid-1993.

APPLIED MAGNETICS CORPORATION
Optical Products Division
18960 Base Camp Road
Monument, CO 80132

Applied Magnetics, which is best known for its magnetic disk drive heads, established OPD as an optical disk drive component development operation in 1988. In July, 1992, AMC announced a corporate restructuring and that the Optical Products Division was up for sale. The organization was sold to Nakamichi's MOST subsidiary in early 1993.

BORETT AUTOMATION TECHNOLOGIES
31324 Via Colinas
Westlake Village, CA 91362

Founded in 1988, Borett Automation is working on a modular library system capable of simultaneously handling optical or tape media units in multiple cartridge sizes. The library is equipped with appropriate drives and storage bays for the cartridges to be used. A general purpose industrial robot capable of exchanging its picking mechanism on the fly permits handling of different cartridge types. Borett announced its product at the 1992 AIIM show, and has since made some improvements to the basic design.

CD-ROM, INC.
1667 Cole Boulevard, Suite 400
Golden, CO 80401

CD-ROM, founded in 1988, is the only U.S. owned and headquartered manufacturer of CD-ROM drives. The product line consists of ruggedized drives sold mostly to the U.S. government, although the firm sells internationally. CD-ROM, Inc. is best known as a distributor of other CD-ROM drives, disks and related products. The company also welcomes customized drive design and consulting assignments.

CHEROKEE DATA SYSTEMS (See Mountaingate Data Systems)

COLORADO TECH DESIGNS, INC.
4755 Walnut Street
Boulder, CO 80301

Founded in 1986, Colorado Tech Designs specializes in mass storage subsystems. Current products are heavily oriented toward tape libraries, although a few optical libraries were built several years ago on a custom contract basis. The company is one of the few to employ a rotary mechanism in its libraries, rather than the more conventional Y-axis positioning mechanism. Future plans include optical libraries using small diameter drives, but no specific timetable has been announced.

CYGNET SYSTEMS, INC.
2560 Junction Avenue
San Jose, CA 95134

Cygnet was founded in 1983 to develop systems to serve the image storage market. Its primary line of business is a series of optical libraries that use various 12" and 5.25" optical drives, plus supporting software. As one of the early entrants into the optical library arena, Cygnet enjoys a substantial share of the available business. The first commercial shipments of 12" based libraries began in 1987. Shipments of libraries with 5.25" drives began in late 1988, although the unusual design of the 5.25" library has caused some drive integration problems, delaying manufacturing ramp up. Cygnet decided in mid-1990 to offer its 5.25" library only with the LMSI write-once drive, but 12" libraries remained Cygnet's main area of activity and production of 5.25" libraries ended in 1992.

Cygnet has licensed Eastman Kodak to manufacture some of its products, and in 1986 received a loan from Kodak. However, the relationship with Kodak is not a happy one, for in mid-1993 Cygnet filed for Chapter 11 protection, accusing Kodak of triggering bankruptcy by demanding immediate repayment of the loan despite Cygnet's currently profitable status.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1992 total net sales: $13,930,872,000 (FY ending 6/27/92) Net income: ($2,795,507,000)

Digital was the first major system supplier to offer the CD-ROM as a system peripheral, using a Philips drive with the Micro-VAX product line. In 1988, DEC announced the RV20, which incorporates a 12", 1 gigabyte per side, write-once drive supplied by Laser Magnetic Storage. Digital also announced the RV64 jukebox (externally procured), which can handle up to four 12" drives, in 1989. In 1991, Digital announced a complete document imaging system, but continues to procure drives and libraries externally. As optical drive demand increases, Digital is a candidate for internal production of its own read/write optical drives, but internal development programs for optical drives are believed to have been put on hold for the moment.

DOCUMENT IMAGING SYSTEMS CORPORATION
543 Weddell Drive
Sunnyvale, CA 94089

DISC was founded in 1986 specifically to develop and manufacture customized optical libraries. The firm's products are built around a modular concept of configuring a system with an appropriate number of 5.25" optical drives, disk storage slots and picker mechanisms to meet customer performance needs. Trade-offs may be made between the number of drives (up to 110), pickers (up to 24) and disk storage slots (up to 2,290). The first commercial showing of the system was at the 1990 AIIM conference. Shipments began in 1991, with production volumes beginning in 1992.

DOCUPOINT CORPORATION
2701 Bayview Drive
Fremont, CA 94538

Docupoint, a document imaging systems manufacturer, is also manufacturing modular 5.25" optical library systems. The firm was founded in 1988. The present configuration holds up to 10 drives and up to 288 5.25" cartridges. Formal introduction of the library was made at the 1992 AIIM conference, with production shipments beginning in early 1993.

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1992 total net sales: $20,183,000,000 Net income: $1,146,000

Eastman Kodak has had two publicly announced optical disk drive production efforts, one a very high capacity 14" write-once optical disk drive and the other a low-end 3.5" magneto-optical drive. The latter product originated at Verbatim Corporation, acquired by Eastman Kodak in 1985. In the Spring of 1989, Eastman Kodak purchased a 40% ownership in Laserdrive and transferred the 3.5" drive development to Laserdrive. Laserdrive was merged into Literal Corporation, in which Eastman Kodak has a 26% interest, in 1990. Verbatim, which was sold to Mitsubishi Kasei in 1990, retained optical media and head development responsibilities.

The Eastman Kodak Photo CD system, which permits photo processing centers to transfer photographic images to write-once CD disks, began shipping in the last half of 1992. CD-ROM players, operating as part of a CD-I system, will be supplied by Philips (and other companies) to attach to consumer TV sets for playback of the images. Philips is also supplying the CD recorders. Kodak has expanded the role of the Photo CD products to include recording and distribution of other types of data, and is marketing software enabling use of Photo CD images and other types of files with IBM compatible personal computers.

The 14" drive began its production run in 1987, but production has been modest to date. It uses a zoned format and employs proprietary dye/polymer media. The drive is used in Eastman Kodak's image storage product lines and is also offered on an OEM basis as a computer peripheral. The company also purchases 12" optical drives from Hitachi and 5.25" optical drives from Literal for use in various product lines.

Eastman Kodak produces automated library units for use with its own 14" drive as well as a 5.25" library for use with purchased drives. Both libraries are also sold on an OEM basis. The firm also purchases library units for systems using 12" drives from other manufacturers.

FILENET CORPORATION
3565 Harbor Boulevard
Costa Mesa, CA 92626

1992 total net sales: $138,256,000 Net income: $(8,012,000)

Filenet, founded in 1982, is a producer of document image storage systems and subsystems including optical libraries. Systems are sold primarily to end users, but 12" libraries are also sold on an OEM basis. OEM customers for libraries have included IBM, N. V. Philips, Eastman Kodak and others. International system sales are handled by foreign subsidiaries and by distributors, most

notably Olivetti in Europe and Australia and Toyo Officemation, a Mitsui subsidiary, in Japan. The company is emphasizing its system business and de-emphasizing OEM library sales.

Production of optical libraries began in 1985. The Filenet product line is built around 12" drives, and offers some of the largest storage capacities available in a noncustomized optical library. Up to 288 disks can be stored in the largest Filenet system. Filenet has a major share of the 12" optical library market, with claimed cumulative shipments of over 600 systems, mostly 12", as of mid-1993. The firm also sells 5.25" libraries purchased from other sources, most recently including Hewlett-Packard.

Filenet is shifting the thrust of its product development activities to libraries able to store larger numbers of disks and to the development of complete systems and software for document imaging, processing and storage.

HEWLETT-PACKARD COMPANY
3000 Hanover Street
Palo Alto, CA 94303

1992 total net sales: $16,410,000,000 Net income: $549,000,000
(FY ending 10/31/92)

Hewlett-Packard announced a high performance 5.25" magneto-optic disk drive, code named Corsair, in 1991, for volume delivery in 1992. The firm had acquired some rewritable drive, technology and related assets from Optotech in 1989. The drives are produced in the Greeley, Colorado, facility, which has also been producing optical libraries since 1989. Some related work on optical and rigid drive technology is being done at H-P Laboratories. In 1989, H-P announced that it would sell the Sony 5.25" rewritable drive as an OEM or end user system peripheral in both standalone and jukebox configurations. The new H-P optical drives have gradually displaced the Sony drive in H-P system and subsystem products. In 1993, the firm announced a double capacity drive, the Corsair II, at the AIIM conference. The 5.25" drive, with 650 megabyte per side capacity, is planned to go into production status in mid-1993.

Write-once technology using magneto-optic media was proposed in 1990 by a group of 14 companies including H-P as the lead proponent. The media uses standard continuous composite servo format and uses information written in the media control track to identify media as write-once or rewritable.

H-P is a major producer of 5.25" optical libraries, with a product line spanning the range from 16 to 144 cartridge capacities. The libraries are used in H-P systems, but H-P also sells them to major OEM accounts.

In September of 1987, the firm announced it would distribute technical documentation for its computer systems on CD-ROM, and followed that up in June of 1988 with distribution of UNIX support information on CD-ROM.

HONEYWELL, INC.
Optical Storage Systems Operation
18401 North 25th Avenue
Phoenix, AZ 85023

Honeywell purchased Sperry's Optical Products Group and Aerospace Group at the time that Sperry and Burroughs merged to form Unisys, and combined them to form the Sperry Space Division. At the same time, Honeywell obtained Sperry's 9% share of ownership in ISI, now renamed as Literal Corporation. Honeywell is continuing development of a militarized drive based on Literal technology. Small quantities of a 300 megabyte 5.25" write-once drive began shipping in 1989 for use in a USAF system. Honeywell is currently developing a militarized rewritable magneto-optic drive for probable delivery in 1994. Capacity per side will probably be in the 400 to 600 megabyte range.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1992 total net sales: $64,523,000,000 Net income: ($4,965,000,000)

IBM started slowly in the optical storage area, but now manufactures or remarkets a variety of products, including CD-ROMs, write-once and erasable drives and optical libraries. IBM has also become a very active participant in the optical drive and media standards committees. Since the formation of Adstar, IBM has become more visible as a supplier of optical storage products. IBM has also become a significant distributor of software and documentation on CD-ROM disks.

IBM's optical program is directed from Tucson, Arizona, but as a result of a mid-1988 reorganization, some IBM optical products may be made in locations other than Tucson. The 5.25" optical drive development staff and laboratories remain in Tucson. Further development of 3.5" drives is under way in Fujisawa, Japan. Some advanced development is done at the Almaden research facilities.

