1994 DISK/TREND® REPORT

OPTICAL
DISK
DRIVES

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OPTICAL DISK DRIVES

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FOREWORD

In 1993 and in the early part of 1994, everything associated with CD-ROM looked like gold. For the rest of the optical drive industry, it was more like mud, with 5.25", 3.5" and 12" drive shipments exhibiting slowing or even negative growth. Some drive manufacturers are expressing reservations about remaining in various segments of the business, and a shakeout seems inevitable. The future for 2.5" drives remains uncertain.

With the number of new suppliers in the CD-ROM drive business growing and average OEM prices in rapid decline, the CD-ROM industry is starting to look a lot like the floppy drive business in its heyday. While growth is still too strong to expect industry consolidation, it will come, especially as advanced products with tougher manufacturing requirements materialize in future years.

The four 'P' problems are now five. Performance, package, price, and profitability have been joined by power, a fifth 'P'. Minimizing power drain is potentially important for small form factor optical drives seeking homes in notebook and subnotebook computers. Optical drives don't yet meet current magnetic drive performance, and rigid magnetic drives, increasing in areal density at 60% per year, are impacting shipments of optical drives in some applications.

The CD-ROM disk library business is doing very well, as are read/write libraries using 1-39 cartridges. For the larger and more expensive library product groups, it's "Wait 'til next year", when more companies will loosen purse strings.

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

The DISK/TREND Report on optical disk drives and optical disk libraries is in its ninth year. The organization of this year's report is consistent with reports of previous years, but we have changed the breakdown of details in the sections on CD-ROM drives and CD-ROM libraries to reflect product changes. Two new tables have been added in the CD-ROM library section to differentiate between small and large libraries. 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, with the exception of the Pinnacle Micro Orray.

* Market share tables, usually included in DISK/TREND reports, are omitted for some product groups of this report, because the 1993 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

Led by an incredibly strong CD-ROM market, optical disk drive revenues grew $2.2 billion in 1993, a 68.1% gain. The good news stopped there, as revenues declined 10.6% for read/write drives under 1 gigabyte and 4% for drives over 1 gigabyte.

Sales of 3.5" magneto-optic drives improved a bit in 1993 although sales to large OEMs remain weak, and the prospects for greatly improved 3.5" sales growth rates remain dim, unless prices decline or capacity improves substantially. Shipments of 5.25" drives actually declined, while shipments of 12" drives remained flat.

More than 11.5 million optical disk drives were shipped in 1993, but nearly 11.1 million were CD-ROM drives. Shipments of drives under 1 gigabyte expanded 20.5% to 457,100 units, due to growth in the Japanese 3.5" market and strong sales growth for CD-R drives, which masked a decline in 5.25" drive shipments. 1993 shipments for drives over 1 gigabyte were absolutely even with 1992 shipments, at 7,100 units.

Optical library shipments grew to 34,236 units in 1993, a gain of 38.8%. 57.9% of 1993 shipments were CD-ROM libraries, and this percentage is expected to increase to 62.6% in 1997. Optical library revenues edged upward 7.4% to $262.7 million, led by libraries in the 1-39 cartridge category. Their 40% share is expected to hold about even throughout the forecast period. (The library revenues don't include revenues of associated drives, to avoid double counting.)

U.S. manufacturers lost revenue share in 1993 with a drop to 7.2% of worldwide optical disk drive revenues, reflecting minimal participation by U.S. firms in the CD-ROM market. U.S. companies also lost seven share points of total 1993 library revenues, capturing 52%. The U.S. share of drive unit shipments fell to .9%, and is expected to decline further 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' 1993 share of library unit shipments fell to 29.5% because of a large increase in CD-ROM library shipments by non-U.S. suppliers, and is expected to decline slightly to 27.9% in 1997.

1993 optical disk drive sales in the United States accounted for 54.2% of worldwide revenue, about the same as in 1992. The U.S. market accounted for 67.2% of library revenues, a slight decline from 1992. The U.S. optical drive market is expected to be 53.2% of a $5.1 billion drive market in 1997, while the proportion of the library market in the U.S. is also expected to grow, reaching 66.6% of an anticipated $469.7 million in 1997.

IBM continues to expand its optical storage activities with new higher capacity 5.25" and 3.5" magneto-optic rewritable drives plus an expanded number of models of the 3995 optical library. 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. Sony is aggressively promoting its 2.5" MD-DATA magneto-optic technology, but the market for 2.5" optical drives is uncertain at best, at their current stage of development.

Other than with CD-ROM libraries, U.S. optical library producers continue to do well, as a result of aggressive new product development, a strong yen, and because of their strengths in system integration and software support. Because optical libraries are used mostly on networked systems, a technology well understood by many U.S. companies, U.S. library producers are very effective in penetrating the domestic market. While non-U.S. producers are becoming more aggressive in the U.S. market, especially in the fast growing 1-39 cartridge segment, they are hampered by unfavorable exchange rates.

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 significantly to 57 participants, but all of the newcomers except one are CD-ROM drive producers. The roster of optical library manufacturers grew to 36, including one new European competitor, four new Japanese competitors, and two new U.S. firms. All of the new entrants in this market are producers of CD-ROM optical libraries, except for one 3.5" and one 5.25" library producer.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	48.2	56.4	58.1	78.9	72.7	108.4	85.8	133.3	93.3	151.0
PCM/Reseller	33.9	54.4	39.9	57.6	50.9	72.1	60.0	86.4	65.9	96.7
OEM/Integrator	34.9	51.5	52.5	81.9	47.9	76.1	62.3	99.4	75.4	126.0
TOTAL U.S. REVENUES	117.0	162.3	150.5	218.4	171.5	256.6	208.1	319.1	234.6	373.7
Non-U.S. Manufacturers										
Captive	123.5	428.4	181.2	649.2	240.2	675.7	312.3	856.9	437.4	1,129.4
PCM/Reseller	315.9	556.9	370.0	696.9	411.2	785.1	463.0	893.1	549.1	1,063.1
OEM/Integrator	637.7	1,056.5	847.3	1,494.3	1,117.0	1,967.2	1,309.5	2,306.0	1,507.7	2,560.9
TOTAL NON-U.S. REVENUES	1,077.1	2,041.8	1,398.5	2,840.4	1,768.4	3,428.0	2,084.8	4,056.0	2,494.2	4,753.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,194.1	2,204.1	1,549.0	3,058.8	1,939.9	3,684.6	2,292.9	4,375.1	2,728.8	5,127.1

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993		Forecast							
	Revenues		1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	25.0	31.3	25.1	32.8	26.9	35.0	27.8	36.4	28.5	38.3
PCM/Reseller	22.0	29.9	30.7	41.2	40.8	55.4	45.3	61.7	46.2	64.1
OEM/Integrator	59.9	75.8	72.7	94.9	81.1	102.4	85.9	112.3	91.1	121.1
TOTAL U.S. REVENUES	106.9	137.0	128.5	168.9	148.8	192.8	159.0	210.4	165.8	223.5
Non-U.S. Manufacturers										
Captive	--	14.3	--	15.8	--	18.6	--	20.8	--	23.7
PCM/Reseller	19.5	30.9	28.8	43.6	40.6	56.4	46.2	66.1	51.3	75.4
OEM/Integrator	50.1	80.5	60.7	95.9	74.7	112.7	85.7	129.8	95.9	147.1
TOTAL NON-U.S. REVENUES	69.6	125.7	89.5	155.3	115.3	187.7	131.9	216.7	147.2	246.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	176.5	262.7	218.0	324.2	264.1	380.5	290.9	427.1	313.0	469.7

Figure 1

CHANGING PRODUCT MIX

Worldwide Optical Disk Drive Revenue

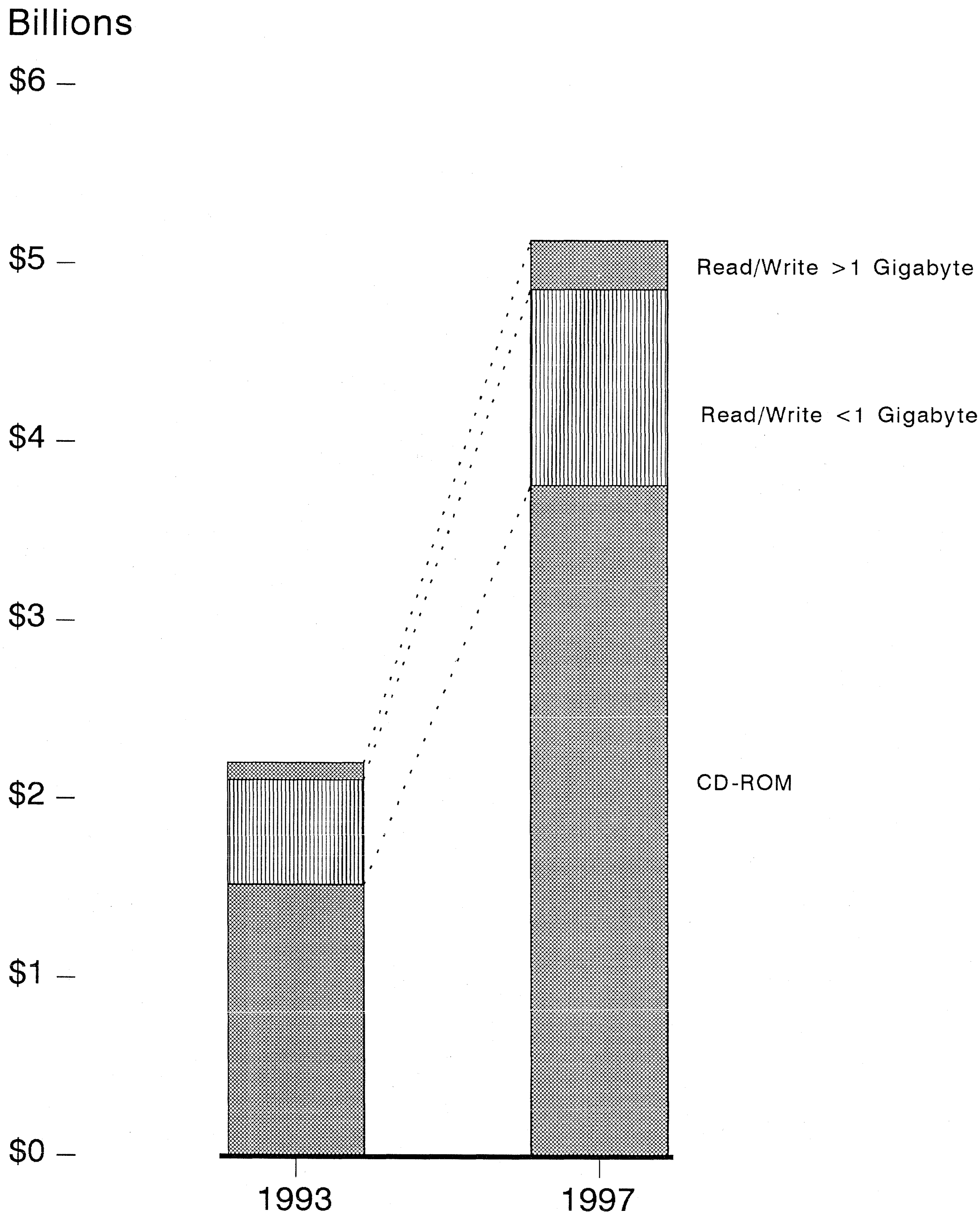
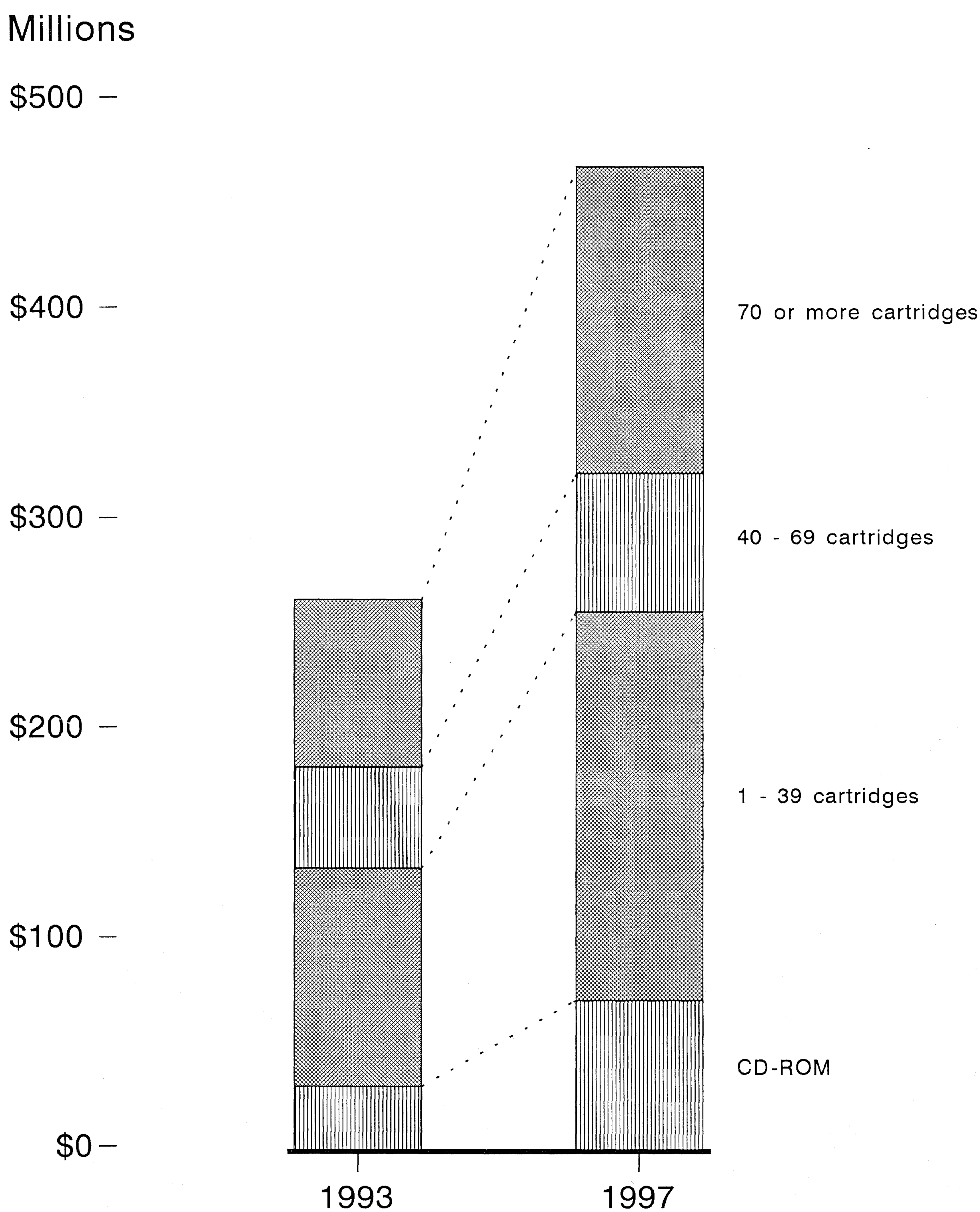


Figure 2

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.

OEM/Integrator optical disk drive revenues rose to 50.3% of 1993 worldwide total revenues of $2.2 billion. PCM/Reseller revenues accounted for 27.7%, while the captive channel contributed 22%. Revenues in all three channels grew sharply over 1992 figures. The CD-ROM product group accounts for most of the revenue growth. In 1997 the pattern will be similar. Total revenues of over $5.1 billion will be divided between the OEM/Integrator channel which will contribute 52.4% of revenues, while the PCM/Reseller share is projected to shrink to 22.6%, and the captive share is forecasted to climb slightly to 25% of 1997 revenues.

1993 optical disk library revenues of $262.7 million were split 59.5% from OEM/Integrators, 23.1% from the PCM/Reseller channel, and 17.4% from the captive channel. In 1997, expected revenues of $469.7 million will be shared among OEM/Integrators with 57.1%, PCM/Reseller sales with 29.7% and captive sales with 13.2%. Because of the complex system integration and support requirements of libraries, only the simplest types are offered by many resellers, but some of the resellers handling libraries have acquired 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. 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, Philips LMS, a Philips subsidiary, is counted as a European company.

12 U.S. companies, 40 Asian firms and 3 European manufacturers currently compete in the optical disk drive market. Asian producers increased their presence, as many new producers in Asia announced CD-ROM drives. Most of the new CD-ROM manufacturers are in Singapore, Malaysia, Taiwan and Hong Kong, but may have a portion of their production done in China. Some of the U.S. firms have their drives made on a contract basis by Asian producers.