Since May, 1986, IBM has demonstrated CD-ROM subsystems with various personal computers, and in 1990 CD-ROM drives were announced as options on the IBM RS/6000 system as well as on some PS/2 systems. IBM relies on outside purchases of CD-ROM drives at present and is judged unlikely to manufacture its own CD-ROM drives, with the possible exception of unique variants such as extended capacity versions targeted at selected markets. IBM is actively involved in the design of systems using multimedia techniques, the XA architecture and the Intel DVI format. These efforts involve a variety of optical drive types, including CD-ROM and magneto-optic drives.

In April, 1987, IBM announced the model 3363 write-once drive for use with its personal computers. The mechanism for this drive was obtained from Matsushita Electric; IBM supplied the electronics, software, and final assembly and

test. The product was unsuccessful, and shipments of mechanisms to IBM ceased in 1988. The 3363 was finally withdrawn from marketing in 1991.

In the spring of 1991, IBM announced a 3.5" 128 megabyte magneto-optic drive that had been designed at its Fujisawa facilities. The drive, which can also function as a read-only drive, is being sold with some PS/2 system models and on an OEM basis. IBM's entry into the 3.5" drive marketplace encouraged other firms to announce similar optical disk drives in the 1991-1992 time period, but IBM's slow rate of adoption, lack of 3.5" OROM published titles, and media interchange problems hampered initial sales. IBM, along with Sony, has pushed for a 230 megabyte standard for the next generation of 3.5" drives. Both companies are expected to introduce such drives in late 1993.

IBM's own 5.25" magneto-optic drive was shown at the 1991 COMDEX show and formally announced in 1992. This ISO standard drive was used in optical libraries sold by IBM and was also sold on an OEM basis. It is likely to be displaced by the double capacity 654 megabyte per side drive introduced by IBM in March, 1993. The new drive is also being used in IBM system libraries and sold to OEMs. IBM and Sony jointly proposed the 654 megabyte per side standard for next generation 5.25" optical drives and media.

IBM has purchased 12" optical drives and library modules for integration into subsystems since 1988, and in 1991 announced the 3995, a family of 5.25" libraries with write-once drives. Hewlett-Packard is the supplier of the library mechanisms, while Mitsubishi write-once drives have been shown with the libraries. IBM uses its own magneto-optic drives to provide rewritable storage for the libraries and announced libraries with double capacity drives in mid-1993. The company offers its optical library systems as attachments to large and mid-range systems used in image management applications. In mid-1992, IBM announced it would also support the libraries as virtual 3390 Model 2 drives, opening up opportunities to use optical technology as general purpose data storage in hierarchical systems operating under IBM's System Managed Storage architecture. IBM currently offers models of its 3995 that attach to its mainframes, the AS/400, RS/6000 and local area networks.

INTERNATIONAL DATA ENGINEERING
727 Washington Avenue South
Edina, MN 55439

Privately held IDE was founded in 1987. Originally the firm was involved in making data cartridge duplicators and tape cartridge stacker mechanisms, but in 1988 started developing a small optical library. The first products were tabletop libraries offering modest performance and capable of holding ten 5.25" cartridges and a single 5.25" drive. A 20 cartridge, two drive model was introduced in 1990. The libraries are being remarketed by subsystem producers and some optical drive producers. Because of the library's very low OEM and distributor prices, the firm was able to sell more libraries in 1990 and 1991 than any other producer.

A five cartridge version was introduced in 1991, and an 8 cartridge library for 3.5" drives made its debut in 1992. As of mid-1993, IDE was the leading supplier of tabletop 5.25" optical libraries.

KUBIK ENTERPRISES, INC.
18873 Allandale Avenue
Saratoga, CA 95070

Kubik is a start-up company that is producing optical libraries for CD and CD-ROM subsystems. Philips/LMSI drive mechanisms are used. The libraries are unusual in that they employ a rotary mechanism, not unlike that used in many slide projectors, to store disks. Single drive and multiple drive configurations with up to four drives are available. Kubik Technologies, located in Vancouver, is a separate organization originally authorized to manufacture Kubik Enterprises designs and use the Kubik name, but production authorization has been withdrawn and the libraries continue to be made in California. Kubik is expected to explore other contract manufacturing arrangements.

LITERAL CORPORATION
2768 Janitell Road
Colorado Springs, CO 80906

Literal began life as Information Storage, Inc. (ISI), in 1983, when it was founded by executives from Optical Peripherals Laboratory, the original Philips and Control Data joint venture for optical drive development. Among the early investors in ISI were CPT (20%) and Tallgrass (20%). Sperry, now incorporated into Unisys, also became a significant investor, and acquired rights to ISI technology for use in military systems. This product area, along with Sperry's investment, was subsequently sold to Honeywell. A funds shortage in early 1986 required scaling back the size of the company, but ISI was successful in attracting additional investment from local and foreign sources, in some cases by licensing its design. In 1986, ISI licensed two other firms, Maximum Storage, Inc., and Kawatetsu Advantech, to use ISI technology and designs. Both firms are currently in low volume production. Kawatetsu is a subsidiary of Kawasaki Steel, which is a current investor in Literal.

In 1990, Literal was formed by combining the operations of ISI and Laserdrive, which was jointly owned by Olivetti and Eastman Kodak. Laserdrive's operations were transferred to Colorado Springs by mid-1990. Olivetti and Eastman Kodak each own about 26% of Literal, and Kawasaki Steel holds about 21%. The remainder is held by earlier ISI investors. The initial ISI product was a 5.25" write-once drive of 122 megabyte capacity, aimed at the personal computer and small system peripherals market. Limited production began in the fourth quarter of 1985. In February, 1988, ISI announced a 600 megabyte per side, 5.25" write-once drive for volume delivery in late 1988. The drive uses a technique called track compression to achieve the higher capacity.

Literal's current efforts are heavily oriented to ramping up production of newer optical drives, and developing device drivers for various operating systems. Development was started on a small diameter magneto-optic drive based upon the Verbatim technology obtained from Laserdrive, but this effort has been suspended and the firm is concentrating its development efforts on higher capacity write-once 5.25" drives.

MARTIN MARIETTA (Formerly General Electric Aerospace)
Government Communication Systems Division
Front and Cooper Streets
Building 13-3-1
Camden, New Jersey 08102

A 14" optical drive based storage system for the U.S. Air Force and NASA has been under development since the mid-eighties. Only a few high performance drives have been sold and the effort is more of an ongoing R&D program than an attempt to create a product for general sale. General Electric was the original supplier, but the operation was sold to Martin Marietta in 1993. The original systems were write-once, but rewritable technology is scheduled for delivery in 1993. Write-once media has been supplied by Eastman Kodak, while 3M has supplied experimental 14" rewritable media. Special 14" optical libraries are also under development.

MAXIMUM STORAGE, INC.
5025 Centennial Boulevard
Colorado Springs, CO 80919

Privately held, MSI was founded in September, 1986, by Paul Schroeder, one of the founders of INMOS. Start-up was rapid, as MSI licensed technology from ISI and began producing a 5.25" write-once drive similar to the ISI drive in early 1987. MSI has designed its drives for use with IBM PC and PC-compatible computers, and developed its own software to optimize data throughput in write-once drives. Shipments are at low levels, mostly to existing customers.

MAXOPTIX CORPORATION
Joint venture of Maxtor Corporation and Kubota, Ltd.
2520 Junction Avenue
San Jose, CA 95134

In March of 1989, Maxtor and Kubota, Ltd. formed Maxoptix, a joint venture now 65% owned by Maxtor. Maxoptix designs, produces and markets rewritable optical disk drives. Kubota has worldwide manufacturing rights and exclusive sales rights in Japan for Maxoptix products. Maxoptix has followed a strategy of emphasizing leading edge performance and capacity, as well as increasing the functional capabilities of its optical drives with each new product introduction.

Maxtor is a supplier of high performance 2.5", 3.5" and 5.25" rigid disk drives. In 1986, Maxtor entered into an agreement with Ricoh in which Maxtor acquired exclusive U.S. OEM marketing rights for the Ricoh 5.25" write-once optical disk drive. Because of Maxtor's strong market penetration in the OEM community, this was a successful effort for both parties, although shipment volume of the write-once drives has flattened out.

In May, 1988, Maxtor announced a 5.25" magneto-optic rewritable drive offering 35 millisecond average seek time, the industry's fastest at the time. Evaluation units began shipping in late 1988, and volume production began in late 1989. Maxtor also announced a 3.5" erasable drive to be supplied by Seiko Epson, but this product was later withdrawn. The rewritable drive program was turned over to Maxoptix for further development and eventual manufacturing. An improved version with similar specifications but improved electronics was introduced in 1991. In 1992, Maxoptix introduced a multifunction 5.25" drive and an upgraded version of the Ricoh write-once drive incorporating embedded data compression. A double capacity drive was introduced in June, 1993.

MOUNTAINGATE DATA SYSTEMS (Formerly Cherokee Data Systems)
1880 S. Flatiron Court
Boulder, CO 80301

MountainGate is the successor corporation to Cherokee Data Systems. Cherokee Data was founded in March, 1984. The firm's key founders included managers previously with Storage Technology Corporation and Sperry Corporation. Cherokee designed a 300 megabyte ruggedized 5.25" write-once drive that it supplied to customers in the defense and mineral resources industries. Shipments began in 1988. The first major customer for the Cherokee drive was Lockheed Corporation, which announced in 1986 that it had invested $2,000,000 in Cherokee and intended to modify the product for potential use in airborne electronic navigation systems for fighter aircraft. Later investments brought Lockheed's share of ownership to 36%. The firm has shipped a modest number of drives since 1988. A nonruggedized version of the drive became available in late 1989. In 1992, Lockheed purchased the remaining interest in Cherokee and moved headquarters to Orange, California, and the factory to a new facility in Reno, Nevada. The name of the organization was changed from Cherokee Data Systems to MountainGate Data Systems at that time.

MOUNTAIN OPTECH, INC.
4775 Walnut Street
Boulder, CO 80301

Mountain Optech, founded in 1985, specializes in optical disk drives for ruggedized and military applications. Its first product was a modified version of the Optotech 5.25" write-once drive, delivered in 1986. The modified drives are

used in harsh environments such as seismic survey, aircraft maintenance, and manned spacecraft. The mechanism and electronics have been modified for ruggedized or militarized requirements.

The firm has begun designing its own drives which will include advanced features such as digitally adaptive read/write electronics. A militarized write-once drive for use in an airborne digital mapping system was delivered in late 1990. An upgraded ISO-compatible version was first shipped in 1992, as was a ruggedized version of a currently available 5.25" magneto-optic rewritable drive.

NEW VISION TECHNOLOGIES
3455 Morgan Avenue N.
Minneapolis, MN 55412

New Vision is a startup that is attempting to use the Capacitance Electronic Disk technology originally developed by RCA for videodisks to produce very high capacity read-only computer peripheral devices. CE-ROM, as the firm calls its intended product family, is still on the drawing board, but is being considered for further development on a partnership basis by several firms.