As of mid-1994, 34 companies produce CD-ROM drives, all but one of which are non-U.S. firms and 16 of which are Japanese organizations. 28 manufacturers are making read/write drives under 1 gigabyte, down from 29 in 1993: 25 of these have rewritable or multifunction drives, an increase from 21 manufacturers last year. 7 companies manufacture optical disk drives with over 1 gigabyte capacity, and the roster of producers is unchanged from 1993. Only one of these is a rewritable drive, and all but one are 12" or greater in diameter.

13 U.S. firms, 16 Asian manufacturers and 7 European suppliers offer optical libraries. Of the 36 companies, 13 make CD-ROM libraries: 8 of these do not participate in any other product groups. Of the 26 read/write library producers, 11 firms make only 5.25" libraries, while 4 make only larger diameter libraries. Only 2 firms make a 3.5" library. 6 firms make read/write library models in two or more disk drive diameters. One firm, Borett Automation, manufactures libraries that can handle multiple type of drives and media simultaneously.

The U.S. count of library manufacturers has gone up by 2 to 13: ADIC, Todd Enterprises and TAC Systems started production, but Cygnet was merged into ATG Gigadisc to become ATG Cygnet, a European owned organization. The net Asian manufacturer count for libraries has increased by 4 with the market entry of Nakamichi, Microboards, Victor Data Systems (all CD-ROM library producers) plus MOST and Olympus, less the departure of Mitsubishi Electric from the roll of producers. The number of European library manufacturers has risen to 7 this year with the addition of Logical Engineering in the U.K.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1993 Revenues $M	1993 Revenues %	Forecast 1994 $M	1994 %	1995 $M	1995 %	1996 $M	1996 %	1997 $M	1997 %
U.S. Manufacturers										
Captive	56.4	2.5%	78.9	2.5%	108.4	2.9%	133.3	3.0%	151.0	2.9%
	-30.4%		+39.9%		+37.4%		+23.0%		+13.3%	
PCM/Reseller	54.4	2.4%	57.6	1.8%	72.1	1.9%	86.4	1.9%	96.7	1.8%
	+173.4%		+5.9%		+25.2%		+19.8%		+11.9%	
OEM/Integrator	51.5	2.3%	81.9	2.6%	76.1	2.0%	99.4	2.2%	126.0	2.4%
	-5.7%		+59.0%		-7.1%		+30.6%		+26.8%	
Total U.S. Manufacturers	162.3	7.2%	218.4	6.9%	256.6	6.8%	319.1	7.1%	373.7	7.1%
	+4.4%		+34.6%		+17.5%		+24.4%		+17.1%	
Non-U.S. Manufacturers										
Captive	428.4	19.4%	649.2	21.2%	675.7	18.3%	856.9	19.5%	1,129.4	22.0%
	+120.5%		+51.5%		+4.1%		+26.8%		+31.8%	
PCM/Reseller	556.9	25.2%	696.9	22.7%	785.1	21.3%	893.1	20.4%	1,063.1	20.7%
	+86.4%		+25.1%		+12.7%		+13.8%		+19.0%	
OEM/Integrator	1,056.5	48.2%	1,494.3	49.2%	1,967.2	53.6%	2,306.0	53.0%	2,560.9	50.2%
	+59.4%		+41.4%		+31.6%		+17.2%		+11.1%	
Total Non-U.S. Manufacturers	2,041.8	92.8%	2,840.4	93.1%	3,428.0	93.2%	4,056.0	92.9%	4,753.4	92.9%
	+76.7%		+39.1%		+20.7%		+18.3%		+17.2%	
Worldwide Recap										
Captive	484.8	22.0%	728.1	23.8%	784.1	21.3%	990.2	22.6%	1,280.4	25.0%
	+76.1%		+50.2%		+7.7%		+26.3%		+29.3%	
PCM/Reseller	611.3	27.7%	754.5	24.7%	857.2	23.3%	979.5	22.4%	1,159.8	22.6%
	+91.9%		+23.4%		+13.6%		+14.3%		+18.4%	
OEM/Integrator	1,108.0	50.3%	1,576.2	51.5%	2,043.3	55.4%	2,405.4	55.0%	2,686.9	52.4%
	+54.5%		+42.3%		+29.6%		+17.7%		+11.7%	
Total All Manufacturers	2,204.1	100.0%	3,058.8	100.0%	3,684.6	100.0%	4,375.1	100.0%	5,127.1	100.0%
	+68.1%		+38.8%		+20.5%		+18.7%		+17.2%	

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	1993 Revenues		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	$M	%	$M	%	$M	%	$M	%	$M	%
U.S. Manufacturers										
Captive	31.3	11.9%	32.8	10.1%	35.0	9.1%	36.4	8.5%	38.3	8.1%
	-23.5%		+4.8%		+6.7%		+4.0%		+5.2%	
PCM/Reseller	29.9	11.3%	41.2	12.7%	55.4	14.5%	61.7	14.4%	64.1	13.6%
	+6.8%		+37.8%		+34.5%		+11.4%		+3.9%	
OEM/Integrator	75.8	28.8%	94.9	29.2%	102.4	26.9%	112.3	26.2%	121.1	25.7%
	+11.1%		+25.2%		+7.9%		+9.7%		+7.8%	
Total U.S. Manufacturers	137.0	52.0%	168.9	52.0%	192.8	50.5%	210.4	49.1%	223.5	47.4%
	--		+23.3%		+14.2%		+9.1%		+6.2%	
Non-U.S. Manufacturers										
Captive	14.3	5.4%	15.8	4.8%	18.6	4.8%	20.8	4.8%	23.7	5.0%
	-4.0%		+10.5%		+17.7%		+11.8%		+13.9%	
PCM/Reseller	30.9	11.7%	43.6	13.4%	56.4	14.8%	66.1	15.4%	75.4	16.0%
	+116.1%		+41.1%		+29.4%		+17.2%		+14.1%	
OEM/Integrator	80.5	30.9%	95.9	29.8%	112.7	29.9%	129.8	30.7%	147.1	31.6%
	+2.7%		+19.1%		+17.5%		+15.2%		+13.3%	
Total Non-U.S. Manufacturers	125.7	48.0%	155.3	48.0%	187.7	49.5%	216.7	50.9%	246.2	52.6%
	+16.8%		+23.5%		+20.9%		+15.5%		+13.6%	
Worldwide Recap										
Captive	45.6	17.4%	48.6	15.0%	53.6	14.1%	57.2	13.4%	62.0	13.2%
	-18.3%		+6.6%		+10.3%		+6.7%		+8.4%	
PCM/Reseller	60.8	23.1%	84.8	26.2%	111.8	29.4%	127.8	29.9%	139.5	29.7%
	+43.7%		+39.5%		+31.8%		+14.3%		+9.2%	
OEM/Integrator	156.3	59.5%	190.8	58.8%	215.1	56.5%	242.1	56.7%	268.2	57.1%
	+6.6%		+22.1%		+12.7%		+12.6%		+10.8%	
Total All Manufacturers	262.7	100.0%	324.2	100.0%	380.5	100.0%	427.1	100.0%	469.7	100.0%
	+7.4%		+23.4%		+17.4%		+12.2%		+10.0%	

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

Product mix

1993 shipments of optical disk drives grew substantially to 11.5 million units, but the lion's share of the growth was in the CD-ROM product group, which increased its share of the shipment mix from 86.8% to 96.1%, over 11 million units. This figure includes shipments associated with both computers and free-standing consumer equipment such as games and CD-I players. As a result of the strong growth in CD-ROM drive shipments, the 1993 shipment share of read/write drives under 1 gigabyte declined from 13% to 3.9%. The share of read/write drives over 1 gigabyte shrank to under .1%.

Within the under 1 gigabyte product group, 5.25" drive shipments shrank slightly, but their weak performance was counterbalanced by moderate shipment growth for 3.5" drives in Japan. Shipments of MO drives in this group are increasingly impacted by competition from high capacity 5.25" and 3.5" magnetic disk drives. CD-R (write-once drives that prepare disks in the CD-ROM format) drive shipments tripled from 1992 levels with growth heavily influenced by lowered prices and improved usability.

In 1993, erasable or multifunction drives captured 91.9% of the less than 1 gigabyte product group, but increasing sales of CD-R drives will reduce that share to 82.5% in 1997. CD-R will become an increasingly important part of the product mix, and has become the dominant type of write-once drive as 5.25" write-once drives have been displaced by multifunction drives.

5.25" drives have made their appearance in the over 1 gigabyte product group, and beginning in 1995 are expected to rapidly increase their participation in the group, exceeding 12"/14" unit shipments in 1996.

The majority of 1993 revenues came from shipments in the CD-ROM product group, which supplied 69% of drive optical revenues. Read/write drives less than 1 gigabyte contributed 26.6% of revenues, followed by read/write drives over 1 gigabyte with 4.3%. The revenue share for CD-ROM drives is expected to grow annually through 1997, reaching 73.4% in that year. Drives under 1 gigabyte will see their revenue share decline slightly to 21.4% in 1997, while the share for read/write drives over 1 gigabyte is expected to grow year-to-year beginning in 1995 as the result of increasing 5.25" drive shipments in that product group.

CD-ROM drive shipments are forecasted to exceed the 50 million unit mark in

1997, as the result of increasing acceptance of the devices as integral parts of personal computer and game systems. Shipments of 8 centimeter drives are expected to be only a small portion of total CD-ROM drive shipments. The performance requirements of multimedia capable systems have shifted demand toward higher performance 12 centimeter drives, with double speed drives almost completely displacing lower performance models by the end of 1993. The double speed CD-ROM models are themselves due for displacement by quadruple speed models in 2 to 3 years.

1993 optical library shipments were led by CD-ROM optical libraries, which gathered a 57.9% share of total library shipments, up from 46.6% in 1992. The next largest segment was the 1-39 disk cartridge library which captured a 28.5% share. Share for the 40-69 cartridge library group declined slightly to 8.3% from 10.8% share in 1992. Libraries with 70 or more cartridges kept the same 5.3% share as last year. The largest year-to-year growth rates were exhibited by CD-ROM libraries (72.7%) and the 70 or more cartridge group (38.8%). 1993 optical library growth was damaged by weak economic conditions in 1993, but higher growth is expected in 1994 and thereafter as conditions return to normal, especially in Europe and Japan.

$262.7 million of optical library revenues, 39.7% of the 1993 total, were held by the 1-39 cartridge group, followed by the 70 cartridge or more group with 30.4% and the 40-69 cartridge group with 18.2%. CD-ROM libraries had a lower 11.7% share as a result of their lower prices. Revenues increased over 129% from 1992 for CD-ROM libraries and grew 33% for the 1-39 cartridge group, but shrank for the larger libraries. The decline for the two larger library groups is the result of price-cutting as a reaction to deteriorating economic conditions and a shift in distribution channel mix, with high value captive sales declining and OEM sales an increasing part of the mix.

CD-ROM libraries are expected to exhibit annual gains in revenue share, reaching 15.4% of total worldwide revenues in 1997, as a result of growing shipments and an increasing proportion of larger, higher priced libraries in the mix for the group. The revenue share for the 1-39 cartridge group will hover about the 40% level during the forecast period, and the share for the 70 cartridge and over group will remain in the 30% range. The 40-69 cartridge libraries are expected to decrease their annual share slightly to 14.1% in 1997.

TABLE 5

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1993		Forecast							
ALL MANUFACTURERS	Revenues		1994		1995		1996		1997	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM	1,521.4	69.0%	2,259.7	74.0%	2,744.3	74.6%	3,262.5	74.7%	3,757.3	73.4%
ALL CAPACITIES	+174.1%		+48.5%		+21.4%		+18.9%		+15.2%	
READ/WRITE	586.9	26.6%	702.3	23.0%	812.2	22.0%	926.6	21.2%	1,095.9	21.4%
LESS THAN 1 GIGABYTE	-10.6%		+19.7%		+15.6%		+14.1%		+18.3%	
READ/WRITE	95.8	4.3%	96.8	3.0%	128.1	3.4%	186.0	4.1%	273.9	5.2%
MORE THAN 1 GIGABYTE	-4.0%		+1.0%		+32.3%		+45.2%		+47.3%	
Total Worldwide Revenue	2,204.1	100.0%	3,058.8	100.0%	3,684.6	100.0%	4,375.1	100.0%	5,127.1	100.0%
	+68.1%		+38.8%		+20.5%		+18.7%		+17.2%	

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	------1993-----		----------Forecast----------							
ALL MANUFACTURERS	----Revenues---		------1994-----		------1995-----		------1996-----		------1997-----	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM FORMAT OPTICAL LIBRARIES	30.7	11.7%	45.4	14.0%	57.4	15.1%	64.9	15.2%	72.4	15.4%
	+129.1%		+47.9%		+26.4%		+13.1%		+11.6%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	104.3	39.7%	131.4	40.5%	153.9	40.4%	172.2	40.3%	185.0	39.4%
	+33.0%		+26.0%		+17.1%		+11.9%		+7.4%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	47.9	18.2%	52.3	16.1%	58.1	15.3%	61.7	14.4%	66.2	14.1%
	-26.0%		+9.2%		+11.1%		+6.2%		+7.3%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	79.8	30.4%	95.1	29.3%	111.1	29.2%	128.3	30.0%	146.1	31.1%
	-9.5%		+19.2%		+16.8%		+15.5%		+13.9%	
Total Worldwide Revenue	262.7	100.0%	324.2	100.0%	380.5	100.0%	427.1	100.0%	469.7	100.0%
	+7.4%		+23.4%		+17.4%		+12.2%		+10.0%	

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 IN THOUSANDS	1993 Shipments Units	1993 %	Forecast 1994 Units	1994 %	1995 Units	1995 %	1996 Units	1996 %	1997 Units	1997 %
CD-ROM	11,074.8	96.1%	19,892.6	97.2%	29,323.0	97.5%	38,366.0	97.4%	48,798.0	96.9%
ALL CAPACITIES	+338.2%		+79.6%		+47.4%		+30.8%		+27.2%	
READ/WRITE	457.1	3.9%	588.0	2.8%	772.7	2.5%	1,044.6	2.6%	1,562.2	3.1%
LESS THAN 1 GIGABYTE	+20.5%		+28.6%		+31.4%		+35.2%		+49.6%	
READ/WRITE	7.1	--	7.9	--	14.0	--	32.4	--	65.6	--
MORE THAN 1 GIGABYTE	--		+11.3%		+77.2%		+131.4%		+102.5%	
Total Worldwide Shipments	11,539.0	100.0%	20,488.5	100.0%	30,109.7	100.0%	39,443.0	100.0%	50,425.8	100.0%
	+296.0%		+77.6%		+47.0%		+31.0%		+27.8%	
% U.S. Manufacturers	.9%		.8%		.7%		.7%		.7%	

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	1993 Shipments Units	1993 Shipments %	Forecast 1994 Units	1994 %	1995 Units	1995 %	1996 Units	1996 %	1997 Units	1997 %
CD-ROM FORMAT OPTICAL LIBRARIES	19,810	57.9%	27,724	58.7%	35,177	59.6%	43,274	60.6%	52,686	62.6%
	+72.7%		+40.0%		+26.9%		+23.0%		+21.7%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	9,759	28.5%	13,801	29.2%	17,087	29.0%	20,382	28.5%	22,736	27.0%
	+6.9%		+41.4%		+23.8%		+19.3%		+11.5%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	2,837	8.3%	3,367	7.1%	3,947	6.7%	4,474	6.3%	4,926	5.9%
	+7.0%		+18.7%		+17.2%		+13.4%		+10.1%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	1,830	5.3%	2,309	4.9%	2,774	4.7%	3,272	4.6%	3,782	4.5%
	+38.8%		+26.2%		+20.1%		+18.0%		+15.6%	
Total Worldwide Shipments	34,236	100.0%	47,201	100.0%	58,985	100.0%	71,402	100.0%	84,130	100.0%
	+39.3%		+37.9%		+25.0%		+21.1%		+17.8%	
% U.S. Manufacturers	29.4%		30.2%		29.8%		29.3%		27.9%	