OPTEX CORPORATION
2 Research Court
Rockville, MD 20850

Founded in 1986, Optex is working on development of rewritable optical disk drives using electron trapping as the recording technology. The materials used are capable of sustaining very high storage densities, but are sensitive to ambient light. However, write rates can be high because there are no thermal inertia effects as there are in magneto-optic or phase change systems. The drives are still in development, and there has been no indication from Optex as to an introduction date of a computer peripheral. Optex has indicated a shift in focus to serve the needs of the broadcast and video editing markets.

PINNACLE MICRO
19 Technology Drive
Irvine, CA 92718

Pinnacle Micro is best known as a subsystem producer and remarketer of optical drives and libraries, but in 1992 the firm began assembling a 5.25" rewritable drive using a purchased mechanism and electronics supplied by Pinnacle. The firm maintains a small development center for optical products in Colorado Springs.

Asian Manufacturers

(All fiscal years end in March, 1992, unless otherwise noted. All companies are in Japan unless otherwise noted.)

AISIN SEIKI CO., LTD.
2-1 Asahi-cho, Kariya-shi
Aichi 448

1992 total net sales: $6,299,685,000 Net income: $93,222,000

Aisin Seiki, a member of the Toyota Group, was established in 1949. The firm's primary activity, about 95% of revenues, is the production of automotive components, but it also produces home and industrial appliances, air conditioning equipment, and cryogenic pumps. Electronic products, including optical libraries, are an area of diversification.

Optical libraries are produced under Aisin's own name and are also produced for other firms on a contract basis. At present, only library units with 5.25" drives are produced. Both write-once and rewritable drives are used. Production started in 1988, but the first libraries with rewritable drives shipped in 1990.

ALPS ELECTRIC CO., LTD.
1-7, Yukigaya Otsuka-cho
Ohta-ku, Tokyo 145

1992 total net sales: $3,632,433,000 Net income: $57,535,000

Alps Electric is a major manufacturer of electronic components and subassemblies for audio, television, instrument and computer applications. Peripheral devices, including printers, floppy and rigid disk drives, accounted for 19% of revenues in 1992. Alps has been working with other companies wishing to supply CD-ROMs and is able to supply design assistance, components, and to manufacture on a contract basis.

ASACA CORPORATION
2-4-1, Nishi-Shinjuku
Shinjuku-ku, Tokyo 163

Founded in January, 1971, Asaca is best known as a supplier of video broadcasting equipment, producing the first Japanese stationary head VTR and the first portable video camera. In 1993 the firm diversified, announcing a high bandwidth optical disk drive and a supporting optical library. The optical drive uses a unique recording format and can read or write eight simultaneous tracks on magneto-optic media, reaching a 12 megabyte/second read rate. The media cartridge holds 600 megabytes per side. Broadcasting and video editing applications remain the primary target markets.

Asaca has shown a prototype 1200 cartridge library, but the company's library focus is on a 450 cartridge unit now entering production.

CANON INC.
2-7-1, Nishi-Shinjuku
Shinjuku-ku, Tokyo 163

1992 total net sales: $15,074,157,000 (FY ending 12/31/92) Net income: $282,709,000

Canon is a major supplier of business machines, copiers, and cameras, but about 38% of the firm's business is in computer peripherals. Another 15% is in other data and communications equipment. Disk drive products include flexible and erasable optical drives. Canon's rewritable optical drive and media were announced in 1988 when Canon formulated an exclusive agreement with NeXT to supply a 256 megabyte 5.25" magneto-optic drive. Shipments began in 1988, making Canon, along with Sony, one of the early suppliers of rewritable drives. In 1989, Canon acquired a 16% interest in NeXT. NeXT was not successful in establishing optical drives as a major system peripheral storage device, and currently Canon ships its optical drives for use in its own document management systems.

The firm has publicly discussed a 350 megabyte, high performance 3.5" drive, but does not anticipate manufacturing the product before 1995.

CHINON INDUSTRIES INC.
1-21-17, Takashima
Suwa City, Nagano 392

1992 total net sales: $428,205,000 Net income: ($26,315,000)

Chinon is best known for its cameras and audio equipment, but 77% of its sales come from floppy disk drives, printers and other equipment for information systems. Eastman Kodak holds approximately 12.3% ownership through Kodak Japan. Chinon has been producing head assemblies for CD equipment and in 1988 began supplying CD-ROM drives to Atari as a custom product. A similar drive has since appeared under Chinon's own label for use with IBM and Apple personal computers. A 128 megabyte 3.5" drive was announced in 1992.

FUJITSU, LTD.
1-6-1, Marunouchi
Chiyoda-ku, Tokyo 100

1992 total net sales: $27,101,945,000 Net income: $96,142,000

Fujitsu is Japan's largest producer of computer systems and also manufactures a wide variety of other electronic equipment. Computer products represented about 75% of Fujitsu's 1992 sales.

Fujitsu announced a write-once 12" drive for use in document storage systems in 1984. The product is currently marketed only in Japan. In 1986, the

company added a similar product for sale in Japan on an OEM basis. The head for the drive was developed in a joint effort with Olympus Optical Company, the industry's leading supplier of optical read/write heads. Media was developed in a joint program with Asahi Chemical. In October, 1986, Fujitsu announced a 5.25" write-once drive with 300 megabyte capacity for delivery in mid-1987. Fujitsu has a development program for erasable optical disk drives and media, and has made a technology announcement of rewritable media using phase change techniques, but has not yet announced such a product. However, an 8", non-removable M-O rewritable drive with 8.9 gigabyte capacity was introduced in 1989. It, also, is offered only in Japan.

In 1989, Fujitsu began to ship a computer system with a bundled CD-ROM drive, one of the first companies anywhere to take such a step. It is currently available only in Japan, but has been displayed in the U.S. and elsewhere. The CD-ROM drive is purchased from another firm.

Since 1992, Fujitsu has been shipping a 5.25" optical library and a high performance 5.25" rewritable drive jointly developed with NTT. It is the first 5.25" optical drive to rotate at 5,400 RPM. Fujitsu also scored another "first" with its August, 1992, announcement of a 25.4 millimeter high 3.5" 128 megabyte magneto-optic disk drive. Since that time, Fujitsu has begun pricing its 3.5" products aggressively, and the firm is widely expected to be among the earliest to introduce a 230 megabyte 3.5" drive.

GOLDSTAR COMPANY, LTD.
20 Youido-dong
Yongdungo-gu
Seoul
Republic of Korea

GoldStar, a leading member of the Lucky-GoldStar group, was founded in 1959, and is one of Korea's major producers of consumer electronics. GoldStar's current strategy involves expansion of its industrial electronics divisions, including computers and peripherals. The company currently offers internal and external CD-ROM drives, and has announced a CD-I player, to be produced in Korea under a Philips license.

HITACHI, LTD.
6-2, Otemachi 2-chome
Chiyoda-ku, Tokyo 100

1992 total net sales: $61,146,024,000 Net income: $1,004,811,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major producer of computer systems. It manufactures rigid disk drives and other peripherals as well as processors. About 48% of 1992 revenues were derived from computing and electronic equipment.

Hitachi was one of the earlier entrants in the optical disk drive market, and the firm's CD-ROM and read/write drives are available in the U.S. as well as in Japan. Hitachi's first write-once 12" optical disk drive has a capacity of 1.3 gigabytes, and began shipping in 1984. In addition to drives, Hitachi makes components used in optical drives such as lasers and special chips.

The CD-ROM drives began shipping in 1985, and since 1987 Hitachi has targeted the high performance drive segment of the market because of its more stable price structure and higher margins. The CD-ROM product line was expanded in 1986 and 1987 to include 5.25" form factor drive packaging and some new features. Later products have emphasized performance improvements and half high form factors. Hitachi is also a major producer of components used in CD-ROM drives.

In early 1986, Sperry announced that the Hitachi 12" write-once optical drive was available as a peripheral device on its mainframes -- the first optical drive offered by a mainframe vendor. A 5.25" continuous servo write-once drive with a capacity of 300 megabytes was announced at COMDEX in 1986. A sampled servo version offering 320 megabytes per side was introduced in late 1987, but was not commercially successful.

In early 1988, Hitachi made a technology announcement of a 3.5" erasable drive under development in its Central Research Laboratory, but the first Hitachi rewritable drive to be announced was a 322 megabyte, 5.25" model in March of 1989. The firm is one of the active proponents of a 5.25" one gigabyte per side magneto-optic drive and displayed a semi-operating prototype at the 1993 AIIM conference. Industry expectations are for formal announcement of this optical disk drive as early as late 1993.

Hitachi also offers automated library storage units for use with 12" and 5.25" drive designs and has successfully marketed its libraries on an OEM and captive basis. Media for Hitachi drives is made by Hitachi Maxell. Hitachi's optical libraries have sold well in Japan, but have had difficulty capturing an appreciable share of the U.S. market.

JVC (VICTOR COMPANY OF JAPAN, LTD.)
1-4 Nihonbashi-Honcho
Chuo-ku, 103 Tokyo

1992 total net sales: $6,603,693,000 Net income: $15,669,000

JVC, as it is commonly known, is a major producer of consumer audio equipment, including CD players. Video tape recorders accounted for 42% of JVC sales in 1992, but JVC has been expanding into computer peripherals and has been shipping rigid disk drives since 1985. Computer related products now account for about 13% of revenues. The firm introduced CD-ROM drives and went into low volume production in the last half of 1987, but has since withdrawn

from the CD-ROM market. A CD-WO drive first shown at the 1990 Fall COMDEX conference went into sample production in late 1991, along with additional mastering subsystems. Full production began in the second quarter of 1992, and JVC has since become a price leader for this type of CD product.

A 2.4" (61 millimeter) 43 megabyte magneto-optic drive was shown at the 1991 Fall COMDEX show, but this was a preliminary showing intended to gather potential customer reaction. JVC hoped to find applications in portable computers and games, but decided not to market the drive.

KAWASAKI STEEL CORPORATION
2-3 Uchisaiwai-cho, 2-chome
Chiyoda-ku, Tokyo 100

1992 total net sales: $10,584,756,000 Net income: $113,346,000

Kawasaki Steel entered the optical drive market through Kawatetsu Advantech, a subsidiary company specializing in electronic instrumentation. The firm began producing 5.25" write-once optical disk drives at its Nishinomiya plant in December of 1986 under license from ISI, now Literal Corporation. Kawasaki Steel markets the drives under the Kawatetsu name to OEM customers in Asian markets through Kanto Denshi, a trading company, and may act as a source of supply to Literal as demand warrants.

In 1988, Kawatetsu Advantech, Kawasaki Steel and four private investors established Advansys Corporation, which is chartered to develop components for optical disk drives. Advantech holds 50% ownership and Kawasaki Steel an additional 25%. Kawatetsu Advantech is maintaining its relationship with Literal, and has begun shipping 5.25" drives based on the ISI 600 megabyte design. The firm also uses drives from other companies in a line of intelligent storage subsystems that emulate hard disks. In addition to the write-once optical drives, Kawasaki manufactures hard disk emulators incorporating optical drives.

LASERBYTE CORPORATION
1330 Bordeaux Drive
Sunnyvale, CA 94089

Laserbyte was founded in 1990 by former employees of Verbatim who had developed Verbatim's 3.5" magneto-optic drive technology. In early 1991, the founders sold a 55% share in Laserbyte to Hyundai, in order to obtain development funds and technical assistance.

The firm announced its first product, a 3.5", 128 megabyte M-O drive in June, 1993. The drive also supports OROM and PROM media. Hyundai will provide volume manufacturing for the drive, and Laserbyte will also maintain a low volume production facility.

MATSUSHITA ELECTRONIC COMPONENTS CO., LTD.
Subsidiary of Matsushita Electric Industrial Co,. LTD.
1006, Kadoma City
Osaka, 571

1992 total net sales: $3,008,236,000 Net Income: $811,000

MACO, as the company is often known, produces a wide variety of electronic items, including audio/visual equipment, appliances, communications and data processing equipment, and instrumentation. Data storage products include CD-ROM drives and floppy disk drives. Half-high CD-ROMs began shipping in 1987, mostly to customers in Japan, for which MACO is a significant OEM supplier of CD-ROM drives.

MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.
1006, Kadoma City
Osaka, 571

1992 total net sales: $58,660,890,000 Net income: $1,046,244,000

MEI's Panasonic, National, Technics, and Quasar brands are among the most widely known in the world for appliances, consumer electronics, and communications equipment. The firm also developed an 8" write-once drive for use by Matsushita Graphics Communication Systems in captive document storage systems. Matsushita-Kotobuki Electronics produces CD-ROM drives for sale by MEI. High volume production commenced in 1991.

In April, 1987, IBM announced a 200 megabyte write-once disk drive whose mechanism was produced for IBM by Matsushita Electric's Disk Division. The product was not a commercial success, although MEI offered similar products under its own brand. The MEI branded product was similarly unsuccessful.

In 1989, the Disk Division of MEI acquired the responsibility for manufacturing and marketing of the Matsushita Communication Industrial optical disk drive product line, adding rewritable drives and optical libraries to the MEI product line. Production of a 470 megabyte 5.25" write-once drive began in the Fall of 1989. MEI has captured a major share of the 5.25" write-once market with this drive.

In 1990, Matsushita announced the first commercially available rewritable phase change drive and media. This 5.25" drive will also accept write-once media, permitting it to operate as a multifunction drive as well. Because no overwrite pass is required, write throughput exceeds that of magneto-optic re-writable drives. However, its unique format and technology have inhibited broad industry acceptance.

MATSUSHITA-KOTOBUKI ELECTRONICS IND.
2-2-10 Kotobuki-machi
Takamatsu-shi 760

Matsushita Electric Industrial owns 57.6% of MKE, which was established in 1948. MKE is a widely known producer of VCRs and other consumer electronic items, some of which are sold by the Matsushita companies and some by other firms. Data storage products are a recent addition to the product line, including rigid disk drives made for Quantum, Floptical disk drives made for Insite Peripherals, and CD-ROMS. CD-ROM production, which commenced in 1992, is expected to become quite large, making MKE one of the leading CD-ROM manufacturers in 1993. Much of MKE's CD-ROM output will be marketed through other Matsushita companies.

MITSUBISHI ELECTRIC CORPORATION
2-2-3, Marunouchi
Chiyoda-ku, Tokyo 100

1992 total net sales: $26,324,969,000 Net income: $284,047,000

Mitsubishi is most noted for heavy machinery production, but is also active in defense electronics and consumer electronics. Data and communication systems represent 34% of sales. In 1987, Mitsubishi introduced a 5.25" 300 megabyte write-once optical drive with 80 millisecond average access time. The drive is sold as part of an optical storage library system that can contain as many as two drives and 152 disks. Higher performance 5.25" M-O type rewritable drives began to ship in the second quarter of 1990. All of Mitsubishi's library products are configured with 5.25" drives, but only libraries with rewritable drives were being marketed as of mid-1993 and these only in Japan.

A 128 megabyte 3.5" magneto-optic drive was announced by Mitsubishi in 1991, but the firm presently manufactures only 5.25" models.

A Mitsubishi write-once drive using a mechanism similar to its rewritable drive was shown by IBM as part of its optical library subsystem in the Spring of 1991 and this drive continues in the IBM product line as of 1993.

MITSUMI ELECTRIC CO., LTD.
8-8-2 Kokuryo-cho
Chofu-shi, Tokyo

1992 total net sales: $1,406,669,000 Net income: $22,929,000

Mitsumi, founded in 1949, is primarily a manufacturer of electronic components, but 21% of 1992 revenues were derived from floppy disk drives and 8% from magnetic heads. The firm introduced CD-ROM drives in 1988, with most of

the drives being sold as attachments to personal computers. Later models have been designed for use with games. Front tray loading drives not requiring a caddy were introduced in 1993. Mitsumi is making a major effort to market CD-ROM drives to firms selling multimedia equipment.

(MOST) MASS OPTICAL STORAGE TECHNOLOGIES
Subsidiary of Nakamichi Corporation
11205 Knott Avenue
Cypress, CA 90630

MOST was formed in 1987. The firm is engaged in the design and manufacture of 3.5" M-O rewritable disk drives. Sales to the VAR/VAD distribution channel are made (nonexclusively) through Ocean Microsystems, another Nakamichi subsidiary. Production of a 128 megabyte 3.5" drive developed by MOST and Nakamichi began in late 1990. A 256 megabyte drive using a GCR recording format was announced in 1991, with shipments to begin in 1992. In early 1993, Nakamichi, MOST's parent firm, acquired the Optical Products Division of Applied Magnetics and placed it within MOST, where it continues to produce optical drive heads and mechanisms.

NAKAMICHI CORPORATION
1-153, Suzuki-cho
Kodaira City, Tokyo 187

1992 total net sales: $204,291,000 (FY ending 2/28/92) Net income: ($12,323,000)

Best known for its top of the line audio equipment, Nakamichi has had an optical disk drive development program for several years, as well as laboratory equipment for optical disk drive development. About 3% of 1992 sales were computer related items. Nakamichi established or purchased several organizations in the United States, including MOST, Mountain Computer, and Ocean Microsystems. Ocean Microsystems is responsible for marketing optical subsystems using the MOST drive. In September, 1990, Nakamichi established Nakamichi Peripherals Corporation, a holding company that supervises the operations of MOST, Mountain, and Ocean.

Responsibility for Nakamichi's line of optical disk test equipment has been transferred to Mountain Computer, which manufactures a variety of test and certification equipment. A 128 megabyte 3.5" rewritable drive developed by MOST and Nakamichi, appeared in 1990, the first 128 megabyte 3.5" M-O drive to reach the marketplace. Nakamichi markets the MOST drives in Japan.

NEC CORPORATION
5-33-1, Shiba
Minato-ku, Tokyo 108

1992 total new sales: $29,715,354,000 Net income: $120,283,000

NEC has defined its product area as communications and computers, with computer products accounting for about 51% of 1992 revenues. The firm has the largest share of the Japanese personal computer market. NEC makes a variety of data storage products, including floppy, rigid and optical disk drives. The firm's first optical drive, which was introduced in 1983, was a 1 gigabyte, 12" unit used primarily for NEC captive document storage systems, but also sold on an OEM basis. A 1.8 gigabyte drive was marketed in 1987 and a 2.5 gigabyte drive was introduced in 1990. A 5.25" M-O rewritable drive started production in mid-1989, and a 650 megabyte per side version was introduced in mid-1993. NEC also offers optical libraries with 12" drives and with 5.25" drives, mostly sold in Japan.

NEC Home Electronics is producing CD-ROM drives for both captive use and worldwide OEM sale, and has had moderate success with a modified CD audio drive as a CD-ROM add-on to its popular PC Engine consumer system. A 1990 attempt to market a similar product in the U.S. was not successful, but NEC is expected to try again with a more powerful game system.

In 1992, NEC introduced CD-ROM drives that operate with a doubled rotation and data transfer rate in order to accommodate multimedia video requirements. The firm also produces a series of portable CD-ROM units easily switched between computers. As a result of increased demand beginning in late 1992, NEC has significantly expanded its production capacity for CD-ROM drives.

NIKKYO CORPORATION
480 Minoridai
Matsudo-shi, Chiba 271

Nikkyo was founded in 1947 and started as a producer of metal parts. Starting in 1956, the company diversified into the production of electrical and electronic components and equipment.

Optical libraries are produced for the data processing and entertainment markets. Videodisk changers proved to be an entry into similar products for computer applications. The computer related products include both 12" and 5.25" libraries manufactured on a contract basis for a number of system producers. Nikkyo is one of Japan's highest volume producers of optical libraries for computer use and a major producer of libraries for videodisks.

Having established itself as a manufacturer of optical libraries on a contract basis, Nikkyo began selling 5.25" optical libraries under the Alaya brand in 1993.

NIKON CORPORATION
3-2-3, Marunouchi
Chiyoda-ku, Tokyo 100

1992 total net sales: $2,144,646,000 Net income: $42,339,000

Nikon, a member of the Mitsubishi group, is best known for its popular line of cameras and other optical equipment. The firm is also a significant supplier of semiconductor production equipment, medical optical instruments, microscopes and telescopes, and other optical instruments. As a way of expanding its scope of business, in 1992, Nikon introduced the first 12" magneto-optic drive sold as a computer peripheral device, a 2 gigabyte per side erasable optical drive. Additional opportunity for Nikon may lie in an innovative media design that solves the overwrite problem exhibited by current magneto-optic media designs. However, it will take additional time for Nikon to fully commercialize the technology.

NIPPON STEEL CORPORATION
Electronics and Information Systems Group
10-1 Fuchinobe 5-chome
Sagamihara-shi, Kanagawa 229

At the 1992 Fall Comdex, Nippon Steel and Sankyo Seiki jointly exhibited a prototype 5.25" magneto-optical drive featuring direct overwrite. While the media offers 326 megabytes per side, only one side can be used. Aside from the restriction to one side, disks are otherwise compatible with ANSI/ISO standard media. Two sided disks can be used if only reading is required. The drive uses a flying magnetic head to orient the magnetic field while the laser is writing.