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

Figure 3

WORLDWIDE SHIPMENT SUMMARY

Total Optical Disk Drives

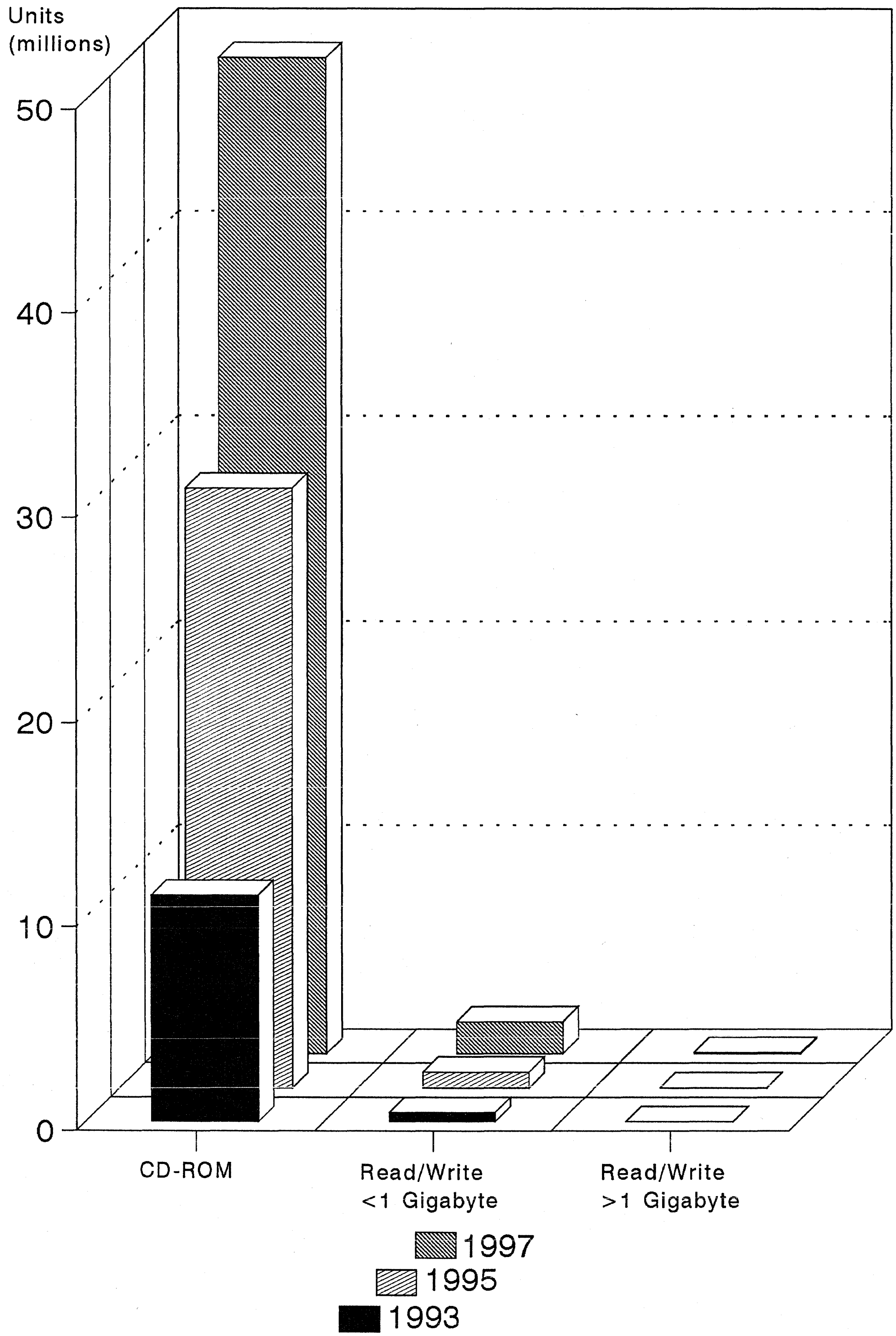
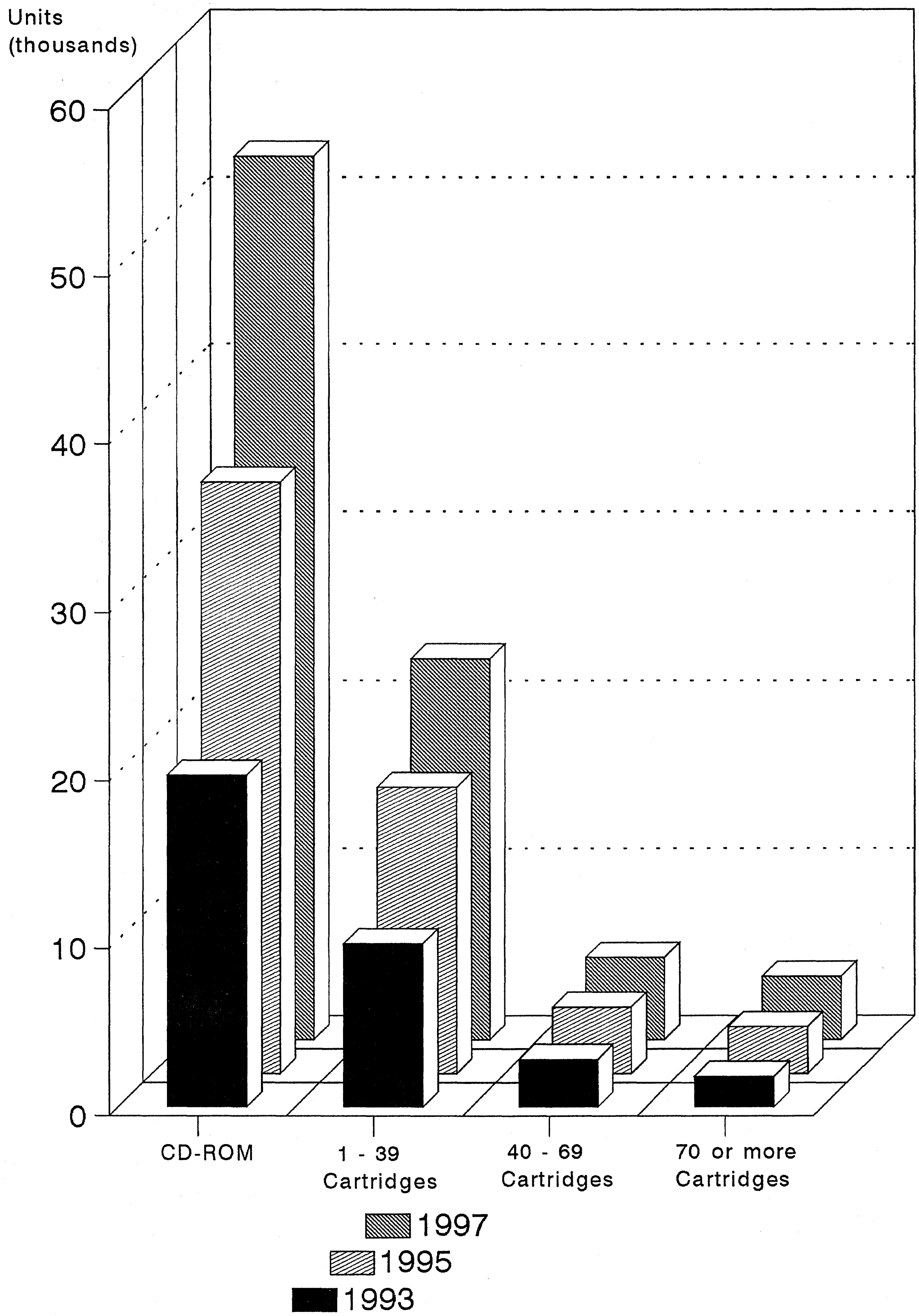


Figure 4

WORLDWIDE SHIPMENT SUMMARY

Total Optical Libraries



Noncaptive market

CD-ROM drive shipments to computer and game manufacturers exploded during the last year, increasing the CD-ROM portion of the noncaptive optical disk drive market (OEM/Integrator and PCM/Reseller distribution channels) to 95.7% of the 9.7 million units shipped in 1993. Because of very strong growth of the CD-ROM market and lackluster performance in the other two product groups, the share of read/write drives less than 1 gigabyte shrank to 4.3% of unit shipments, while the share for read/write drives over 1 gigabyte was less than .1%.

Driven by demand from PC and game manufacturers, growth in CD-ROM drive shipments is expected to continue, but CD-ROM market share growth will flatten toward the end of the forecast period as shipments of higher capacity 3.5" and 5.25" drives put some zip back in read/write drive markets.

CD-ROM drives' fraction of $1.7 billion 1993 revenues improved to 66.6%, but weakening markets for 5.25" and 3.5" drives caused the revenue share of read/write drives less than 1 gigabyte to decline to 28.7%. The relatively high prices for the drives over 1 gigabyte enabled them to obtain a 4.7% share. For CD-ROM drives, very strong growth in unit shipments again exceeded the effects of price declines, resulting in a major year-to-year share gain. 1997 noncaptive revenue of $3.8 billion will be dominated again by revenue from CD-ROM drives, which is expected to increase moderately to 70.8% by the end of the forecast period due to continued strong shipment growth and declining average prices.

The major 1993 OEM/Integrator drive revenue producers were Sony, Matsushita Electric, Philips and Toshiba, in that order. The top four companies accounted for 77% of total OEM/Integrator sales of $1.1 billion. Sony led with 33.3% of the OEM/Integrator total, a gain from 1992. The share held by the top four OEM channel manufacturers is up from 1992, reflecting a strong, but concentrated CD-ROM market. Mitsumi, NEC, Matsushita Electric and Sony were the leading PCM/Reseller channel suppliers, together holding a 54.4% share of the $611 million sales in this channel. U.S. producers captured only 4.6% of total 1993 OEM/Integrator revenues, and an 8.9% share of PCM/Reseller revenues.

The very strong growth of the CD-ROM drive market will drive an expansion of the noncaptive market share through 1997, completely overwhelming anticipated increases in captive sales by IBM, Hewlett-Packard and others as well as the generally higher price levels for products sold on a captive basis.

1993 CD-ROM library shipments generated 59.8% of the 33,185 noncaptive optical library units shipped, followed by the 1-39 cartridge library product group with 27.5% share. The CD-ROM library and low-end segments of the library market are expected to remain the dominant segments through 1997, with the CD-ROM library product group expanding to 64.1% share and the 1-39 cartridge libraries holding their own with 26.2%. Noncaptive shipments of the other library groups are also growing, but more slowly.

1993 noncaptive library revenues exceeded $217 million. Because of their higher prices, the larger library group's revenue shares exceeded their unit shipment shares. The 40-69 cartridge and more than 70 cartridge segments together captured 45.5% of 1993 noncaptive revenue. However, the 1-39 disk product group remained the largest single revenue producing segment with an increased 40.4% share. This product group, with higher AUP than the CD-ROM library group, will remain the strongest revenue producer throughout the forecast period, and is expected to hold a 39.1% share in 1997. The 70 or more disk product group will hold a 27.8% share in 1997. The CD-ROM segment share, 14.1% in 1993, will rise slightly to 17.8% in 1997, limited by lower average prices, although shipments are rapidly growing.

U.S. library manufacturers captured 48.5% of the OEM/Integrator channel revenues and 49.2% of the PCM/Reseller channel revenues in 1993. Hewlett-Packard, Sony and Eastman Kodak were the leading OEM/Integrator suppliers, accounting for 53.2% of over $156 million channel revenues between them. The three top OEM/Integrator supplier's share was about the same as in 1992. In the PCM/Reseller channel, IDE, Hewlett-Packard, Pioneer and NKK were the leaders, together capturing 78.3% of nearly $61 million sales in the channel. Noncaptive library revenues will rise slightly from a 88.6% share of the worldwide total in 1993 to a 90.4% share in 1997, with the strongest growth coming from sales of low-end libraries. The PCM/Reseller channel is expected to gradually increase its share of optical library revenues as a result of the increasing number of low end and CD-ROM libraries that do not require sophisticated technical knowledge to install and support. In 1993, the PCM/Reseller group held 24.6% of worldwide revenues, and is expected to increase its share to 30.6% in 1997.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1993 Revenues $M	1993 Revenues %	Forecast 1994 $M	1994 %	1995 $M	1995 %	1996 $M	1996 %	1997 $M	1997 %
CD-ROM	1,143.4	66.6%	1,665.8	71.6%	2,129.5	73.5%	2,481.9	73.4%	2,721.5	70.8%
ALL CAPACITIES	+138.2%		+45.7%		+27.8%		+16.5%		+9.7%	
READ/WRITE	493.6	28.7%	578.6	24.8%	656.3	22.6%	737.7	21.8%	882.1	23.0%
LESS THAN 1 GIGABYTE	+2.5%		+17.2%		+13.4%		+12.4%		+19.6%	
READ/WRITE	82.3	4.7%	86.3	3.6%	114.7	3.9%	165.3	4.8%	243.1	6.2%
MORE THAN 1 GIGABYTE	+10.6%		+4.9%		+32.9%		+44.1%		+47.1%	
Total Worldwide Revenues	1,719.3	100.0%	2,330.7	100.0%	2,900.5	100.0%	3,384.9	100.0%	3,846.7	100.0%
	+66.0%		+35.6%		+24.4%		+16.7%		+13.6%	

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	1993		Forecast							
ALL MANUFACTURERS	Revenues		1994		1995		1996		1997	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM FORMAT OPTICAL LIBRARIES	30.7	14.1%	45.4	16.5%	57.4	17.6%	64.9	17.5%	72.4	17.8%
	+129.1%		+47.9%		+26.4%		+13.1%		+11.6%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	87.3	40.4%	112.8	41.0%	132.7	40.7%	148.9	40.4%	159.0	39.1%
	+29.3%		+29.2%		+17.6%		+12.2%		+6.8%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	45.7	21.0%	49.7	18.0%	55.1	16.8%	58.4	15.8%	62.7	15.3%
	-12.6%		+8.8%		+10.9%		+6.0%		+7.4%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	53.4	24.5%	67.7	24.5%	81.7	24.9%	97.7	26.3%	113.6	27.8%
	-4.1%		+26.8%		+20.7%		+19.6%		+16.3%	
Total Worldwide Revenues	217.1	100.0%	275.6	100.0%	326.9	100.0%	369.9	100.0%	407.7	100.0%
	+14.9%		+26.9%		+18.6%		+13.2%		+10.2%	

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 IN THOUSANDS	1993 Shipments		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM ALL CAPACITIES	9,297.8	95.7%	17,173.6	97.0%	25,793.0	97.4%	33,951.0	97.2%	43,448.0	96.7%
	+304.1%		+84.7%		+50.2%		+31.6%		+28.0%	
READ/WRITE LESS THAN 1 GIGABYTE	424.2	4.3%	542.7	3.0%	713.7	2.6%	968.2	2.8%	1,463.5	3.3%
	+26.1%		+27.9%		+31.5%		+35.7%		+51.2%	
READ/WRITE MORE THAN 1 GIGABYTE	6.5	--	7.2	--	12.4	--	28.8	--	59.2	--
	+10.2%		+10.8%		+72.2%		+132.3%		+105.6%	
Total Worldwide Shipments	9,728.5	100.0%	17,723.5	100.0%	26,519.1	100.0%	34,948.0	100.0%	44,970.7	100.0%
	+268.0%		+82.2%		+49.6%		+31.8%		+28.7%	
% U.S. Manufacturers	.9%		.8%		.6%		.6%		.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	1993		Forecast							
SINGLE UNITS	Shipments		1994		1995		1996		1997	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM FORMAT OPTICAL LIBRARIES	19,810	59.8%	27,724	60.4%	35,177	61.2%	43,274	62.1%	52,686	64.1%
	+72.7%		+40.0%		+26.9%		+23.0%		+21.7%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	9,127	27.5%	13,006	28.3%	16,146	28.1%	19,320	27.7%	21,540	26.2%
	+4.8%		+42.5%		+24.1%		+19.7%		+11.5%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	2,734	8.2%	3,255	7.1%	3,821	6.6%	4,342	6.2%	4,786	5.8%
	+16.4%		+19.1%		+17.4%		+13.6%		+10.2%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	1,514	4.5%	1,964	4.2%	2,388	4.1%	2,843	4.0%	3,301	3.9%
	+41.8%		+29.7%		+21.6%		+19.1%		+16.1%	
Total Worldwide Shipments	33,185	100.0%	45,949	100.0%	57,532	100.0%	69,779	100.0%	82,313	100.0%
	+40.6%		+38.5%		+25.2%		+21.3%		+18.0%	
% U.S. Manufacturers	28.6%		29.6%		29.2%		28.8%		27.4%	