At the time of the exhibit, pricing and a firm introduction schedule were not available, although it was indicated that if market response was favorable, the drive might be available in 1994.

NKK CORPORATION
1-1-2 Marunouchi
Chiyoda-ku, Tokyo 100

1992 total net sales: $15,208,512,000 Net income: $63,472,000

NKK, founded in 1912, originally was a steel pipe producer. It is now one of Japan's largest steel producers and is diversifying into other areas such as electronics, automation, CAD/CAM systems, biotechnologies, advanced materials and urban development. Steel represents about 71% of the firm's revenues. Optical libraries were originally the responsibility of the Electronics Division, but in 1993, optical libraries were transferred to NK-EXA, a subsidiary originally formed to support NKK's internal data processing operations but which now has an expanded role and provides system integration services and peripheral equipment to outside customers. The NKK brand name will be retained.

NKK is offering optical libraries with both 5.25" write-once and rewritable drives. The 56 disk library unit was developed jointly with another manufacturing company. First shown in 1989 at the Spring COMDEX show, it is being marketed on a worldwide basis and has appeared in numerous document management systems. A variety of write-once and erasable drives are offered in the library, with the most recent addition being Pioneer's multifunction 5.25" drive. In 1992, a larger library with a maximum capacity of 160 cartridges was added to the NKK product line. A 20 cartridge 5.25" library was introduced in 1993.

OLYMPUS OPTICAL CO., LTD.
22-2, Nishi-Shinjuku 1-chome
Shinjuku-ku, Tokyo

1992 total net sales: $2,048,118,000 Net income: $39,984,000

Founded in 1919, Olympus Optical company is known primarily for its cameras and optical instruments. In recent years the company has broadened its activities to include electronics and some specialty products, including optical heads for disk drives. Development of optical disk drive technology began in 1981 when Olympus and Fujitsu began a joint project that resulted in one of the first commercial write-once optical disk drives. The firm's optical electronic products include optical heads, an optical card reader compatible with the Drexler Lasercard and a 5.25" erasable optical disk drive announced in November, 1987. The disk drive, which has a capacity of 326 megabytes per side, was provided in sample quantities as of mid-1988, and Olympus mechanisms have been adopted by Ricoh and others as the basis of their own rewritable drives.

A 3.5" 128 megabyte drive is currently marketed as an Olympus product; the company is currently expanding its marketing channels in the United States for the drives.

PIONEER ELECTRONIC CORPORATION
4-1, Meguro 1-chome
Meguro-ku, Tokyo 153

1992 total net sales: $4,826,843,000 Net income: $224,165,000

Pioneer, founded in 1947, is a major manufacturer of consumer electronic equipment. 98% of Pioneer's 1992 revenues came from sales of audio and video equipment. The firm is especially strong in the laserdisc and automotive audio CD markets.

Pioneer and Ricoh had a joint development program on an 8" 750 megabyte optical write-once disk drive, with Ricoh being Pioneer's most significant customer for the product. First shipments began in late 1985, and Pioneer has established a separate division to make and sell the product. Pioneer has also developed a 5.25" write-once drive, with first shipments in mid-1988. The media

used in these drives is a cyanine dye-based type that appears to offer superior resistance to corrosion. The active layer is placed on the PMMA substrate by spin coating, a relatively inexpensive production process. Pioneer's media is the first commercial version of dye-based media to be brought to market. In 1989, Pioneer introduced a CD-ROM drive integral to an automatic library mechanism. The library contains up to six disks and is derived from a design developed for use with audio CD players and disks. A version with quadruple rotation and data transfer rate was first shipped in the Fall of 1992. At the 1993 AIIM show, Pioneer displayed prototypes of an 18 disk version, now scheduled for production in late 1993.

In 1990, Pioneer introduced a multifunction drive using dye or M-O media interchangeably. The drive uses sampled servo format. This drive and other Pioneer 5.25" drives are being resold by certain drive producers who have not yet put their own designs into production.

RICOH CO., LTD.
15-1, Minami-Aoyama 1-chome
Minato-ku, Tokyo 107

1992 total net sales: $8,011,157,000 Net income: $16,071,000

Copiers, photographic equipment, and sensitized papers provide most of Ricoh's revenues, but the firm also produces a growing line of data processing equipment, which accounted for 27% of 1992 revenues. Ricoh has been Pioneer's partner in the development of an 8" write-once optical drive which Ricoh uses in a document storage system, and the firm showed a prototype OEM 8" write-once drive at the 1986 NCC show. However, Ricoh has concentrated upon developing optical disk drives in the 5.25" form factor, rather than expending further effort on an 8" product.

In early 1987, Ricoh and Maxtor entered an agreement whereby Maxtor is the exclusive marketing agent for Ricoh OEM 5.25" write-once optical disk drives in the United States. Ricoh is marketing subsystems containing optical drives in the U.S., an activity permitted under the terms of the Ricoh-Maxtor agreement. Since 1987, Ricoh has supplied more write-once drives than any other manufacturer, largely as a result of its collaboration with Maxtor. The Ricoh-Maxtor agreement for write-once drives continues, even though Maxtor went its own way with rewritable drives. Ricoh has also announced two generations of 5.25" optical libraries, the newer of which is made for Ricoh on a contract basis.

In 1988, a half high version of its original 5.25" optical disk drive design was announced. Also in 1988, Ricoh adopted a rewritable drive mechanism supplied by Olympus on an exclusive basis, and, supplying the required electronics and packaging, began shipping a rewritable 5.25" 300 megabyte per side optical drive in the second quarter of 1989. In early 1990, Ricoh announced a multifunction drive using magneto-optic rewritable media with 220 megabyte capacity per side and 393 megabyte per side write-once media. An ISO-standard high per-

formance 5.25" rewritable drive was introduced in 1991. A 3.5" 128 megabyte drive announced in 1991 was made for Ricoh by another Japanese firm, but Ricoh has since begun manufacturing a drive of its own design.

SANYO ELECTRIC CO., LTD.
2-18 Keihan-Hondori
Moriguchi, Osaka 570

1992 total net sales: $12,329,063,000 (FY ending 11/30/92) Net income: ($10,150,000)

Sanyo is a major supplier of facsimile equipment, consumer electronics, appliances, batteries and components such as solar cells, and is one of Japan's more active offshore manufacturers. About 28% of sales are computing and business equipment. Sanyo is actively involved in CD equipment and media production and introduced a CD-ROM drive in 1987. Shipments began in 1988. Half high drives began shipping in 1989, and a portable version was introduced in 1991, a CD-ROM product category that Sanyo continues to emphasize.

SEIKO EPSON CORPORATION
80 Hirooka
Shiojiri-shi, Nagano 399-07

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also control Japan's Seiko companies, known for watches and electronics. Epson is best known for its line of printers, but also manufactures a portable computer, displays, paper tape equipment, and floppy and rigid disk drives. In 1988, Epson agreed to supply Maxtor with a 160 megabyte 3.5" erasable optical disk drive and media then under development. While plans to deliver such a drive to Maxtor have been terminated, Seiko Epson has continued its development program, announcing a 128 megabyte 3.5" drive in 1992. However, the firm has elected to remarket certain 3.5" and 5.25" models rather than produce them internally.

SHARP CORPORATION
22-22 Nagaike-cho
Abeno-ku, Osaka 545

1992 total net sales: $12,234,465,000 Net income: $307,535,000

Founded in 1935, Sharp was originally a producer of mechanical pencils. Sharp is now a supplier of electrical and electronic equipment for both consumer electronics and office automation. About 49% of sales are derived from computer or computer related products, including desktop and transportable personal computers. Sharp has actively developed magneto-optic disk drives and media for several years and has made several technology announcements during this

period. In mid-1987, the firm announced a 5.25" 190 megabyte erasable optical drive. An improved 325 megabyte version began production in 1990 and a 41.3 millimeter high version in 1992. In 1993, Sharp introduced an 80 millimeter CD-ROM drive as a part of its Electronic Organizer system.

Sharp is a Sony licensee for the MiniDisc system and could be expected to produce a computer peripheral version of the MiniDisc once Sony establishes the parameters for such a product.

SONY CORPORATION
6-7-35, Kitashinagawa
Shinagawa-ku, Tokyo 141

1992 total net sales: $30,829,890,000 Net income: $945,835,000

Sony is a leader in consumer electronics and has also earned a position as a leading supplier of 3.5" floppy disk drives. TV, VCR, and audio products make up about 80% of revenues. Sony also holds the largest share of the magneto-optic disk drives and high performance CD-ROM drive markets.

Sony is fielding a product line of CD-ROM, write-once and rewritable optical drives. The write-once product line includes 12" drives with up to 3.3 gigabyte per side capacity, while the rewritable drives are 5.25" and 3.5" ISO standard models. The rewritable drive product line is being aggressively developed. An 8" write-once drive produced earlier has been discontinued. To support its write-once drives, Sony offers an automated library unit, first shown at COMDEX in the Fall of 1985. A smaller library holding 12 cartridges was introduced in mid-1992.

Sony is vertically integrated and supplies its own media. The company is currently the largest producer of magneto-optic media. Because of its strong position in the audio CD player market, Sony is very competitive in the CD-ROM marketplace with products aimed at the personal computer and small systems market. Sony, together with Philips, has been a moving force in establishing standards for CD and CD-ROM devices and in the CD-I multimedia standards effort. Sony showed a writable CD format drive as part of a CD-ROM mastering system at the 1990 Microsoft Conference but does not intend, at least for the moment, to sell the drive separately. In mid-1990, Sony introduced the Data Discman, a portable CD-ROM system using the first 3.15" CD-ROM drive to go into production. The product was introduced in the U.S. in late 1991, although software availability is still limited.

In 1987, Sony announced and shipped its first few erasable 5.25" optical drives, using magneto-optical technology. Production units were shipped in late 1988, and Sony has been successful in capturing the largest market share for rewritable drives. From 1989 through 1992, Sony was the largest supplier of rewritable optical disk drives, and claimed over 150,000 cumulative shipments by mid-1992. Sony, with IBM and others, is a proponent of the 654 megabyte per side proposed standard, and announced such a drive in the spring of 1993.

Sony introduced a 3.5" 128 megabyte rewritable drive in mid-1991. The drive has a specified average seek time of 40 milliseconds and rotates at 3,000 RPM, among the faster optical drives. Another 1991 Sony announcement concerned the MiniDisc, a 2.5" magneto-optic drive intended for use in a portable audio recorder and currently in production as an audio device. In mid-1993, Sony announced a proposed standard for the MD-DATA, a 140 megabyte CLV 2.5" magneto-optic drive with 150 kilobyte per second data transfer rate. A separate erase pass is not required. Shipment in 1994 seems likely.

TEAC CORPORATION
3-7-3 Naka-cho
Mushashino, Tokyo 180

1992 total net sales: $965,331,000 Net Income: $16,441,000

TEAC is best known for its leadership position in the flexible disk drive industry, but the firm also has a development program for optical disk drives. A 3.5" 128 megabyte drive was announced in 1991, but production shipments did not begin until 1992. TEAC is also offering a CD-ROM drive.

TEXEL (SHINANO KENSHI)
1078 Kami-maruko
Maruko-machi, Chiisagata-gun
Nagano-ken

Shinano Kenshi, founded in 1918 as a silk spinning company, is perhaps best known under the name of its sales subsidiary, Texel. The company has produced CD players, printers, and floppy disk drives under contract for other companies. In 1989, the firm began selling a CD-I encoding system. CD-ROM drives bearing the firm's own label first shipped in 1990, but subsequently have appeared under the Texel brand. The half high drives are available in internal and external configurations. In 1992, Texel began shipping a double speed RPM drive in internal and external configurations, following up in 1993 with a high performance version. The firm has achieved a moderate degree of success selling through reseller channels in the United States.

TOSHIBA CORPORATION
1-1-1, Shibaura
Minato-ku, Tokyo 105

1992 total net sales: $37,184,118,000 Net income: $310,921,000

Toshiba is a major factor in consumer electric and electronic products, and also has a leading position in the office computer market in Japan. About 54% of sales in 1992 were related to data communications or computer products. Optical, rigid and floppy drives are produced by Toshiba, which was one of the

first firms to market a 12" write-once drive. A 12" 2.5 gigabyte drive began shipments in 1988. Toshiba shipped production level 5.25" write-once optical disk drives in early 1989, although it began shipping samples of its 5.25" write-once drive in 1986. However, 5.25" drive shipments never reached appreciable levels and the company withdrew from the write-once market in 1992. Toshiba showed a 3.5" rewritable drive rotating at 3,600 RPM at the 1991 Tokyo Business show, but is currently selling it only in Japan.

CD-ROM shipments also began in 1986, with half high drives scheduled for the latter half of 1987. Toshiba's later CD-ROM models have unusually short seek times for CD-ROM drives, and this has helped Toshiba capture a significant and growing market share. The high performance drives are particularly favored by system integrators building file servers incorporating CD-ROM, and in 1990, Toshiba CD-ROM drives appeared in the product lines of major system manufacturers, including IBM. A 3.15" CD-ROM drive was announced in 1992.

YAMAHA CORPORATION
10-1 Nakazawa-machi
Hamamatsu, Shizuoka

1992 total net sales: $4,038,528,000 Net income: $45,197,000

Yamaha is the world's largest manufacturer of musical instruments, which account for 63% of the firm's sales. The firm is also a significant supplier of thin film heads for rigid disk drives.

Among more recent activities is the development of a CD format system capable of recording on write-once media. The Yamaha system is intended for use in situations where fast preparation of a master disk is required or where relatively few copies are needed. It contains the first commercial write-once CD format drive. The drive is not available as a separate item. The write-once system is remarketed by companies specializing in CD-ROM authoring tools and systems.

European Manufacturers

AMBER TECHNOLOGY LIMITED
5 Colne Way Court
Watford, Hertford WD2 4NB
United Kingdom

Amber made its entrance into the optical library market in 1993 when it displayed a 52 cartridge library at the 1993 AIIM show. The unit can be expanded to hold 104 cartridges. The product architecture is unusual in that the cartridges are placed in a circle around a rotary picker mechanism rather than employing the usual X-Y axis picker movement.

ATG GIGADISC
1270 Avenue General Eisenhower
31047 Toulouse
France

Beginning as the optical disk operation of Thomson-CSF, ATG was formed as a joint venture in 1984 when CIT-Alcatel, a maker of image processing systems, joined with Thomson-CSF, Rhone-Poulenc, Bull, and several other French companies to form Alcatel-Thomson-Gigadisc. Drive and media production began in Toulouse in early 1986. ATG was one of the first firms to get into production of optical drives, but media shortages hampered its growth. Disappointing sales caused Alcatel to decide to withdraw from the venture, and for a short time ATG was dormant while new investors were found. Officially renamed Art Tech Gigadisc, the firm became known as ATG Gigadisc.

In 1991, Optix S.A., a French holding company owned by private investors acquired a 75% interest in ATG Gigadisc. Optix also owned Dorotech, a French systems integrator of optical subsystems. In 1993, a complicated transaction occurred in which ATG Gigadisc and Dorotech became subsidiaries of Network Imaging Corporation. NIC, while headquartered in the U.S., remains controlled by French interests. NIC owns 100% of Dorotech and 75% of ATG Gigadisc. While ATG Gigadisc markets its products internationally, it has its strongest market presence in Europe.

ATG Gigadisc products include 12" write-once drives up to 5 gigabytes per side capacity. The firm designed a library storage unit containing a drive and six 12" disks, but has continued to market Cygnet's line of larger library units in order to concentrate its resources on its own product development and manufacturing while continuing to offer a full 12" product line. In 1993, the firm became the exclusive remarketer of the Access optical library. It has also begun to market a local area network interface card allowing the connection of a drive or jukebox directly to an Ethernet network operating with Novell NetWare or Sun Microsystem's NFS. The card was designed by NIC.

DETERNER STEURERUNGS UND MACHINENBAU GMBH & CO. (DSM)
Birkenstrasse 2
D-2951 Deternerlehe
West Germany

DSM, established in 1987, is a small, specialty products engineering firm. It has produced a small number of custom optical libraries which can be configured with various numbers of drives and cartridge storage slots. Some standard configurations are also available. Library configurations with either 12" WORM or 5.25" drives of any type are produced. Drives from most manufacturers are supported in the library system. DSM announced capabilities include optical libraries with up to 2,100 storage slots for disks.

K & S SYSTEMTECHNIK U. VERTRIEBSGES. MBH
Marienbergstrasse 80
W-8500 Nurnberg 10
Germany

K & S was founded in 1985 and began development of a family of tabletop optical libraries in 1990. A few evaluation units of a 10 cartridge 5.25" library were shipped in 1991, but formal introduction and the start of production shipments occurred in 1992. The libraries are sold mostly in Germany. 20 and 30 cartridge versions are planned for the future. Sony, Ricoh and Maxoptix drives are being used, but the libraries are adaptable for use with most 5.25" drives.

LASER MAGNETIC STORAGE INTERNATIONAL
Subsidiary of N.V. Philips
4425 ArrowsWest Drive
Colorado Springs, CO 80907

LMSI was formed in 1986 through the combination of Optical Storage International, Computer Peripherals International, and Philips' CD-ROM operations. Philips owned 51% of the company. CPI was a CDC and NCR joint venture that produced tape drives. OSI, formed in 1984, was a joint venture of Philips and Control Data. The organization originally was managed by Control Data and combined two earlier joint ventures, Optical Peripherals Laboratory in Colorado and Optical Media Laboratory in the Netherlands. The entire U.S. operation, at one time split between California and Colorado, was consolidated at the Colorado facility in 1986. In 1986, Philips assumed management responsibility for LMSI and in 1990 purchased Control Data's interest. In 1992, LMSI was placed in the Philips Technologies Group and received new senior management.

LMSI makes optical disk drives and also produces tape drives, which are the firm's most profitable products. LMSI optical disk drives currently include CD-ROM drives, a 12" write once drive, 12" automated libraries, and a 5.25" write-

once drive using sampled servo tracking. The 5.25" drive was introduced at the Fall COMDEX conference in 1987 and went into production in late 1988. In 1990, LMSI introduced the first optical disk drive with two independently operating heads scanning both sides of the media. The drive uses 12" media and is available as a freestanding drive or as part of a jukebox unit containing the drive and five disks. Production of the new 12" products was delayed until the latter part of 1991, and production was sporadic until late 1992 when the manufacturing process was stabilized. Media is obtained from an LMSI manufacturing operation sharing Philips media manufacturing facilities at Blackburn in the UK. Philips and Dupont Optical (PDO) also is a qualified media supplier.

Along with other CD-ROM suppliers, LMSI benefited from the 1992-1993 surge in CD-ROM demand. As a result, the firm's 1993 production is expected to exceed 1992 production by at least a factor of five, assuming an adequate supply of components is available.

NSM AKTIENGESELLSCHAFT
Im Tiergarten 20-30, D 6530
Bingen am Rhein
Germany

NSM introduced an optical library for CD-ROM drives in 1991. The company has produced many libraries with audio drives in them in previous years. The NSM design can handle up to 100 disks, which can be inserted in magazines holding up to 50 disks for convenient loading and unloading. NSM markets primarily in Europe. At the 1993 AIIM conference, the Eastman Kodak display included photographs of the NSM library.

N. V. PHILIPS
5600 MD Eindhoven
The Netherlands

1992 total net sales: $33,444,000,000 Net income: $514,286,000

The Philips organization, established in 1891 as a manufacturer of electrical equipment, has been active for many years in the development of optically based information systems. Initial development work was spun off to joint ventures with Control Data. Philips' initial digital optical developments were a 12" write-once drive and the CD-ROM. Philips, together with Sony, has been instrumental in establishing standards for CD and CD-ROM drives. The Philips CD-ROM has the distinction of being the first CD-ROM to be accepted by a major system OEM: Digital Equipment Corporation offered it as a peripheral on its MicroVax line. Philips and Sony continue to innovate standards for CD-ROM, including CD-I and CD-ROM XA. Magneto-optic recording has been under development at Philips for many years, but the effort has been intermittent.

In 1985, Philips entered into a joint venture with DuPont, named Philips and DuPont Optical (PDO), to produce optical media of various types in large quantities. PDO did not meet financial expectations and was put up for sale in late 1990. The CD-ROM portion of PDO was sold to Disc Manufacturing, Inc. in mid-1991. Mitsubishi Kasei acquired U.S. manufacturing and marketing operations for plastic substrate writable media, while the remainder of PDO, including European marketing and the manufacture of 3.5", 5.25" and 12" glass substrate media, is now owned completely by Philips.

In 1986, OSI, a joint venture between Philips and Control Data, was reorganized as Laser Magnetic Storage and charged with the responsibility of manufacturing and marketing the Philips CD-ROM, write-once optical disk drives designed by OSI using Philips-developed technology, and magnetic tape drives previously produced by another CDC joint venture. Philips owned 51% of LMSI; Control Data held the other 49%. In 1990, Philips purchased Control Data's share and is now the sole owner of LMSI.