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

Figure 5

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Disk Drives

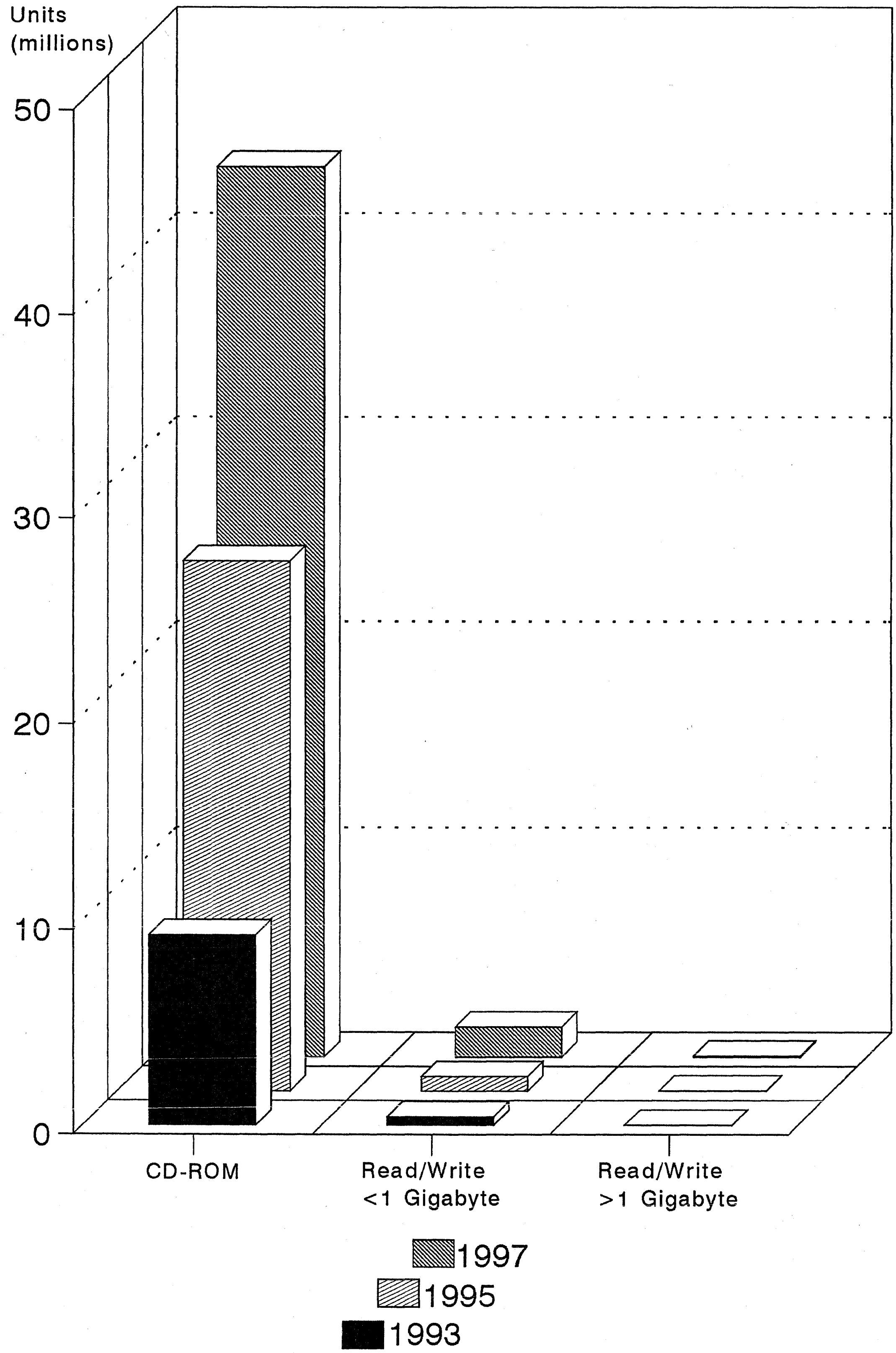


Figure 6
WORLDWIDE SHIPMENT SUMMARY
Noncaptive Optical Libraries

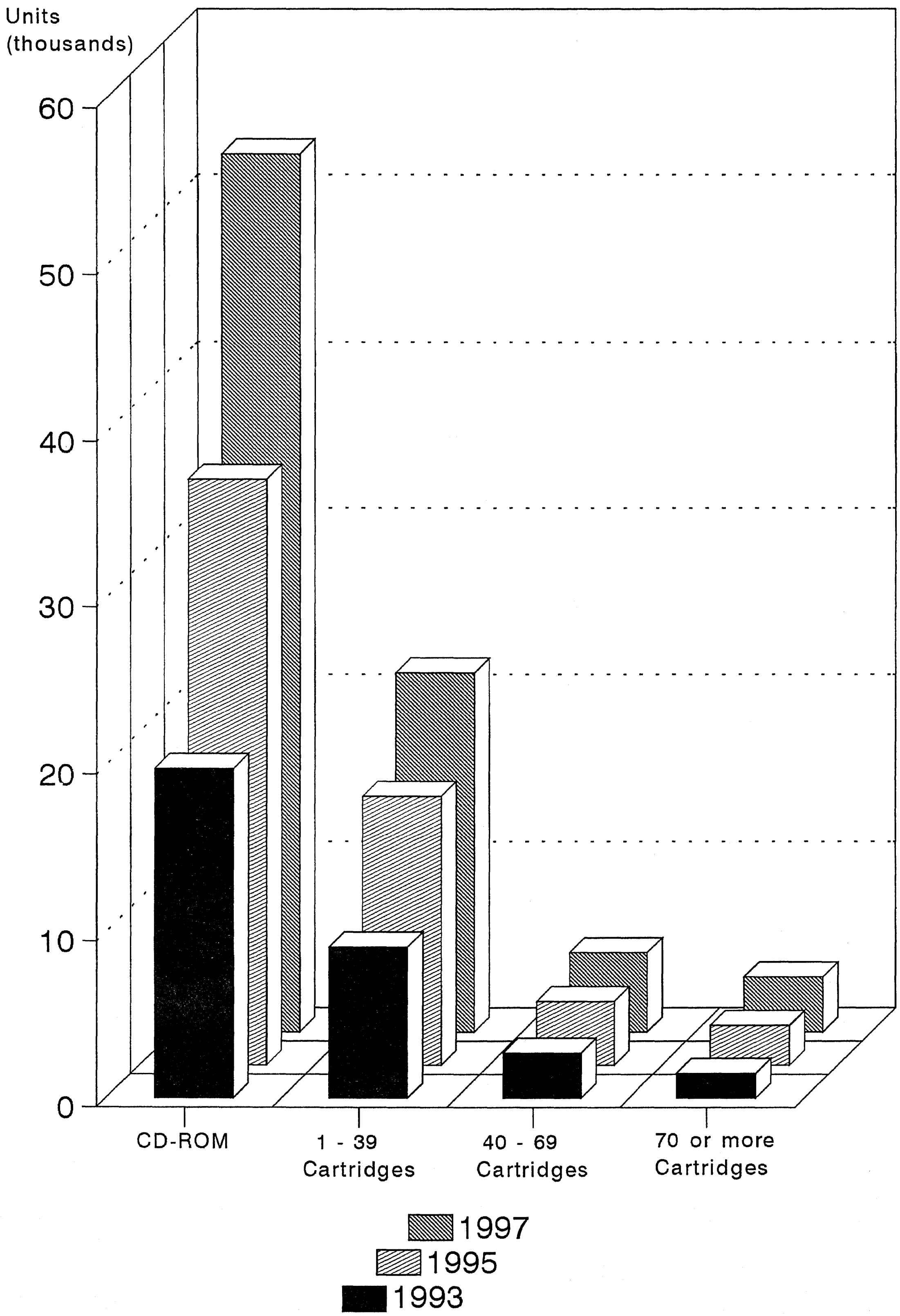


TABLE 13

1993 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK DRIVES
(Value of non-U.S. currencies estimated at average 1993 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Hewlett-Packard	30.2	6.2	4.8	.8	16.7	1.5	51.7	2.3
IBM	20.2	4.2	24.6	4.0	13.2	1.2	58.0	2.6
Maxoptix	--	--	14.9	2.4	18.0	1.6	32.9	1.5
Other U.S.	6.0	1.2	10.1	1.7	3.6	.3	19.7	.9
U.S. Total	56.4	11.6	54.4	8.9	51.5	4.6	162.3	7.4
NON-U.S. MANUFACTURERS								
Fujitsu	--	--	22.1	3.6	27.6	2.5	49.7	2.3
Hitachi	12.7	2.6	45.9	7.5	10.5	.9	69.1	3.1
Matsushita Electric Industrial	--	--	90.4	14.8	327.1	29.5	417.5	18.9
Mitsumi Electric	--	--	96.6	15.8	32.7	3.0	129.3	5.9
NEC	35.1	7.2	92.0	15.0	31.8	2.9	158.9	7.2
Philips (Includes Philips LMS)	121.3	25.0	38.7	6.3	89.6	8.0	249.6	11.4
Ricoh	13.0	2.7	17.5	2.9	30.8	2.8	61.3	2.8
Sega Enterprises	189.0	39.0	--	--	--	--	189.0	8.6
Sony	53.8	11.1	53.7	8.8	368.7	33.3	476.2	21.6
Toshiba	--	--	30.8	5.0	68.4	6.2	99.2	4.5
Other Non-U.S.	3.5	.7	69.2	11.3	69.3	6.3	142.0	6.4
Non-U.S. Total	428.4	88.4	556.9	91.1	1,056.5	95.4	2,041.8	92.6
WORLDWIDE TOTAL	484.8	100.0	611.3	100.0	1,108.0	100.0	2,204.1	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

1993 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL LIBRARIES
(Value of non-U.S. currencies estimated at average 1993 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Eastman Kodak	7.5	16.4	.8	1.3	13.5	8.6	21.8	8.3
FileNet	8.8	19.3	--	--	2.0	1.3	10.8	4.1
Hewlett-Packard	14.8	32.5	11.3	18.6	47.4	30.3	73.5	28.0
International Data Engineering	--	--	17.4	28.6	2.6	1.7	20.0	7.6
Other U.S.	.2	.4	.4	.7	10.3	6.6	10.9	4.1
U.S. Total	31.3	68.6	29.9	49.2	75.8	48.5	137.0	52.2
NON-U.S. MANUFACTURERS								
ATG Cygnet	--	--	1.0	1.6	12.0	7.7	13.0	4.9
Philips LMS	--	--	6.7	11.0	10.1	6.5	16.8	6.4
Matsushita Electric Industrial	--	--	--	--	11.2	7.2	11.2	4.3
NEC	13.0	28.5	--	--	2.5	1.6	15.5	5.9
NKK	--	--	9.4	15.5	6.9	4.4	16.3	6.2
Pioneer Electronic	--	--	9.5	15.6	6.0	3.8	15.5	5.9
Sony	--	--	--	--	22.4	14.3	22.4	8.5
Other Non-U.S.	1.3	2.9	4.3	7.1	9.4	6.0	15.0	5.7
Non-U.S. Total	14.3	31.4	30.9	50.8	80.5	51.5	125.7	47.8
WORLDWIDE TOTAL	45.6	100.0	60.8	100.0	156.3	100.0	262.7	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 library manufacturer include net sales of libraries only and do not represent total revenues for individual companies

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

TABLE 15

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL DISK DRIVES

DISK/TREND PRODUCT GROUP:		10	11	12
U.S. Manufacturers (11)	Type	CD-ROM Optical Drives	Read/Write Optical Drives <1 GB	Read/Write Optical Drives >1 GB
CD-ROM, Inc.	P	12 cm		
Eastman Kodak	C,O,P		12 cm	14
Hewlett-Packard	C,O,P		5.25E	
Honeywell	O		5.25	
IBM	C,O,P		3.5E, 5.25E	
Maxoptix	O,P		5.25E	
Media Vision	P	12 cm		
MountainGate Data Systems	O		5.25	
Mountain Optech	O		3.5E, 5.25E	
Pinnacle Micro	O,P		5.25E	
Sierra Technologies	O,P		5.25	
Asian Manufacturers (43)				
Aiwa	P	12 cm		
Alco Digital Devices	O,P	12 cm		
Alps Electric	O	12 cm		
Asaca	O		5.25E	
Aztech Systems	O,P	12 cm		
Behavior Tech Computer	O,P	12 cm		
Canon	C,O		5.25E	
Chinon	O,P	12 cm	3.5E	
Elitegroup Computer Systems	P	12 cm		
Fujitsu	C,O,P		3.5E, 5.25E	
Funai Electric	O	12 cm		
GoldStar	O,P	12 cm		
Group Sense	O,P	12 cm		
Hitachi	C,O,P	12 cm	5.25, 5.25E	5.25E, 12
Hopax Industries	O,P	12 cm		
Juko Electronics	O,P	12 cm		
JVC	O		12 cm	
LaserByte	O,P		3.5E	
Lion Optics	O,P	12 cm		
Longshine Electronics	O,P	12 cm		
Matsushita Electric Ind.	C,O,P	12 cm	3.5E, 5.25, 5.25E	
Matsushita Electronic Comp.	O	12 cm		
Mitsumi Electric	O,P	12 cm		
MOST	O,P		3.5E	
NEC	C,O,P	12 cm	3.5E, 5.25E	12
Nikon	O			12E
Nippon Steel	O		5.25E	
Olympus	O		3.5E, 5.25E	
Optics Storage	O,P	12 cm		
Pioneer Electronic	O,P	12 cm	5.25, 5.25E	
Plextor (Shinano Kenshi)	O,P	12 cm		
Ricoh	C,O,P		3.5E, 12cm, 5.25, 5.25E	
Samsung Electronics	O	12 cm		
Sanyo Electric	O,P	12 cm		
Sega Enterprises	P	12 cm		
Seiko Epson	O		3.5E	
Sharp	O,P	8 cm	5.25E	
Sony	C,O,P	8 cm,12 cm	2.5E,3.5E,12cm,5.25E	12
TEAC	O,P	12 cm	3.5E	
Toshiba	O,P	12 cm		
TXC	O,P	12 cm		
Wearnes Technology	O,P	12 cm		
Yamaha	O,P		12 cm	
European Manufacturers (3)				
ATG Cygnet	O			12
Philips Consumer Electronics	C,O,P	12 cm	12 cm	
Philips LMS	C,O,P	12 cm	12 cm	12

Numbers in table are diameters in inches except for CD format drives.

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 (13)	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		
Advanced Digital Information	O,P		3.5		
Borett Automation Tech.	O	12 cm			5.25, 12
Document Imaging Systems	O	12 cm			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		5.25		5.25
International Data Engin.	O,P		5.25	5.25	
Kubik Enterprises	O	12 cm			
Sigma Designs Imaging Systems	C,O				5.25
TAC Systems	O	12 cm			
Todd Enterprises	O,P	12 cm			
Asian Manufacturers (16)					
Aisin Seiki	O		5.25		
Asaca	O				5.25
Fujitsu	C,O		5.25		5.25
Hitachi	C,O		5.25, 12	5.25, 12	5.25
Matsushita Electric Ind.	C,O			5.25	
Microboards	O,P	12 cm			
MOST	O		3.5		
Nakamichi	O,P	12 cm			
NEC	C		5.25, 12	5.25	
Nikkyo	O		5.25	5.25	
NKK	O,P		5.25	5.25	5.25
Olympus	O,P		5.25		
Pioneer	O,P	12 cm			
Ricoh	C,O		5.25	5.25	
Sony	O,P		5.25, 12	12	12
Victor Data Systems (JVC)	O	12 cm			
European Manufacturers (7)					
Amber Technology	O,P	12 cm		5.25	
ATG Cygnet	O		12		12
DSM	C,O	12 cm	5.25, 12	12	5.25, 12
K+S	O,P		5.25		5.25
Logical Engineering	O,P	12 cm			
NSM	O	12 cm			
Philips LMS	O,P		12		

Numbers in table are diameters in inches except for CD-ROM libraries.

TECHNICAL REVIEW

1994 is a transition year between the old and the new for many optical drive products. New announcements of higher capacity and higher performance drives in several categories are expected in late 1994 and 1995. Anticipated are higher capacity 5.25" magneto-optic and phase change drives, faster CD-R drives, higher capacity 12" and 14" drives, and a new 3.5" drive generation. Some of the key areas where changes are occurring 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.
* New interface chip sets, including ATAPI chips.
* Cost reduced drives and media.
* Rationalization of incompatible physical and recording standards, which prevent media interchange between systems for some types of drives.
* Low mass and lower complexity head design for improved performance and cost.
* Reduced susceptibility to hostile environments, especially dust.
* Higher data transfer rates to support large files and full motion video.
* Direct overwrite for at least some magneto-optic drives and media.
* Fewer incompatibilities between optical drives and optical libraries.
* Repackaging of drives into smaller industry standard form factors.
* Smaller and lower power drives for use with or 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 well after 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, are not sufficient to overcome optical drive and media economic and performance deficiencies compared to other storage solutions, except where removability is required.

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 disk drives, write-once disk drives, and rewritable disk drives.

* Read-only optical disks: The read-only optical disk group is dominated by 12 centimeter diameter CD-ROM drives, which have typical capacities of 550 to 680 megabytes depending upon the format used. An 8 centimeter 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 attempted to launch an ISO format 8 centimeter CD-ROM drive capable of storing 180 to 200 megabytes of data, but with no great success to date. In the booming market for standard 12 centimeter 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 higher capacity, backward compatible CD-ROM format. Faster drives offering two to four times today's capacity is expected within two years, but agreement from major suppliers on specs and standards is required for new standard designs to be implemented.