Philips' Professional Interactive Media Systems (IMS) is responsible for CD-ROM, CD-I, CD-ROM XA, CD-R, and supporting the Kodak Photo CD effort. Mechanisms are sold on an OEM basis by the Philips Key Module Group (KMG), which also provides drive mechanisms to other Philips business units. Organizationally, IMS and KMG are divisions of Philips Consumer Electronics.

Philips Consumer Electronics Company, a division of North American Philips, began volume shipments of CD-I players in mid-1992, marketing under the Magnavox brand name. The firm is also selling freestanding CD-ROM drive subsystems bundled with software. Marketing under the Philips brand name began in late 1992. Write-Once compact disk drives, also known as CD-R (CD-Recordable) or CD-WO drives began shipping in 1992 and Philips is currently one of the leading manufacturers of CD-R equipment.

Sun Microsystems and Philips are involved in a joint effort to develop CD-ROM and CD-I authoring systems using Sun workstations. Philips is a producer of CD media through its Polygram operation and several joint ventures with Japanese companies.

SOCIETE D'APPLICATIONS GENERALES D'ELECTRICITE ET DE MECANIQUE (SAGEM)
6, Avenue d'lena
75783 Paris CEDEX 16
France

SAGEM is a French high technology company specializing in electronic products. About 25% of revenues are obtained from military and avionic systems, 31% from industrial telecommunications products and 44% from data processing and related telecommunications products. The firm makes small quantities of militarized rigid disk drives for use in harsh environments.

SAGEM is involved with other European commercial and academic organizations in a consortium directed toward the development of magneto-optic disk drives, drive components and media, but there is no near term production planned. SAGEM has drive development responsibilities, and media is to be developed by Hoechst. The long-term target is a 5 gigabyte 5.25" magneto-optic drive.

DISK/TREND ON DISK

1993 DISK/TREND REPORT

DISK/TREND ON DISK

Introduction

DISK/TREND ON DISK is a licensed set of floppy disks available for separate purchase that contain the statistical tables and specification tables from the annual DISK/TREND Reports. The disk files have been prepared in a format usable on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. A system with a hard disk is highly recommended, but a system with two floppy disks can be used if necessary. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended.

Two types of diskette files are supplied for each DISK/TREND disk drive report. The first type contains the statistical tables in ASCII format. File names are keyed to the table numbers in the report for easy identification. The second type contains the specification section in a Lotus 1-2-3 data base format. Multiple disks of each type are provided where the files are too numerous or too large to fit on a single floppy disk. The color of the label of the floppy disk is similar to the color used on the cover of the corresponding report for ease in identification.

Because the statistical tables are provided in ASCII format, they can be used with any spreadsheet program that can import ASCII text files. However, the specification tables have been prepared specifically in Lotus 1-2-3 format to allow them to be searchable using Lotus 1-2-3 data base commands. If you are using a spreadsheet program other than Lotus 1-2-3 that can translate Lotus WK1 formatted files to its own format, it may be able to import the specification tables without difficulty.

A file translation program, AutoImport, is available from DISK/TREND to assist in converting the data supplied to the formats of several popular spreadsheet programs. One copy of AutoImport is provided automatically at no extra charge to DISK/TREND subscribers who have purchased an original copy of DISK/TREND ON DISK but is provided only in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any

time. If you have not purchased DISK/TREND ON DISK, but would find AutoImport useful with other file translation tasks, it may be purchased independently from DISK/TREND or White Crane Systems, Inc.

The authors of this manual assume that you are familiar with personal computers, Lotus 1-2-3 or other spreadsheets, and MS-DOS, and do not cover their operation in this manual. This manual deals specifically with how to load and use the files supplied on the floppy disks.

Note: Please read the license on the following page.

DISK/TREND ON DISK

Information License

DISK/TREND supplies diskettes containing selected information from the 1993 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1993 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.

2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.

3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.

2. Transfer the information through or within a computer network.

3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.

4. Transfer this license to another party.

AUTOIMPORT

Use of AutoImport is subject to license terms and conditions of White Crane Systems, Inc.

Trademarks

IBM is a trademark of International Business Machines Corporation.
Lotus and Lotus 1-2-3 are trademarks of Lotus Development Corporation.
MS-DOS is a trademark of Microsoft Corporation.
AutoImport is a trademark of White Crane Systems, Inc.

1993 DISK/TREND REPORT

Getting started

The first thing you should do is to make working copies of the original DISK/TREND diskettes. Place the originals in a safe location and use only the working copies for day-to-day operations. This procedure will help to protect your data from inadvertent destruction or loss due to a malfunction of the computer or its operator. We also recommend that you place a write protect tab on the working copies (after you create them) for the same reason. Use the hard disk or another floppy disk copy for day-to-day manipulations of the files.

The statistical tables are provided in ASCII text format. This allows you to use any word processor to edit the file prior to importing it into Lotus 1-2-3. Appropriate editing removes any material you don't wish to work with and allows you to add figures or text to the data tables. You may also embed the data in internal documents or reports you are preparing for use within your company.

To convert the statistical tables to a spreadsheet you may use the AutoImport utility software, which is probably quicker and easier than the typical text file import and conversion procedure provided with spreadsheet programs. One copy of AutoImport is provided automatically at no extra charge to each DISK/TREND subscriber who has purchased an original copy of DISK/TREND ON DISK and is provided in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any time.

DISK/TREND ON DISK is normally shipped on 1.2 megabyte 5.25" floppy disks, but is also available on 1.44 megabyte 3.5" disks if requested.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked "Tables" in a floppy disk drive able to read your size disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the Lotus 1-2-3 system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the "Tables" disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which Lotus 1-2-3 normally stores worksheet files. Using the DOS 'COPY' command, copy all the statistical table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?T*.*

   Several utility files should also be copied. The command is:

   COPY A:*.PRN (if you are using the Lotus 1-2-3 data parsing commands)
   COPY A:*.MSK (if you are using AutoImport)

   The utility files named FORMLIN?.PRN are specifically for usage with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   Installing AutoImport: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place AutoImport disk 1 in drive A and type: A:INSTALL C:\AIMP and then ENTER. Follow any instructions appearing on the screen until installation is complete. To make AutoImport accessible from any directory, place C:\AIMP in your AUTOEXEC.BAT file's 'PATH' statement. See your MS-DOS instruction manual for information about this step.

   If you are using a floppy-only system, copy the AutoImport disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

3. If you are using AutoImport (highly recommended) for translation of files to spreadsheet format, do the translation at this point. See the following section on using AutoImport for details.

4. Now you are ready to start your spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the spreadsheet system disk in drive A. If you are using a rigid disk system, place a copy of the spreadsheet system disk in floppy drive A if required by the security provisions of your spreadsheet program. Now start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the appropriate file retrieval command to select a file. An example of a Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XTYY.WK1, where:

   X= Type of data
   F (Flexible disk drive data)
   R (Rigid disk drive data)
   O (Optical disk drive data)
   A (Disk drive array data)

   YY= Table number, as shown in the appropriate report volume

   Examples:
   File RT10.WK1 is Rigid Disk Drive Report Table 10
   File FT2.WK1 is Flexible Disk Drive Report Table 2
   File OT1.WK1 is Optical Disk Drive Report Table 1
   File AT3.WK1 is Disk Drive Array Report Table 3

   The file selected will be loaded as a worksheet. If this is the first time the file has been loaded, you may want to create your own formulas linking the cells of the spreadsheet. See your spreadsheet reference manual for details on numerical manipulations and graphics.

If you don't use AutoImport

If you don't use AutoImport but still want to translate ASCII files to your spreadsheet format, you will have to use spreadsheet tools such as the Lotus 1-2-3 Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics. Let's take Lotus 1-2-3 as an example. Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

The trickiest and most time-consuming part of using the Data Parse com-

mands is setting up the format line. Several utility files have been provided on the tables disk to make this process easier. These are used with various table formats encountered in the DISK/TREND Reports and correspond with the precomputed masks provided for use with AutoImport:

o FORMLINA.PRN	Used with Tables 1 and 2 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
o FORMLINB.PRN	Used with Tables 3 and 4.
o FORMLINF.PRN	Used with Tables 5 through 12.
o FORMLIND.PRN	Used with Application tables.
o FORMLINE.PRN	Used with Drive Height, Drive Capacity and Track Density tables in Flexible Disk Drive Report.

There are no FORMLIN format files for disk diameter tables or market share tables, as these are variable in format. You will have to construct the format line directly, but after you have seen how it is done for the other tables, this should not be too big a job.

After you have used spreadsheet tools to translate a file, you will understand why we recommend AutoImport for this function.

Using AutoImport

Using AutoImport is a two-step process. Step one is creation of a translation mask for each format used in files to be converted. The typical DISK/TREND Report uses 5 to 7 standard mask designs (which have been precomputed and included on your Statistical Tables disk) plus additional masks that are dependent upon table content, as some table types have variable numbers of columns. You will have to create your own masks for such tables, but this can be done easily as shown below.

Step two is the translation process. Once the mask has been created, it can be used with any table matching the mask format. See the tables below which relate table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Flexible Report	Optical Report	Array Report
MASKA	<-------- Table 1--------->		Tables 1,2	Table 1
	<-------------- Product Group Revenue ---------->			
	<-------------- Product Group Shipment ---------->			
MASKB	<-------- Table 2 -------->		Tables 3,4	Table 2
MASKC	Tables 3,4,6,9, 10,11	Tables 3,4	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			N/A
MASKE	N/A	Drive Height, Track Density, Drive Capacity	Write-Once/ Erasable Analysis	N/A
MASKF	N/A	Applications Summary	N/A	N/A
MASKG	*	Product Group Market Share	*	*
MASKH	Tables 7,8	N/A	N/A	N/A
MASKI	Product Group Price/Megabyte	N/A	N/A	N/A

N/A = Not applicable to this report

* Variable format depending upon number of disk diameters in the product group.