  The high production volumes achieved by CD-ROM drives have stimulated development of advanced versions and enabled steep cost reductions. CD-ROM drives from NEC, TEAC, Plextor and others have quadrupled 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). Average seek times are dipping under 200 milliseconds for some models.

  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 multisession disks written on CD-R drives.

In read-only recording, the disk is normally mass produced using a mold which impresses the data upon the surface of the disk, followed by the deposition of a metal layer and a protective layer to establish the proper reflectivity. When scanned by a laser beam, the reflected beam is modulated by the data pattern on the disk, and the signal pattern is processed within the drive. 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-R drives appear poised to address this need.

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 has had even cursory consideration, as a vehicle for software distribution and multimedia presentations.

* Write-once 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, the first write-once drives (and rewritable drives) were capable of higher areal densities than magnetic recording drives then in use. However, because of the relatively slow rate of increase in optical drive areal density compared to the rate of improvement in rigid magnetic drives, magnetic drive areal density has now threatened to surpass optical drive areal density for both rewritable and write-once drives.

  Write-once recording involves 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, while others deform the surface of the media to cause a reflectance change at the point where a bit is written. A more recently developed write-once technology (known as Continuous Composite WORM, or CCW, or MO-WORM) uses magneto-optic media, which is normally rewritable, prestamped with information indicating that it is to be used only in a write-once mode. With the recent success of CD-R format write-once recording, media incorporating dye that absorbs the laser beam energy, changing its state and creating a mark, is becoming the most prevalent form of pure write-once media.

Writing power required at the surface of the disk is in the range of 10 milliwatts 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 interchange, 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 a poor performer compared to magnetic disk drives. However, fast 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 tape, with 10 years being the minimum specification for archival life of the media. Some media suppliers specify a 30 year lifetime and claims of lifetimes exceeding 50 years have been made. Ablative write-once media is typically based on tellurium films. 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 corrosion resistance, but may trade off write sensitivity for the improved longevity obtained.

The largest application for write-once recording technology is still the archival storage of documents. The document is typically stored as a document image, rather than as character data. CD-R is used for a variety of applications, including archiving, data distribution and preparing master disks for subsequent replication. 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 (MO) 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 MO 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 are shipping second generation 5.25" drives with 650 megabytes per side capacity, and Hitachi is producing drives with 1 gigabyte per side capacity. Drives and media with 1.3 gigabytes per side are being considered by various standards bodies, and such drives are expected to be announced in late 1994 and 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 temperature 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 MO 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.

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. It uses a flying magnetic head to write data while the laser heats the surface of the media above the Curie temperature. Sony subsequently announced a computer peripheral version as the MD-DATA, with about 140 megabyte capacity, and 150 kilobyte per second data transfer rate for production in late 1994.

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 over long periods of time, excessive 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 most MO 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 MO drives.

A third recording technology, potentially the least expensive to manufacture, is rewritable dye or dye/polymer. Only limited success has been zobtained with this technique because developers have not been able to demonstrate a large number of write/erase cycles and 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 pursued 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 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 disks.

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.

* <u>Optical libraries</u>: 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 migrated to the computer world as an accessory for the CD-ROM. As of mid-1994, 13 firms were selling CD-ROM libraries with capacities ranging from 6 to 20,000 disks.

Drives designed for use in optical disk 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. Integration into a mainframe environment is a major task that can involve 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.

* Areal Density: The rate of improvement of areal density for optical drives has lagged the average 60% per year rate shown by magnetic drives, but there are some approaches in the lab that may speed optical's progress. A mix of approaches is likely, including denser coding methods such as pulse width recording, shorter wavelength lasers, elimination of grooved media in favor of sector servo recording, and nonconventional optics to reduce spot size.

High areal densities can be obtained by using multiple lasers of differing wavelength to record multiple bits at a given spot. In 1993, NHK reported their research facilities had demonstrated the ability to record 100 gigabytes on a 3.5" disk using this technique.

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 areal density might recapture a commanding lead. Using a tapered fiber optic tube to replace the conventional MO drive optics, the researchers achieved a 60 nanometer spot size, albeit at a writing rate of 10 kilobits per second. In 1993, Hitachi announced work with an optical fiber approach that could record an hour of HDTV signal on a 2.5" MO disk.

* 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: Optical recording heads are relatively complex devices incorporating a diode laser, detector, optics, and, frequently, a fine positioning mechanism. The typical first generation head assembly had relatively high mass, slowing access time and increasing head positioning power. Average access time in excess of 125 milliseconds was not unusual. However, the demands of data processing systems required faster average access time, leading to development of the 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. The Maxoptix 5.25" rewritable drive, for instance, has an average seek time below 20 milliseconds.

  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. MEI expects to produce a head with unconventional optics for CD-ROM drives weighing only .2 grams.

  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.

Philips LMS brought the first two-headed drive to market. The introduction had a significant impact on the plans of drive producers, many of which began seriously considering multiple heads in their optical drives.

* Lasers: The key issues for lasers are laser power, laser wavelength, and laser lifetime. The amount of power available from the laser governs the time required to write a spot on the disk, thus limiting 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. Shorter wavelength lasers likely to appear within the next few years should result in smaller spot sizes and an increase in bit and track density. 780 nanometer lasers will be displaced by 680 nanometer lasers in the 1995-1996 period, enabling a 40% gain in areal density. Green and blue frequency doubled lasers are likely to be in wide use in the 1997-1998 period: The blue laser should quadruple today's areal densities, but may require the abandonment of grooved media in favor of a sampled servo tracking system.

  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.

* 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 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.

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 media is required and is available only from a single drive or media manufacturer. Manufacturers of rewritable drives claim a significant degree of media interchange capability 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.

Most of the substrates used so far have been plastic. While glass is more expensive, its smoothness, freedom from distortion at high rotation rates, minimal optical dispersion and superior environmental protection cause glass to be preferred as a substrate material when archival life and reliability are critical. Glass substrates, being smoother, result in substantially improved error defect rates, which in turn can reduce drive latency due to error correction time. But the mass of glass is greater than polycarbonate, requiring more time to spin-up in a drive.

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 used 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.

In mid-1994, IBM announced the results of a research project which demonstrated a stacked disk approach to increasing the capacity of optical disks. By changing the focal plane of the lenses in the head, individual disks in the stack can be addressed. IBM believes that up to 10 disks can be stacked in this manner, but so far only a 4 layer read/write stack and a 6 layer read-only stack have been demonstrated.

Media life is a declining concern. Accelerated life tests indicate that re-writable 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 life-times 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 Cygnet and Philips LMS, 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, was used 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.

  Major increases in track density are not expected until red lasers come into use, at which time TPI is expected to move above 20,000 TPI. The 5.25" 650 megabyte per side drives and media specified a 1.4 micron track pitch, or about 18,000 TPI. 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. Most 3.5" rewritable drives fit into a standard 41.3 millimeter high space. Fujitsu announced a one inch high 3.5" drive in 1992. Sony has shown 17.5 millimeter high CD-ROM drives and may be able to package rewritable drives in this thinner format.

Because small diameter optical disk drives are forced to conform to magnetic disk drive form factor standards, which continue to evolve, CD-ROMs and 3.5" optical drives are now being challenged to move to form factors thinner than 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.

* <u>Power</u>: The power requirements of optical drives make them largely unsuitable for use in portable systems, although a few systems, such as the Sony Data Discman and the Sony MMCD (multimedia compact disk) have appeared using CD-ROM drives. Some notebook systems due in 1994 are expected to incorporate internal CD-ROM also.

* <u>Interface</u>: 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.

  CD-ROM drives began using the ATAPI interface in 1994 because of its lower cost compared to SCSI and its ease of integration into personal computer systems. In 1995 and after, ATAPI will be the dominant form of interface for CD-ROM drives and has some prospects for adoption in the next generation of high capacity 3.5" drives.

  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 Cygnet 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, incorporated internal data compression and decompression as well as error correction.

  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 higher density CD-ROM media are reopening basic standards issues for CD-ROMs.

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 Rock Ridge concerns and support for the multisession recording format used by CD-R.

Multimedia formats are an area of standards conflict. Multiple "standard" formats contend in the marketplace 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. The MPEG encoding in use in 1994 offers enough compression to enable 74 minutes of near VHS quality video to be stored on a CD-ROM disk, but the next generation MPEG-2 may be required to get a full length movie in VHS or better quality on a single 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 specification 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. 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 acquired by General Electric when it acquired RCA. G.E. subsequently sold the DVI technology to Intel. DVI received support from Lotus, IBM and other firms having interest in business applications of multimedia, but its relatively high costs and competition from other approaches have hampered acceptance.

A third multimedia format, CDTV, was 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 (DIS 13346/ECMA 167: Nonsequential recording (NSR)) is independent of the type of equipment used and may have applications beyond optical storage.

Standardization efforts for rewritable drives and media proceeded more quickly, as they were able to build on much of the work done for the 5.25" write-once effort. 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 formalized 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. With the announcement of IBM's own 5.25" and 3.5" 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.

A standard for 14" write-once media has been prepared. 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 semiconductor 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

* <u>Rigid disk drives</u>: 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. More pertinent, rigid disk drives offer serious competition to optical drives in some situations. SyQuest's 3.5" 270 megabyte removable drive competes strongly with 3.5" 230 and 128 megabyte optical drives. And 5.25", drives such as the 9 gigabyte Seagate Elite 9, challenge the 650 megabyte per side 5.25" optical drives by offering several times the capacity at a fraction of the price.

  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-15 millisecond times on drives of the same capacity or larger. Sub-10 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, now in excess of 500 megabits per square inch, are approaching the areal density of optical drives at a fast rate and are expected to be at 5 gigabits per square inch or more by the end of the decade. 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 in its role as a high performance system disk.

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: The 20 megabyte Floptical disk drives from Iomega and Insite Peripherals did not offer serious competition to optical drives because of their limited capacity, but there are some prospects for extending the technology of high density floppy drives to the 100 megabyte range, where, if appropriately priced, they might offer limited competition to 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.

* <u>Optical tape</u>: 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 magne-to-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 cosponsored a research program at MCC (Microelectronics and Computer Technology Corporation) to develop a rewritable, fast, high capacity holographic memory. 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 is a holographic WORM with jukebox, fitting in a full size 5.25" form factor and offering 30 gigabytes of capacity.

  The holographic memory may eventually reach 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, an array of strontium barium niobate or lithium niobate crystal fibers has 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

* <u>High performance tape drives</u>: 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 are also able to 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 a small degree by CD-R 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.

* Philips LMS 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 1994 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:

Very high performance: Disk drives or disk libraries attached directly to the system or to a terminal associated with a supercomputer or a high end imaging system.

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

Network/mini/multiuser 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, IBM PS/1, Apple Macintosh, Compaq and general purpose "home computers".

Workstations: Single user high end workstations used for engineering, graphics, medical, military, publishing and other applications, plus specific office applications such as word processing, electronic mail or document storage. Specialized hardware is normally used. Examples: Canon Canofile, Hitachi HITFILE.

Consumer, game 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 Sega Genesis and most CD-I players are also included in this category.

Other applications: Any application not included above.

CD-ROM OPTICAL DISK DRIVES

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CD-ROM OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter (4.72") disk diameter

Aiwa	ACD-300
Alco Digital Devices	CDR 931, CDR 938
Alps Electric	DC52
Aztech Systems	CDA 268
Behavior Tech Computer	CDD-110
CD-ROM, Inc.	CRI 100
Chinon	CDS-535, CDS-525, CDS-545
Elitegroup Computer Systems	Vertos 100, Vertos 300
Funai Electric	E2540UA, PL1345
Goldstar	GCD-R320B, GCD-R420B
Group Sense	CDAT-300, CDSI-100
Hitachi	CDR 1700S, CDR-1900S, CDR 3700
Hopax Industries	520/E, 520/A
Juko Electronics	JOCD-5X
Lion Optics	XC 200
Longshine Electronics	LCS 7260
Matsushita Electric Industrial	CR-563, LK-MC501, LK-MC521
Matsushita Electronic Components	EBP-103, EBP-302, EBP-601
MediaVision	Reno
Mitsumi Electric	CRMC-LU0, CRMC-FX-D, CRS-XP
NEC	PC-CD160F, CDR-74, CDR-84
Optics Storage	Dolphin 8000
Philips LMS	CM206, CM207
Philips Consumer Electronics	CM 405ABK, CDI-360, CDF 100
Pioneer	DRM-602X, DRM-604X, DRM 1804
Plextor (Shinano Kenshi)	4 Plex, DM-3028, DM-5028
Samsung Electronics	SCDR-300
Sanyo	CRD-400, CDR 93, CDR H93
Sony	CDU-33, CDU-561, CDU-6811
TEAC	CD-50, CD-55, CD-100
Toshiba	XM-3401B, XM4100A
TXC	TXCD-A4, TXCD-11
Wearnes Technology	CDD-110, CDD-120

8 centimeter (3.15") disk diameter

Sharp	PU-CDI
Sony	Data Discman

A standard 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 12 centimeter (4.72") or 8 centimeter (3.15") media. 12 centimeter drives usually also accept 8 centimeter media. Recordable CD format drives (CD-R) are considered a form of write-once recording and are covered in section DT-11 of this report, which follows this chapter. 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.

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 quantity and types of information that publishers provide. In addition to the estimated 8,000 to 10,000 titles now sold to the public by CD-ROM publishers, there are numerous "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.

Market status

Shipments of CD-ROM drives continued their explosive growth during 1993, and growth remains high in 1994. Spurred by rapidly declining prices and the availability of thousands of CD-ROM titles, personal computer manufacturers added CD-ROM drives to many low end, high shipment volume models intended for home and office use. Video game manufacturers also greatly increased drive usage. Large numbers of multimedia kits, typically incorporating a sound board and a CD-ROM drive, and sold through retail and mail order channels, were the largest aftermarket factor for CD-ROM drive sales, but will gradually decrease in significance as personal computer manufacturers increasingly bundle drives into systems at the factory. While the industry has mostly managed to keep up with demand, the high growth rate has resulted in occasional supply restrictions over the past year.

1993 unit shipments leaped to slightly over 11 million units, an increase of 338% above 1992 shipments, while worldwide revenues grew 174% to exceed $1.5 billion. Revenue growth was limited by sharply declining prices resulting from manufacturing economies, lower cost designs and competitive pressures. The booming market has attracted a flood of new entrants, many in Southeast Asia, and encouraged the growth of contract manufacturing of CD-ROM drives in Japan, China and other locations. Many of the newcomers purchase the optical and mechanical mechanisms and complete the drive by adding their own electronics and packaging. 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 by companies using purchased mechanisms.

Nearly all CD-ROM drives use 12 centimeter (4.72") diameter media. Sony introduced an 8 centimeter (3.15") CD-ROM in the Data Discman in 1990, and until Toshiba announced an 8 centimeter drive in 1992, it was the only one in production. Chinon and Sharp introduced 8 centimeter drives in late 1992. Sony and Sharp are the primary producers of information products that incorporate an 8 centimeter drive, but the Sony drive uses a proprietary format. The 8 centimeter format has not been very successful because of its low capacity (about 180 megabytes) and lack of published titles, although some manufacturers of notebook computers are planning to offer it as a feature.

The Matsushita companies, Sony and Mitsumi were the leading noncaptive CD-ROM drive producers in 1993, followed by Toshiba and NEC. Sega displaced NEC as the leading captive producer on the strength of sales for its game products, although it should be noted that Sega relies upon several contract manufacturers for assembly of proprietary designs. The MediaVision drive is also made on a contract basis.

CD-ROM drives capable of operating with multimedia titles are now in the marketplace, with such features as embedded XA support, support for Eastman Kodak multisession disks, improved seek times, and at least doubled spin rate and data transfer rates to support full screen, full motion video. Such CD-ROM drives are being incorporated in computer systems and in computer based players and games that attach directly to a television receiver or monitor.

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

Shipments of CD-ROM drives are on a steep ramp expected to continue for several years. Shipments of nearly 49 million units are anticipated in 1997, with associated revenues exceeding $3.75 billion. Shipments of 8 centimeter drives, about 3% of 1993 shipments, are expected to remain in this range throughout the forecast period due to capacity limitations and a relative scarcity of titles. However, new CD-ROM technology expected to reach the market in two to three years could increase the capacity of the 8 centimeter disk enough to broaden its applications thereafter.