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1992 Rigid Report	1992 Flexible Report	1993 Optical Report	1993 Array Report
1	MASKA	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA	MASKB
3	MASKC	MASKC	MASKB	MASKC
4	MASKC	MASKC	MASKB	MASKC
5	MASKC	--	MASKC	MASKC
6	MASKC	--	MASKC	MASKC
7	MASKH	MASKF	MASKC	MASKC
8	MASKH	MASKA	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKE	MASKC	MASKA
11	MASKC	MASKD	MASKC	MASKA
12	--	MASKG	MASKC	--
13	--	MASKA	--	--
14	MASKA	MASKA	--	--
15	MASKA	MASKE	--	MASKA
16	--	MASKE	--	MASKA
17	--	MASKD	MASKA	--
18	MASKD	MASKG	MASKA	--
19	MASKI	MASKA	--	--
20	--	MASKA	--	MASKA
21	MASKA	--	MASKD	MASKA
22	MASKA	--	--	--
23	--	MASKE	MASKA	--
24	--	MASKE	MASKA	--
25	MASKD	MASKD	--	MASKA
26	MASKI	MASKG	--	MASKA
27	--	MASKA	--	--
28	MASKA	MASKA	--	--
29	MASKA	--	MASKE	--
30	--	--	MASKD	
31	--	MASKD	--	
32	MASKD	MASKG	MASKA	
33	MASKI		MASKA	
34	--		--	
35	MASKA		--	
36	MASKA		MASKD	
37	--		MASKA	
38	--		MASKA	
39	MASKD		MASKA	
40	MASKI		MASKA	
41	--		--	
42	MASKA		--	
43	MASKA		MASKE	
44	--		MASKA	
45	--		MASKA	
46	MASKD		--	
47	MASKI		--	

Cross reference (continued)

Table Number	1992 Rigid Report	1992 Flexible Report	1993 Optical Report
48	--		MASKE
49	MASKA		MASKA
50	MASKA		MASKA
51	--		--
52	--		--
53	MASKD		MASKE
54	MASKI		
55	--		
56	MASKA		
57	MASKA		
58	--		
59	--		
60	MASKD		
61	MASKI		
62	--		
63	MASKA		
64	MASKA		
65	--		
66	--		
67	MASKD		
68	MASKI		
69	--		
70	MASKA		
71	MASKA		
72	--		
73	--		
74	--		
75	MASKD		
76	MASKI		
77	--		

-- indicates that the format of this table is variable. Create a mask using AutoImport if a spreadsheet is needed.

Translation using precomputed masks

1. First, copy the files you wish to translate to the AIMP directory from DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

   COPY A:?T*.*
   COPY A:*.MSK

   These commands copy the data files and mask files you need.

   If you are using a two floppy disk system, copy the files you want to translate to a second floppy disk along with the mask files. Make sure that no more than half of the floppy disk is filled, because you will need space for the converted files.

2. Now start AutoImport. When the opening screen appears, select the "TRANSLATE" menu item using the arrow keys or just type "T". (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears, enter the name of the mask to use on the top line where the highlighted space is. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press "ENTER".

4. Select the output file name. Type /OFT (Output:File:Type-in)

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (R, F, or O), T is just that, and nn is the DISK/TREND Report table number matching the file being translated. You should not enter the file name extension as the system adds it automatically for you. Press "ENTER".

   Examples: RT4 FT12 OT14 AT20

5. Enter the input file name using the same file naming convention as above. Type /IT (Input:Type-in)

   Enter the name of the file, including the extension, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.93R FT12.93F OT14.93O AT19.93A

6. The default spreadsheet type to which the translation is made is Lotus 1-2-3 version 2.x. If you wish to translate to a different spreadsheet format you may choose it by typing /TS (Task:Spreadsheet)and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Type "G" for "GO" or select "GO" using the arrow keys. You will see the file being translated scroll by as the translation proceeds.

8. If you want to do more translations, repeat from step 3.

9. When you are done translating, leave AutoImport by typing /Q (Quit) to return to the AutoImport main menu and then /E (Exit) to leave AutoImport and return to DOS. It will save you some keystrokes if you copy your new spreadsheet files to your spreadsheet directory. If you are using a two floppy system, just remove the AutoImport disk from drive A and substitute your spreadsheet disk.

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select "Mask" using the arrow keys or type "M".

2. Name the file you will use as the template to create the mask. The file name will be of the form ?Tnn.yy?, where ? is the type of report (R, F, or O, A), nn is the table number and yy is the report year.

   Example: OT10.93O

   To name the file, type /FIT (File:Input:Type-in). When the highlighted blank space appears, fill it in with the file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now type /LH (Line:Header). Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'Enter'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, typing /LH, extending the highlight area over the note and pressing 'Enter'.

4. Next, locate the longest left margin label (excluding the header lines) in the table. Position the cursor so that it is at the left margin of the line containing the longest label. Type /AY (Auto:Yes). This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

   In a few cases, the automatic feature may be confused by a table layout and all values will not be picked for conversion. In these unusual cases, you may be able to get the overlooked values included by repeating this step on another line.

   Another unusual case can occur in which the right-hand part of a label is somehow included in a value occurring in the next column to the right. Deal with this rare case as follows:

   o Place cursor in left margin of offending line. Type /CW to adjust width and then use arrow keys to move right column margin clear of the column of values.

   o Set cursor on last position of column to the right of the left margin labels. Type /DCO to delete this one column from the mask.

   o Now place the cursor in the first space to the right of the left margin

label column. Type /C and then adjust the column width to encompass all places in the values column you have been working with. This will restore the mask column, also.

5. Save the mask in a mask file. Type /FMS (File:Mask:Save). Fill in the name of the mask file.

   Example: OT10MSK

6. Save the output file. Type /FOT (File:Output:Type-in). Now enter the file name.

   Example: OT10. You don't need to enter the file extender.

7. To make more masks, repeat from step 2. To quit the mask function, type /Q (quit). This returns you to the AutoImport main menu. To leave AutoImport, type /E.

Other AutoImport Functions

AutoImport can do much more than the functions described above, which are those concerned with a basic understanding of how to create spreadsheets from DISK/TREND ON DISK files. See the separate AutoImport manual provided for details of these other functions.

SPECIFICATION TABLES

Loading

1. Place the floppy disk marked "Specifications" in a floppy disk drive able to read your size disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the spreadsheet system disk in drive A. Use the DOS "DIR" command to examine the file directory on the "Tables" disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which your spreadsheet normally stores worksheet files. Using the DOS "COPY" command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus spreadsheet system disk in drive A. If you are using a rigid disk system, place the spreadsheet system disk in floppy drive A. If your spreadsheet is not Lotus 1-2-3, you will have to translate the data from Lotus 1-2-3 to your format. Almost all spreadsheet packages of recent vintage are able to do this translation. After translation, if needed, start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the spreadsheet File Retrieve command to select a file. The equivalent Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XSYZZ.WK1 or XSYZZ.WKS, depending upon which version of Lotus 1-2-3 you are using. X,Y, and Z are:

   X= F (Flexible disk drive data)
   O (Optical disk drive data)
   R (Rigid disk drive data)
   A (Disk drive array data)

Y= Table number. Usually, there is only one table, but if the specification file is so large as to need multiple disks to hold it, there may be several.

ZZ= Year of report.

Example: OS193 Optical disk drive specification table.
LS193 Optical library specification table.

Note that the specification tables load directly as a data base. You can use the data base functions of Lotus 1-2-3 to sort, count or otherwise manipulate the data for purposes of special analysis. Other spreadsheets may have similar capabilities.

Using the specification data base

Introduction: If you have not used the Lotus 1-2-3 /DATA QUERY commands, it will be helpful for you to review the sections of the Lotus 1-2-3 reference manual that pertain to their use before proceeding further.

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon whether rigid, optical or floppy drives are involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND report. Each column represents a specific specification parameter, and is equivalent to one row of the DISK/TREND report.

The data base has been set up for data extraction using Lotus 1-2-3 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

Expanding the input or output ranges: The predefined output range is of a nominal size, and a search with broad parameters may result in overflowing the output range. In such a case, merely extend the output range (add more rows) using the Lotus 1-2-3 /DQEO command. Similarly, it is possible to extend the input range to add more products, but be sure you move the output range so that there is no overlap.

Memory overflow: If you should receive a memory overflow message while manipulating the specification data, it is usually because:

- There are other "pop-up" programs resident in the memory of your computer. These should be removed.
- You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.
- If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You probably will have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 640K memory, you will probably get this message.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups you are interested in into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

Make sure that when you save a worksheet using the FILE SAVE command

that you save it in a new file name. If you save it in the file name from which it was loaded, the original copy will be overwritten. If a file is overwritten unintentionally, it can take a long time to recreate.

If you are interested in only a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and then use the second file for analysis. The smaller file will take less time to process.

Technical support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: **415-961-6209**

Ask for Technical Support for DISK/TREND ON DISK

In order to make this process efficient, when you call--

1. Tell us what is on the diskette label.

2. Have your computer up and displaying the data or operation that is the subject of your call.

3. Have this manual and the Lotus 1-2-3 reference manual handy.

If you have questions about AutoImport as it is used with DISK/TREND ON DISK, contact DISK/TREND at the number above. Questions about other functions of AutoImport should be referred to White Crane Systems.

Apple Macintosh compatibility: While DISK/TREND on DISK has been prepared for use on IBM PC compatible computers, users have reported that they are able to translate files into Macintosh format using Apple Computer software. The specific software reported used is Apple File Exchange.

Special data

The specification data base contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

In order to make it easier to do sorting or extraction analysis on the data, the contents of certain fields have been modified and are not exactly the same as in the printed report tables. Some affected fields have been converted to purely numeric fields as described below. Where multiple values existed, the value representing the highest level of performance or capability has been retained.

Comments and asterisks in the affected fields have been eliminated. A '0' means that no data was available. Asterisks are retained in the comment field so that you will have an indication that one or more characteristics of the drive was referenced to a comment. Check the printed report table for details.

The affected fields for the drive specification data base are:

Group:	Numeric conversion: You can extract a range of groups.
BPI:	Numeric conversion: You can extract a range of BPI.
TPI:	Numeric conversion: You can extract a range of TPI.
Pos_Time:	Numeric conversion: You can extract a range of seek times.
Aver_rot_del:	Numeric conversion: You can extract a range of rotational latencies.
Access_time:	Numeric conversion: You can extract a range of average access times.

The affected fields for the library data base are:

Group:	Numeric groups. You can extract a range of groups.
Num_disks:	Numeric conversion: You can extract for the minimum number of disks in the library.

Capy_expan:	Numeric conversion: You can extract for the largest number of disks for which the library can be configured.
Max_drive:	Numeric conversion: You can extract for the maximum number of drives for which the library can be configured.
Avg_exch:	Numeric conversion: You can extract for a range of average disk exchange times.

A country code field has been added in the last column of the data base.
The code explanation is:

1 = U.S. manufacturer
2 = Asian manufacturer
3 = European manufacturer
4 = South American or other manufacturer

Codes are based upon the location of the manufacturer's headquarters.

First ship date has been modified so that the last two characters will always represent the year of shipment. An entry of ??89 in the criterion field for the First Ship Date column will cause all products first shipped in 1989 to be extracted.