Average OEM prices are expected to decrease from $111 in 1993 to $60 in 1997, under the stimulus of increased competition, larger quantities and an increasingly consumer oriented share of the applications mix. Prices for lower performance drives are already well under the $100 mark and expected to be in the low $70 range in 1995, but the large number of high performance drives shipped will keep average prices higher. Older single speed CD-ROM drives have been advertised by mail order firms below the $100 retail level, and the retail price of low performance double speed drives was beginning to dip below $120 as of mid-1994.

Non-U.S. firms will continue to be the major producers, but Asian countries other than Japan are competing for a share of the market, even as Japan is moving much of its own production offshore. Some contract production has moved from Japan to other Asian locations, and this is stimulating local manufacturing of CD-ROM drives. Wearnes Technology, Lion Optics, and Optics Storage are among the firms that have begun production in Southeast Asia in the last year, while several Japanese firms are having their drives manufactured in China. In Taiwan, TXC, Behavior Tech, Elitegroup and others have begun production using purchased mechanisms. The rush of companies into the business will be familiar to those who remember the onetime heady growth of the floppy disk drive industry, which the CD-ROM drive industry increasingly resembles.

1997 OEM shipments are projected at about 69% of total shipments, up from 62% in 1993. Reseller shipments, 21.5% of the 1993 total, will decline, lowering to 19.7% in 1997. The share of captive shipments is expected to decline from 16.1% in 1993 to 11% in 1997. Both captive and reseller unit shipments are actually increasing, but will decline as a percentage of the total because OEM sales will grow faster.

Single speed drives (150 KB/second data transfer rate) will phase out completely in 1994, with double speed (2X) drives accounting for over 95% of 1994 shipments. 3X and 4X drives (now available from NEC, TEAC, Pioneer, Plextor and others) will represent only a few percentage points share of 1994 shipments. 4X drive shipments are expected to completely displace 3X drives by the end of 1994 and will grow rapidly starting in late 1995, largely displacing 2X drives in 1997.

Increasing 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, Philips and others had significant 1993 shipments, and 1994 shipments are expected to exceed 2 million units as Sony launches its new home system.

The use of CD-ROM as a vehicle for multimedia data storage is expected to grow rapidly over the next several years, but several competing formats may confuse the marketplace. In addition, new video oriented formats are expected to appear over the next several years to provide the capability to contain complete movies in compressed form on a single disk.

Among the multimedia formats already in the market are CD-I, sponsored by Sony and Philips, and DVI, sponsored by Intel. Neither has been greatly successful to date, primarily because of the high cost of associated hardware. CD-I has attracted some followers in the education, point-of-sale and consumer camps, but most sales have been in Europe. Eastman Kodak has demonstrated Photo CD on both CD-I and DVI systems.

A number of proprietary formats have also been offered. CDTV, Commodore's consumer oriented CD-ROM multimedia was introduced formally in the spring of 1991, but has been unsuccessful. 3DO, a well funded startup company licensing its proprietary format for multimedia players made by other firms, is achieving modest success, although shipments have been below projections.

Formats employing compression will increasingly be employed, with JPEG and MPEG the most significant contenders for general acceptance. For instance, CD-I supports full screen full motion video with the addition of an MPEG decoder chip to the drive controller. Personal computers equipped with MPEG decoders can also play back CD-ROM video content.

Video CD, also using MPEG, has attracted some industry interest, with players expected by late 1994 from JVC, Sony, Goldstar, Philips, Samsung and others. Image quality is (roughly) similar to VHS video playback. However, it can hold only 74 minutes of video and audio, insufficient for many movies. Because Video CD and CD-I are based upon a common format, Video CD disks will play on CD-I and compatible equipment. Video CD may have a short life, as high density formats able to hold two or more hours of video content are expected to be available in the next 2-3 years and there is not yet any guarantee of backward compatibility.

While CD-ROM sales are expected to benefit from multimedia activities, the multimedia area has been overmarketed to the point where the expectations of many may be overinflated. Conflict between various multimedia and compression standards may also retard growth. Game and educational applications will probably be the fastest growing multimedia application area for the next several years. However, multimedia titles may require a substantial investment of time and money to procure rights to copyrighted material or to script and produce a title making extensive use of full motion video, audio and other elements.

Applications

CD-ROM drives are used mostly with microbased systems, including personal computers, multiple user microcomputers, games and consumer appliances based upon microcomputers. The consumer applications have become one of the fastest growing areas of CD-ROM use.

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. Widespread acceptance of video on CD awaits a high density format that permits a single disk to contain a 2 hour movie.

Individual personal computers accounted for 68.4% of CD-ROM drive unit shipments in 1993. Consumer computer and other applications, notably games such as Sega's and CD-I players, increased to 19.7%. CD-ROM drive use on multiuser systems declined to 4.8% in 1993, although unit shipments in this category increased, they were swamped by the very large increases in usage on personal computers. In 1997, single user personal computers will remain the largest application for CD-ROM drives, capturing 55.2% of the drive shipments in 1996. Consumer applications, led by entertainment and education uses, are expected to be the second largest application area, with 34.2% of the units sold. Multiuser systems will use 3.9% of the drives shipped.

In the consumer area, games, education, music and arts, are likely to develop as large-scale applications of CD-ROM and related multimedia technology, but there is significant overlap of educational and reference titles between consumer, business and education markets. The development of the consumer market will be further aided by the availability of multimedia players and computer based systems which incorporate a CD-ROM player in a relatively inexpensive home computer.

Photo CD applications will probably continue to develop in the industrial photography area at a faster rate than in the consumer area, but the consumer market is potentially much 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 computers and equipment that is attached to television receivers and television monitors.

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 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. In home applications, games and education are the most significant, but the introduction of tax preparation software (ChipSoft's TurboTax) on CD-ROM in early 1994 suggests that personal finance may also become a significant category. Another possibility is home shopping using a periodically distributed disk as a catalog.

IBM, Hewlett-Packard, DEC, Sun Microsystems and other firms use the 12 centimeter CD-ROM to distribute software and system documentation for network servers and workstations. Personal computer makers are also expected to use CD-ROM to distribute software and documentation, taking advantage of the large number of personal computers now equipped with drives as part of a major effort to reduce costs and improve service to customers. A few CD-ROM disks containing software are available from independent publishers. Other types of company data distributed on CD-ROM include product information and product demonstrations, with some disks available containing software and on-line manuals that can be installed from the CD-ROM demo disk. The software author provides an unlock code after customer payment so that installation is enabled.

Business use of CD-ROM is oriented towards reference and training uses. Reference materials may include purchased databases or may be internally generated documents such as parts lists or customer data. For instance, MCI distributes billing data on CD-R disks, permitting customers to analyze billings on systems equipped with CD-ROM drives. IBM has placed its "universal sales manual" on CD-ROM and updates it monthly.

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. A broad range of titles are being marketed to both consumer and education markets, and many companies have their service manuals on CD-ROM to take advantage of multimedia capabilities.

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 most widely distributed government produced CD-ROM concerns the management of hazardous materials. This disk is currently distributed to over 7,000 sites.

Today's 8 centimeter CD-ROM is not expected to be an important multimedia vehicle because of its limited storage capacity, but it may become more significant as CD-ROM evolves to higher areal densities in the future. It also has potential to become important as a game format. The 8 centimeter format is expected to be heavily oriented toward consumer applications, but business applications may eventually use 8 centimeter drives where portability is required, such as field maintenance. Some notebook computers appearing in 1994 will permit user exchange of a removable 3.5" floppy drive for an 8 centimeter CD-ROM drive. Some of the data bases currently published are small enough to fit within the capabilities of the 8 centimeter drive, but users of desktop and file server type installations will want the flexibility of using either 8 centimeter or 12 centimeter media and will prefer the 12 centimeter drive. However, all of the CD-ROM firms mastering the 8 centimeter format are in Japan, so there is less incentive for U.S. publishers to use the 8 centimeter 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.

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. Within two to three years, a new generation of higher capacity CD-ROM drives is expected to become available as a result of pressures to increase the ability of the disk to contain increased video and audio content. 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 storing a two hour movie currently 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. IBM has announced a stacked disk approach in which several disks are bonded together, with the desired disk addressed by varying the focal point of the pickup lens. Philips and others are developing their own approaches as well, but as of mid-1994, no industry consensus on a high density format had been reached.

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 year except, possibly, as technology announcements. Other obstacles are the investment and time that will be required to upgrade mastering facilities to be able to produce any new high capacity format, plus cost and yield problems with the advanced components needed.

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. In mid-1994, CD-ROM Inc. and STAC Electronics jointly announced a driver permitting PC compatible systems to decompress data stored on CD-ROM that had been compressed with STAC's data compression algorithm. Data compression is included in video standards such as MPEG which will be important in video data storage on CD-ROM.

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.

Because of cost pressures, game machines and other consumer oriented CD-ROM designs have done 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 high speed picker mechanisms to handle than unprotected disks, although lower performance libraries seem to be able to handle unenclosed disks satisfactorily. Higher performance drives (3X, 4X and up) may require the caddy to position the disk for reliable operation at higher spin rates.

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.

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. A further extension to cover multisession recording was prepared by the Frankfurt group, a similar organization. This proposal became the ECMA 168 standard, which is used by the Kodak Photo CD system.

The XA format proposed by Philips, Sony and Microsoft in 1988 extended the ISO 9660 standard to provide improved interactive capabilities. For some of the drives marketed that initially claimed XA compliance, there were unfavorable interactions between the drive and the controller preventing full compliance. While early drives that could read a Photo CD disk were XA compliant, many could read only the first session on multisession disks. By late 1993, most manufacturers offered 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. More complex encoder chip sets made their appearance by mid-1993. However, full screen picture quality using MPEG-1 is considered by many to offer inferior image quality compared to conventional VHS video tape, so an improved version may be required to fully activate the CD-ROM based video market. However, some semiconductor companies are also working on techniques to upgrade MPEG-1 based video quality. 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.

Performance: Average access times have dipped to well under 300 milliseconds and seek times have gone to well under 200 milliseconds. Users are getting faster data transfer rates by means of faster rotation rates. CD-ROM drive producers manufacture drives with at least double the original 150 KB/second data transfer rate, with the improvement in performance achieved by doubling, tripling or quadrupling the rotation rate. Several firms have announced quadrupled rate drives and were shipping them in small quantities as of mid-1994, and 6X or 8X drives are expected to further improve CD-ROM drive performance.

The presence of a large buffer is becoming increasingly important for adequate multimedia performance. 64 kilobyte buffers are a minimum requirement (per Multimedia PC level 2 specification), and some drives with 256 kilobyte and 1 megabyte buffers have appeared. The larger buffers are appropriate for applications requiring smooth full motion video and/or higher data transfer rates. Higher performance drives also increase pressure for higher capacity, because the faster drives encourage increasing the video content of the application stored on the disk.

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, although the situation has improved greatly over the last year. Additional development of drivers is needed to support new generations of data compression/decompression techniques. Additional software will be needed to support the new generation of high capacity drives when they enter the marketplace.

<u>Interface</u>: CD-ROM drives have typically been designed with SCSI interfaces, with the SCSI-2 command set and small connector widely adopted in current CD-ROM drives. SCSI-2 is likely to remain the interface most used on servers because of its ability to handle many devices. Cost pressures prompted 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.

The IDE/ATAPI interface (originated by Western Digital) has been widely adopted by personal computer manufacturers because it is less expensive than SCSI, has SCSI-like performance, and permits adding CD-ROM drives to systems using the IDE interface for other storage devices (up to a limit of 4 devices total, adequate for most small systems). Large shipments of drives with this interface are expected in the second half of 1994, and it is expected to become the most used interface in 1995 as a result of widespread adoption by personal computer manufacturers. Compaq, AST, Dell, and Gateway 2000 are expected to be among the early adopters of IDE/ATAPI. Oak Technology is currently shipping most of the IDE/ATAPI interface chips sold to the CD-ROM industry.

<u>Cost reduction</u>: Cost reduction programs are continuing and accelerating. 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. Superfluous components, such as audio jacks and related circuitry, will be removed in some designs. Plastic has replaced sheet metal in some low end drive packaging. The cost of the electronic elements used are also declining with increasing volume and expanded use of ASICs.

<u>Packaging</u>: 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 mostly half high models, but a few inch high models have appeared and even thinner units capable of fitting under the keyboard of a notebook computer have been privately shown by manufacturers. 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.

<u>Authoring systems</u>: 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 (CD-R) will encourage product offerings that include all software and hardware tools needed to produce the playable disk. As of mid-1994, easy to use production

tools for use with CD-R drives were just starting to make their appearance. CD-R drives are more fully discussed in chapter DT-11.

Networks and libraries: System integrators are increasingly 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 adopt multiple drive configurations. An increasing number of firms have announced autochangers for CD-ROM: The number of manufacturers more than doubled in 1993, with libraries ranging in storage capacity from six disks to several hundred disks. However, 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: Early CD-ROM drives 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 and are now commonplace. Some reliability problems have been reported on early models of 3X and 4X drives, with at least a portion of these due to media not conforming fully to mechanical specifications.

There remains some concern about disk reliability. 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. There have been some problems noted with media that operate correctly on low spin rate drives but develop unacceptable error rates on 3X and 4X drives. Media replicators and drive producers seem to be overcoming these problems.

Writable CD: Writable CD-format (CD-R) media and systems are expensive but are becoming more affordable. Philips, Sony, Yamaha, JVC and Ricoh are among the firms currently shipping drives, often as part of a complete recording system. Many companies are exploring the internal uses of rewritable CD-ROM format recording because of the large numbers of CD-ROM drives already installed or anticipated within their organizations. The expected appearance of CD-ROM drives in portable computers will encourage the use of CD-R in organizations with a large population of traveling employees. 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 initially by Sony in the Spring of 1991 and more definitively in 1994. 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 8 centimeter CD-ROM, especially for portable applications. Sony is expected to make further announcements concerning the applicability of MD-DATA technology to CD-ROM applications in late 1994.

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 substantially higher prices make strong competition with CD-ROM drives unlikely in the short term.

The rapidly declining costs of CD-ROM make it increasingly unlikely that any competing technology can offer an effective challenge in the period of the forecast.

Forecasting assumptions

1. CD-ROM drive production capability will substantially meet demand, although there may be component shortages for 4X drives in 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 CD-ROM models, 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 some shipments of expanded capacity CD-ROM drives starting in 1996, but until the characteristics of these drives are fully established, they are not being specifically forecasted.
5. CD format write-once or rewritable drives will have little impact on CD-ROM sales. No other form of read-only optical memory will seriously challenge CD-ROM through 1997.
6. The CD-I format will impact primarily the home and education markets. Growth will be modest until prices decline. 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. Replication quality will be sufficient for 4X and higher operating rates.
8. CD-ROM drives will be available in selected PC systems from almost all major producers.
9. There will be insignificant impact on CD-ROM shipments from the Sony 2.5" minidisk or other unannounced low-end optical drives through 1997.

TABLE 17

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	9.1	10.0	10.8	11.9	12.2	13.5	12.2	13.5	11.3	12.5
TOTAL U.S. REVENUES	9.1	10.0	10.8	11.9	12.2	13.5	12.2	13.5	11.3	12.5
Non-U.S. Manufacturers										
Captive	120.6	378.0	177.8	593.9	236.1	614.8	307.8	780.6	433.2	1,035.8
PCM/Reseller	224.4	369.2	259.5	470.4	288.8	522.9	325.3	591.5	365.4	665.5
OEM/Integrator	488.7	764.2	685.4	1,183.5	917.7	1,593.1	1,077.6	1,876.9	1,219.7	2,043.5
TOTAL NON-U.S. REVENUES	833.7	1,511.4	1,122.7	2,247.8	1,442.6	2,730.8	1,710.7	3,249.0	2,018.3	3,744.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	842.8	1,521.4	1,133.5	2,259.7	1,454.8	2,744.3	1,722.9	3,262.5	2,029.6	3,757.3
OEM Average Price ($000)		.111		.090		.079		.071		.060

TABLE 18

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	38.0	41.8	54.0	59.4	68.0	75.0	81.0	90.0	94.0	104.0
TOTAL U.S. SHIPMENTS	38.0	41.8	54.0	59.4	68.0	75.0	81.0	90.0	94.0	104.0
Non-U.S. Manufacturers										
Captive	780.0	1,777.0	1,081.0	2,719.0	1,370.0	3,530.0	1,745.0	4,415.0	2,340.0	5,350.0
PCM/Reseller	1,400.0	2,369.0	2,104.8	4,001.2	3,070.0	5,582.0	4,120.0	7,490.0	5,274.0	9,604.0
OEM/Integrator	4,402.0	6,887.0	7,468.0	13,113.0	11,554.0	20,136.0	15,165.0	26,371.0	20,144.0	33,740.0
TOTAL NON-U.S. SHIPMENTS	6,582.0	11,033.0	10,653.8	19,833.2	15,994.0	29,248.0	21,030.0	38,276.0	27,758.0	48,694.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6,620.0	11,074.8	10,707.8	19,892.6	16,062.0	29,323.0	21,111.0	38,366.0	27,852.0	48,798.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	9.8	16.6	20.5	36.5	36.6	65.9	57.7	104.2	85.5	153.0

TABLE 19

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER/SPEED

	1993 Revenues				Forecast 1994				1995			1996			1997		
	12cm. 1X	12cm. 2X	12cm.>2X	8cm.	12cm. 1X	12cm. 2X	12cm.>2X	8cm.	12cm. 2X	12cm.>2X	8cm.	12cm. 2X	12cm.>2X	8cm.	12cm. 2X	12cm.>2X	8cm.
U.S. MANUFACTURERS																	
PCM/Reseller	--	10.0	--	--	--	11.9	--	--	13.5	--	--	13.5	--	--	12.5	--	--
TOTAL U.S. REVENUES	--	10.0	--	--	--	11.9	--	--	13.5	--	--	13.5	--	--	12.5	--	--
NON-U.S. MANUFACTURERS																	
Captive	324.5	2.5	--	51.0	12.5	520.1	15.0	46.3	466.6	99.2	49.0	405.0	324.0	51.6	137.5	844.2	54.1
PCM/Reseller	88.2	245.6	35.4	--	6.7	403.5	60.2	--	393.9	120.0	9.0	276.8	302.7	12.0	177.1	471.6	16.8
OEM/Integrator	114.0	649.2	1.0	--	--	1,137.2	35.3	11.0	1,330.0	235.6	27.5	896.0	938.9	42.0	193.3	1,804.2	46.0
TOTAL NON-U.S. REVENUES	526.7	897.3	36.4	51.0	19.2	2,060.8	110.5	57.3	2,190.5	454.8	85.5	1,577.8	1,565.6	105.6	507.9	3,120.0	116.9
WORLDWIDE RECAP																	
Captive	324.5	2.5	--	51.0	12.5	520.1	15.0	46.3	466.6	99.2	49.0	405.0	324.0	51.6	137.5	844.2	54.1
	--	--	--	--	-96.1%	--	--	-9.2%	-10.3%	+561.3%	+5.8%	-13.2%	+226.6%	+5.3%	-66.0%	+160.6%	+4.8%
PCM/Reseller	88.2	255.6	35.4	--	6.7	415.4	60.2	--	407.4	120.0	9.0	290.3	302.7	12.0	189.6	471.6	16.8
	--	--	--	--	-92.4%	+62.5%	+70.1%	--	-1.9%	+99.3%	--	-28.7%	+152.3%	+33.3%	-34.7%	+55.8%	+40.0%
OEM/Integrator	114.0	649.2	1.0	--	--	1,137.2	35.3	11.0	1,330.0	235.6	27.5	896.0	938.9	42.0	193.3	1,804.2	46.0
	--	--	--	--	--	+75.2%	--	--	+17.0%	+567.4%	+150.0%	-32.6%	+298.5%	+52.7%	-78.4%	+92.2%	+9.5%
Total Revenues	526.7	907.3	36.4	51.0	19.2	2,072.7	110.5	57.3	2,204.0	454.8	85.5	1,591.3	1,565.6	105.6	520.4	3,120.0	116.9
	--	--	--	--	-96.4%	+128.4%	+203.6%	+12.4%	+6.3%	+311.6%	+49.2%	-27.8%	+244.2%	+23.5%	-67.3%	+99.3%	+10.7%
ANNUAL SHARE, BY DIAMETER	34.7%	59.6%	2.4%	3.3%	.8%	91.8%	4.9%	2.5%	80.4%	16.6%	3.0%	48.9%	48.0%	3.1%	13.9%	83.1%	3.0%

Note: 1X, 2X, >2X refer to data transfer rates relative to 150 kilobytes per second.

TABLE 20

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER/SPEED

	1993 Shipments				Forecast 1994				1995			1996			1997		
	12cm. 1X	12cm. 2X	12cm.>2X	8cm.	12cm. 1X	12cm. 2X	12cm.>2X	8cm.	12cm. 2X	12cm.>2X	8cm.	12cm. 2X	12cm.>2X	8cm.	12cm. 2X	12cm.>2X	8cm.
U.S. MANUFACTURERS																	
PCM/Reseller	--	41.8	--	--	--	59.4	--	--	75.0	--	--	90.0	--	--	104.0	--	--
TOTAL U.S. SHIPMENTS	--	41.8	--	--	--	59.4	--	--	75.0	--	--	90.0	--	--	104.0	--	--
NON-U.S. MANUFACTURERS																	
Captive	1,601.0	6.0	--	170.0	81.0	2,419.0	34.0	185.0	3,010.0	320.0	200.0	3,000.0	1,200.0	215.0	1,100.0	4,020.0	230.0
PCM/Reseller	609.0	1,642.0	118.0	--	67.0	3,688.0	246.2	--	4,282.0	1,200.0	100.0	3,460.0	3,880.0	150.0	2,530.0	6,834.0	240.0
OEM/Integrator	1,069.0	5,814.0	4.0	--	--	12,770.0	220.0	123.0	17,500.0	2,310.0	326.0	12,800.0	13,040.0	531.0	3,020.0	30,070.0	650.0
TOTAL NON-U.S. SHIPMENTS	3,279.0	7,462.0	122.0	170.0	148.0	18,877.0	500.2	308.0	24,792.0	3,830.0	626.0	19,260.0	18,120.0	896.0	6,650.0	40,924.0	1,120.0
WORLDWIDE RECAP																	
Captive	1,601.0	6.0	--	170.0	81.0	2,419.0	34.0	185.0	3,010.0	320.0	200.0	3,000.0	1,200.0	215.0	1,100.0	4,020.0	230.0
	--	--	--	--	-94.9%	--	--	+8.8%	+24.4%	+841.2%	+8.1%	-.3%	+275.0%	+7.5%	-63.3%	+235.0%	+7.0%
PCM/Reseller	609.0	1,683.8	118.0	--	67.0	3,747.4	246.2	--	4,357.0	1,200.0	100.0	3,550.0	3,880.0	150.0	2,634.0	6,834.0	240.0
	--	--	--	--	-89.0%	+122.6%	+108.6%	--	+16.3%	+387.4%	--	-18.5%	+223.3%	+50.0%	-25.8%	+76.1%	+60.0%
OEM/Integrator	1,069.0	5,814.0	4.0	--	--	12,770.0	220.0	123.0	17,500.0	2,310.0	326.0	12,800.0	13,040.0	531.0	3,020.0	30,070.0	650.0
	--	--	--	--	--	+119.6%	--	--	+37.0%	+950.0%	+165.0%	-26.9%	+464.5%	+62.9%	-76.4%	+130.6%	+22.4%
Total Shipments	3,279.0	7,503.8	122.0	170.0	148.0	18,936.4	500.2	308.0	24,867.0	3,830.0	626.0	19,350.0	18,120.0	896.0	6,754.0	40,924.0	1,120.0
	--	--	--	--	-95.5%	+152.4%	+310.0%	+81.2%	+31.3%	+665.7%	+103.2%	-22.2%	+373.1%	+43.1%	-65.1%	+125.8%	+25.0%
ANNUAL SHARE, BY DIAMETER	29.7%	67.8%	1.1%	1.4%	.7%	95.3%	2.5%	1.5%	84.9%	13.1%	2.0%	50.5%	47.2%	2.3%	13.8%	84.0%	2.2%

Note: 1X, 2X, >2X refer to data transfer rates relative to 150 kilobytes per second.

TABLE 21

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	15.5	.1	97.6	.2
MAINFRAME SYSTEMS General purpose,	--	--	48.8	.1
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	531.6	4.8	1,903.1	3.9
PERSONAL COMPUTERS Business and professional, single user	7,570.7	68.4	26,936.5	55.2
WORKSTATIONS Engineering and office, single user	749.8	6.8	2,683.9	5.5
CONSUMER, GAME AND HOBBY COMPUTERS	2,177.3	19.7	16,688.9	34.2
OTHER APPLICATIONS	29.9	.2	439.2	.9
Total	11,074.8	100.0	48,798.0	100.0

TABLE 22

CD-ROM OPTICAL DISK DRIVES, ALL CAPACITIES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	1X*	2X*	>2X*	8cm.	Total		1X*	2X*	>2X*	8cm.	Total	
Matsushita Electric	--	1200.0	--	--	1200.0	20.5	--	2850.0	--	--	2850.0	30.7
Sony	409.0	1780.0	--	--	2189.0	37.5	642.0	2090.0	--	--	2732.0	29.4
Mitsumi Electric	215.0	280.0	--	--	495.0	8.5	430.0	560.0	--	--	990.0	10.6
Toshiba	--	570.0	--	--	570.0	9.8	--	790.0	--	--	790.0	8.5
NEC	--	392.0	84.0	--	476.0	8.2	--	560.0	122.0	--	682.0	7.3
Philips LMS	370.0	76.0	--	--	446.0	7.6	500.0	130.0	--	--	630.0	6.8
Other U.S.	--	38.0	--	--	38.0	.7	--	41.8	--	--	41.8	.4
Other Non-U.S.	76.0	350.0	--	--	426.0	7.2	106.0	476.0	--	--	582.0	6.3
TOTAL	1070.0	4686.0	84.0	--	5840.0	100.0	1678.0	7497.8	122.0	--	9297.8	100.0

Notes: 1. * indicates a 12 centimeter drive.
2. See section DT-11 for data on CD-R.

READ/WRITE OPTICAL DISK DRIVES LESS THAN 1 GIGABYTE

1994 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 300 (E)
Fujitsu	M2511A (E), M2512A (E)
IBM	MD 3125B (E)
LaserByte	LB3230 (E)
Matsushita Electric Industrial	LF-3100 (E), LF-3294 (E)
MOST	RMD 5200-S (E), RMD 5300-S (E)
Mountain Optech	SE-250, SI-250
NEC	PC-OD301 (E)
Olympus	MOS300E (E), MOS320E (E)
Ricoh	RO-3012E (E)
Seiko Epson	OMD 5010 (E)
Sony	SMO-E301 (E), RMO-S310
TEAC	OD-3000 (E), OD-5000

12 centimeter disk diameter

Eastman Kodak	PCD Writer 200, PCD Writer 600
JVC	XR-W1001
Matsushita Electric Industrial	LF-7300A
Philips Consumer Electronics	CDD521, CDD522
Ricoh	RS-9200CD
Sony	CDW-900E
Yamaha	YPR-301, CDR-100, CDE-100

5.25" disk diameter

Asaca	AMD-1341NS (E)
Canon	MO-5001S (E), OM-500D (E)
Fujitsu	M2507B (E)
Hewlett-Packard	C1716T (E)
Hitachi	OD 101-1, OD-112-1 (E), OD 152 (E)
Honeywell	AN/MU-928
IBM	0632-C2X (E), 0632-CBX
Matsushita Electric Industrial	LF-7010, LF-7012 (E), LF-9000 (E)
Maxoptix	Tahiti II (E), T3-1300
MountainGate Data Systems	CR6000, CR6800
NEC	N7915 (E), N1137 (E), ODD-155 (E)
Pinnacle Micro	PMO-650, Sierra, Orray
Pioneer	DD-M5101, DE-U7001 (E), DE-SH7101 (E)
Ricoh	RO-5043, RO-5030E (E), RO-5031E (E)
Sierra Technologies	525GB+

5.25" disk diameter (continued)

Sharp	JY 700 (E), JY-750 (E)
Sony	SMO-F521 (E), MDM-111

(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, CD-R) 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. This includes MO multifunction drives (MO-WORM or Continuous Composite WORM), certain phase change drives and IBM's multifunction magneto-optic/ablative media drive.

The read/write drives discussed in this section are typically used with small and midrange 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 in this class are increasingly being used in larger optical libraries as well.

Market status

1993 was not a great sales year for optical drives in this product group. While the group as a whole saw a moderate increase in unit shipments to 457,100 units, almost all of the growth was in 3.5" drives shipped in the Japanese domestic market. Even this growth was misleading, because many suppliers cleaned out their inventories of 3.5" 128 megabyte drives late in the year in anticipation of new 230 megabyte models. 5.25" drive shipments actually declined, with the decline reflected in both write-once and rewritable drive shipments. The primary reasons for this lackluster performance were poor economic conditions in many areas that depressed library sales, and poor cost/performance trade-offs compared to new high capacity magnetic disk drives such as SyQuest's family of removable cartridge drives and the 9 gigabyte 5.25" Seagate Elite 9. 12 centimeter CD-R drives did well, growing 226%, to 16,000 units shipped in 1993, but this was the only bright spot in the group.

Shipments of 3.5" drives rose, primarily due to price incentives offered by manufacturers, but the lack of networks in Japan (3.5" drives are used as a substitute for data exchange) and a relatively weak SyQuest presence in Japan also helped produce atypically strong demand for this product in that country that assisted in boosting 1993 shipments. OEM demand remains small, with integrators and resellers moving most of the drives shipped. The Apple Macintosh add-on market, where there is less price sensitivity, has been the strongest 3.5" market segment, but the 3.5" MO drive is being challenged by SyQuest's new family of 3.5" removable cartridge drives which are available with higher capacity, lower prices and superior performance.

Total 1993 unit shipments reached 457,100 units, up 20.5% from 1992. 5.25" write-once drive shipments declined 28% to 20,800 units, and 5.25" rewritable drive shipments declined 7.6% to 166,400 units. 5.25" write-once shipments have been heavily impacted by multifunction drives. 12 centimeter CD-R drive shipments were up 226% to 16,000 units in 1993 and strong growth, spurred by falling prices and improved supporting software, is expected to continue.

Matsushita Electric, Sony, Ricoh and Olympus were the leading noncaptive producers of 5.25" drives in 1993, while Fujitsu, Matsushita Electric and Sony were the leading 3.5" producers. Matsushita remains the leading manufacturer of write-once drives. Sony retained its lead as the leading producer of rewritable drives, but Fujitsu is a close second. Rewritable drive shipments far outnumbered write-once drive shipments, with rewritable drives capturing 91.9% of unit shipments. 39.6% of the rewritable drives shipped in this product group were 5.25" drives, and 3.5" drive shipments increased to 60.4% of 1993 rewritable drive shipments. This shift is more the result of weak 5.25" drive sales than strength in the 3.5" market.

1993 worldwide revenues declined, dropping 10.6% to $586.9 million, with the largest part of the decline coming from dropping 5.25" drive shipments and declining AUP. This continues the trend of declining 5.25" drive revenues noted in 1992. 3.5" drive revenues were up a modest 13.8%, not enough to counter 5.25" revenue declines. U.S. firms accounted for 24.5% of 1993 revenues, up from 22.3% in 1992, with IBM and Hewlett-Packard turning in a particularly strong performance. The U.S. market accounted for 48.9% of worldwide revenues in

1993, up from 45.8% in 1992 and consistent with weakening non-U.S. markets, especially given that U.S. pricing is generally lower than non-U.S. pricing.

Marketing trends

With economic recovery in Europe and Japan under way, modest growth for 5.25" rewritable drive shipments is expected for the next several years, aided by the expected availability of 1.3 gigabyte per side drives and media beginning in late 1995. Competition from 5.25" magnetic drives, expected to be available with 15-20 gigabyte capacity and $.10 per megabyte OEM pricing in the next year, will tend to limit shipment growth. Growth will also be constrained by increasing shipments of very high capacity 3.5" magnetic disk drives. The inability of the optical drive industry to match the 60% per year areal density growth rate of the magnetic drive industry has hurt optical disk drive sales. Optical libraries have become increasingly significant in the application mix, with over 10% of the 5.25" drives in this class now going into libraries. 5.25" write-once drive shipments will continue to decline, but 12 centimeter CD-R shipments will grow strongly through the forecast period as prices decline and usability improves.

With the advent of the 230 megabyte 3.5" drive, significant shipments of 128 megabyte models will be restricted to models that are priced considerably below 230 megabyte pricing levels. For all 3.5" models together, only modest growth is projected. Until a new generation of drives with capacities exceeding 500 megabytes enters the market, growth will be unimpressive. Even the limited growth forecast assumes a steady reduction in drive prices to match competition from removable magnetic cartridge drives such as SyQuest's 270 megabyte model. When 3.5" optical disk drives with capacities exceeding 600 megabytes, and using standardized, competetively priced media are introduced at attractive drive prices ($350 or less), there is an opportunity for 3.5" drives to improve upon the projected shipment forecast.

In May of 1991, Sony made a preliminary announcement of a 2.5" magneto-optic drive for the audio market, and followed with a proposed media standard for the MD-DATA, a 2.5" 140 megabyte CLV computer peripheral in mid-1993. The drive was further defined in early 1994, but production was delayed until the second half of the year. Because of size, power, cost, and performance constraints, the 2.5" MO drive has not been well accepted by the OEM community and it seems likely that significant product redesign will be needed to launch a successful version of the drive. While the Sony product requires no erase pass before writing, a feature that can be expected in other MO drives in the future, the drive performs otherwise much like a compact disk drive.

Multifunction 5.25" drives will continue to displace single function designs. While 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, especially those using optical libraries, have been more accepting of magneto-optic multifunction drives. MO-WORM capable drives can share cost decreases and capability increases with rewritable magneto-optic media, and provide adequate recognition of MO-WORM media. And for users who insist upon ablative media, IBM's multifunction drive satisfies that requirement as well.

588,000 units are expected to ship in 1994 for the entire product group, growing to 1,562,200 units in 1997. Rewritable drives are expected to account for 82.5% of shipments in 1997, of which 57% will be 3.5", and 27.6% 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 and capture 15.4% of rewritable shipments in 1997. Because of the strong growth of CD-R, 17.5% of the forecasted 1997 overall total will be write-once units, with 95.9% expected to be 12 centimeter drives operating in CD-ROM compatible format.

The average capacity of drives in this product group is expected to expand over the next several years. Optical library users, in particular, desire expansion of 5.25" media capacity beyond the current 650 megabytes per side offered by most drives today. IBM, Sony, and others announced 650 megabyte per side drives in 1993, and the same producers are expected to be among the early manufacturers of 1.3 gigabyte per side (quadruple capacity) drives in late 1994 or early 1995. Hitachi is manufacturing a triple capacity drive, but is the only company with a drive in this range and hasn't received broad customer support. 3.5" drive capacities are expected to exceed 600 megabytes starting in 1995.

Applications

5.25" 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. When attached to file servers, often as an element of an optical library, the 5.25" drive may provide a second tier storage capability in a hierarchical storage subsystem. Users of magnetic disk drive arrays are displaying increasing interest in optical library subsystems operating with hierarchical storage management software for use in data and video servers.

Despite recent gains in capacity and performance for optical drives, limitations in performance, packaging, power dissipation and price relative to rigid magnetic disk drives cause optical drives to compete poorly against rigid drives unless a combination of high capacity and removability are mandatory.

CD-R drives are used to prepare master disks for CD-ROM replication and also for short run disk duplication where volume does not warrant replication one time costs. They are also being used in CD-ROM libraries to automate disk handling when multiple disks must be produced and human exchange of disks is infeasible or uneconomical.

If available at a low enough price and in thin form factors, 2.5" drives may also acquire the role of a data distribution device, especially in portable systems, but no clear application has yet emerged.

Specific applications for drives in this product group include:

<u>Save/restore operations</u>

* Archival storage of files.

<u>Hierarchical storage systems</u>

* Storage of rarely used files, freeing up rigid drives for high use files

<u>Document storage and processing</u>

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

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

* Convenient storage of files 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.

Graphic presentation and multimedia

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

* When installed in optical library, may contain content for video server. Files are staged to magnetic drives for distribution.

The faster erasable drives such as the Maxoptix "Tahiti" series have found limited application as system disks in high security applications requiring vault storage of recorded media when the equipment is unattended.

3.5" drives are used to provide project oriented storage on a single volume, and are often used in desktop publishing environments where they are used to transfer large amounts of data needed for pre-press processing. They have established a role as add-on devices to Apple Macintosh systems, which are frequently used for desktop publishing.

The largest application platform for optical drives in this product group in 1993 again was personal computers, which grew to 65.8% of the units shipped, an increase reflecting growth of 3.5" drive shipments. The share held by workstations declined to 19.6%, while the 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 almost never used on network servers.

The increasing capacities of 5.25" drives will expand usage with workstations, office systems and multiuser networks. 3.5" drives are expected to increase in capacity to the 600 megabyte range early in the forecast period and usage will spread beyond personal computers to small workstations and office systems. 2.5" drives may develop usage in consumer and hobby systems and, to some extent, with personal computers if their current deficiencies are overcome.

During the forecast period, about 10 to 11% 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. Only a small percentage of 3.5" drives will be installed in optical libraries.

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. However, the low market penetration of optical drives and high media costs have discouraged this application.

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.

Technical trends

Optical drive technology is advancing, although it is proving difficult for the industry to match the 60% per year growth rate in areal density exhibited by the rigid drive industry. The key areas of change are reviewed below.

Capacity: The capacity of announced 5.25" rewritable drives is expected to reach the 1.3 gigabyte per side level by late 1994 or early 1995, although shipments aren't expected until the second quarter of 1995. Similar improvements in write-once phase change technology are possible, though less certain. 3.5" MO drive capacity is expected to increase to above 640 megabytes in 1995. Capacity increases for 12 centimeter CD-R will track progress for CD-ROM drives. 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 (100% improvement), zoned recording (about a 33% improvement), land and groove recording (50-100% 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 and advantageous. 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 of some drives by 1995. Some capacity improvement techniques, such as zoned recording, are used on optical drives currently in production.

Toshiba has proposed a 3.5" drive with capacity exceeding 600 megabytes using rewritable phase change media. Matsushita Electric is widely understood to be developing a similar product, but availability is uncertain.

Write-once recording: A variety of optical recording technologies and media fabrication processes are in use, creating interchange problems and confusion. Pit forming writing (IBM) and writing using the phase change between amorphous and crystalline states to vary reflectivity at a spot (Matsushita) are the most commonly used methods. Write-once dye-based media is being used by Pioneer and Ricoh and in all CD-R drives. 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 (CCW, or Continuous Composite Worm), a form of magneto-optic media which 5.25" drives can recognize and treat 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 has gradually become the dominant form of write-once recording on 5.25" drives, but it will require 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 MO overwrite may not be available on a production basis in 1994, except on 2.5" drives and, possibly, 3.5" drives using similar technology.

Multifunctionality can also 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 rewritable optical technology. 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 offers at least 100,000 write cycles and there are prospects for extending the number of write cycles to over one million.

Phase change technology 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 MO drives. Efforts to create specific standards for phase change media are in progress.

Dye-based media currently has only write-once capability, but might someday evolve into a form usable for erasable optical disks. While it has been investigated by several firms over the last ten years, rewritable dye based media remains in R&D status at best.

Media lifetime: While accelerated life tests indicate that media lifetimes of 10 years or more are achievable, this aspect of media performance remains 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. Whatever reservations may exist about the archival life of magnetic media, it is regarded as superior to magnetic tape in this respect as it requires no retensioning while in storage and is less subject to damage than magnetic tape.

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, although tight process control is required to minimize birefringence distortion.

Glass substrates are free of birefringence effects that distort the optical path, are nonpermeable to moisture, are flat, and distortion free. The flat glass surface, coupled with high purity materials, reduces defect levels, which 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. However, glass is denser than plastic, resulting in longer spin-up and spin-down times, a disadvantage when used in optical libraries and is also more costly than plastic substrates.

<u>Average access times</u>: A major limitation of optical drives is average access time (seek time plus latency), which exceeds 40 milliseconds on most 5.25" drives so far announced. With the use of split optics heads performance is increasing. Drives from IBM and Hewlett-Packard are available with sub-30 millisecond seek times, while the Maxoptix' T3-1300, introduced in 1993, offers a seek time below 20 milliseconds. Newer 3.5" optical disk drives typically have average access times below 40 milliseconds due to their smaller size and shorter stroke lengths, with Laserbyte going under the 30 millisecond level. Increasing rotational speed has also helped to improve performance. CD-R access times are improving, tracking gains in CD-ROM performance.

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 MO 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, as in the case of the Sony MD-Data drive. Phase change drives do not need an erase pass.

Long access times for optical disk drives are less significant when the 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 have less mass than do glass substrates, so are preferable to minimize spin-up time, but are less likely to match glass for long archival life.

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 has increased 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 (650 megabyte/side) 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.

<u>Data transfer rate</u>: Specified internal drive maximum data transfer rates are in the 2 megabyte per second range for 5.25" and 3.5" drives, and are expected to increase as bit density and spin rate increase. The average data transfer rate will be lower, since bit density varies from track to track.

2.5" MO drives currently offer 150 kilobyte per second transfer rates, which are expected to improve over the next year. CD-R performance is already up to the 600 kilobyte per second level and will increase to 900 kilobytes per second as 6X drives enter the market this year. Further increases to 1.2 megabyte per second within the next 12 to 18 months seem likely.

An innovative approach to improving data transfer rates for optical drives is Pinnacle Micro's Orray, which operates four drive mechanisms in parallel from a single controller using a matched set of cartridges to achieve a specified 8 megabytes/second data transfer rate. The four 4,500 RPM spindles are read or written independently and are not synchronized. The media units are formatted and controlled as if they were a single disk drive.

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. Some half-height 5.25" drives are available, including IBM's multifunction drive and drives from Matsushita, NEC, Pioneer, Ricoh, Sharp, Sony and TEAC. 3.5" models 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 ship a 25.4 mm high 3.5" drive. CD-R drives usually fit a 41.3 mm profile, but are often packaged in bulkier subsystems. The 2.5" MD-DATA drive is in the one inch high form factor, but a thinner profile would be desirable for the portable equipment market for which the drive is positioned.

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 as well as by redesign of mechanical components.

Standards: ANSI X3B11, ECMA TC31, ISO TC91/SC23 are all involved in standardization programs for 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 versus 128 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 has been approved by ECMA. 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. It has 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 is an important standard, because at present media written on the same model drive but on different systems using different controllers and driver software could be incompatible. It does not cover sequential file organization of the type used in CD-ROM drives. In the future, X3B11.1 may be folded into a larger organization under X3 auspices that would consider similar issues for a broad range of media.

No standard device level interface for optical drives exists, but at the system level, SCSI-2 has the status of a de facto standard. The IBM PC/AT interface also has de facto standard status for small read/write drives. While different versions of SCSI and some differences between internal controller design have caused interchangeability problems, these have largely been resolved.

<u>Software</u>: 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.

Competing Products: Strong competition for the 3.5" 128 megabyte and 230 megabyte optical drive is coming from the SyQuest 3.5" 270 megabyte cartridge drive. The OEM price, in the $300 range, is substantially under current prices for 3.5" MO drives, although 3.5" drives soon to be announced are expected to compete more strongly in price. Performance of the SyQuest drive is currently superior to that of MO drives now in production.

High capacity 5.25" magnetic drives from Seagate, Micropolis and others are negatively impacting 5.25" optical drive sales in those stand-alone applications where a removable disk is not mandatory.

Forecasting assumptions

1. 5.25" drives with over 1.3 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. 12 centimeter CD format write-once drives will be available from multiple sources throughout the forecast period. Drive prices will decline sharply.

4. 2.5" drives will be shipped in the last half of 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 1997, although they will be displaced by multifunction drives in most new installations.

6. 600+ megabyte 3.5" drives will be introduced by major producers with shipments beginning in 1995.

TABLE 23

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	42.2	50.4	52.3	73.1	65.5	100.2	77.1	122.7	79.5	134.1
PCM/Reseller	24.8	44.4	29.1	45.7	36.9	55.8	44.0	67.3	49.7	76.9
OEM/Integrator	32.4	49.0	50.2	79.6	43.9	70.9	52.3	84.6	58.8	100.8
TOTAL U.S. REVENUES	99.4	143.8	131.6	198.4	146.3	226.9	173.4	274.6	188.0	311.8
Non-U.S. Manufacturers										
Captive	2.9	42.9	3.4	50.6	4.1	55.7	4.5	66.2	4.2	79.7
PCM/Reseller	84.0	177.7	102.1	216.9	112.1	247.8	122.9	280.2	159.9	362.1
OEM/Integrator	100.9	222.5	109.4	236.4	134.5	281.8	148.2	305.6	172.9	342.3
TOTAL NON-U.S. REVENUES	187.8	443.1	214.9	503.9	250.7	585.3	275.6	652.0	337.0	784.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	287.2	586.9	346.5	702.3	397.0	812.2	449.0	926.6	525.0	1,095.9
OEM Average Price ($000)		1.264		1.241		1.094		.953		.758

TABLE 24

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	11.1	13.9	13.8	22.0	17.7	32.2	21.6	42.9	25.8	56.3
PCM/Reseller	13.5	24.8	21.4	36.8	30.3	51.3	40.1	67.7	52.1	87.9
OEM/Integrator	18.3	28.7	30.5	51.5	28.0	50.6	35.5	64.6	53.6	108.9
TOTAL U.S. SHIPMENTS	42.9	67.4	65.7	110.3	76.0	134.1	97.2	175.2	131.5	253.1
Non-U.S. Manufacturers										
Captive	1.0	19.0	1.3	23.3	1.6	26.8	2.0	33.5	2.3	42.4
PCM/Reseller	78.4	184.6	102.9	251.4	128.3	340.2	181.5	491.4	310.2	791.7
OEM/Integrator	70.9	186.1	82.6	203.0	113.5	271.6	151.3	344.5	219.3	475.0
TOTAL NON-U.S. SHIPMENTS	150.3	389.7	186.8	477.7	243.4	638.6	334.8	869.4	531.8	1,309.1
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	193.2	457.1	252.5	588.0	319.4	772.7	432.0	1,044.6	663.3	1,562.2
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	677.0	1,390.0	929.5	1,978.0	1,248.9	2,750.7	1,680.9	3,795.3	2,344.2	5,357.5

TABLE 25

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

WRITE-ONCE DRIVES: BREAKDOWN BY DISK DIAMETER

	1993 Revenues		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.
U.S. MANUFACTURERS										
Captive	--	--	--	2.5	--	4.0	--	11.1	--	10.9
OEM/Integrator	1.0	--	1.0	7.2	.8	5.3	.6	13.4	.6	12.5
TOTAL U.S. REVENUES	1.0	--	1.0	9.7	.8	9.3	.6	24.5	.6	23.4
NON-U.S. MANUFACTURERS										
Captive	3.2	2.6	3.0	3.2	2.8	3.4	2.7	3.4	2.6	2.4
PCM/Reseller	13.5	15.5	10.6	42.5	9.0	57.2	7.8	59.2	6.4	70.0
OEM/Integrator	14.2	30.3	12.1	38.3	10.3	44.2	9.5	45.4	9.0	54.2
TOTAL NON-U.S. REVENUES	30.9	48.4	25.7	84.0	22.1	104.8	20.0	108.0	18.0	126.6
WORLDWIDE RECAP										
Captive	3.2 +190.9%	2.6 -50.9%	3.0 -6.2%	5.7 +119.2%	2.8 -6.7%	7.4 +29.8%	2.7 -3.6%	14.5 +95.9%	2.6 -3.7%	13.3 -8.3%
PCM/Reseller	13.5 -25.0%	15.5 +330.6%	10.6 -21.5%	42.5 +174.2%	9.0 -15.1%	57.2 +34.6%	7.8 -13.3%	59.2 +3.5%	6.4 -17.9%	70.0 +18.2%
OEM/Integrator	15.2 -58.0%	30.3 +111.9%	13.1 -13.8%	45.5 +50.2%	11.1 -15.3%	49.5 +8.8%	10.1 -9.0%	58.8 +18.8%	9.6 -5.0%	66.7 +13.4%
Total Revenues	31.9 -42.3%	48.4 +108.6%	26.7 -16.3%	93.7 +93.6%	22.9 -14.2%	114.1 +21.8%	20.6 -10.0%	132.5 +16.1%	18.6 -9.7%	150.0 +13.2%
ANNUAL SHARE, BY DIAMETER	39.8%	60.2%	22.2%	77.8%	16.7%	83.3%	13.5%	86.5%	11.0%	89.0%

TABLE 26

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

WRITE-ONCE DRIVES: BREAKDOWN BY DISK DIAMETER

	1993 Shipments		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.
U.S. MANUFACTURERS										
Captive	--	--	--	.1	--	.4	--	1.4	--	2.6
OEM/Integrator	.4	--	.4	.4	.3	.8	.2	2.8	.2	5.2
TOTAL U.S. SHIPMENTS	.4	--	.4	.5	.3	1.2	.2	4.2	.2	7.8
NON-U.S. MANUFACTURERS										
Captive	1.2	.4	1.2	.8	1.1	1.2	1.0	1.6	.9	2.0
PCM/Reseller	8.5	6.1	7.2	22.6	6.2	44.0	5.2	80.0	4.0	140.0
OEM/Integrator	10.7	9.5	9.1	18.1	7.8	34.0	6.8	63.0	6.0	113.0
TOTAL NON-U.S. SHIPMENTS	20.4	16.0	17.5	41.5	15.1	79.2	13.0	144.6	10.9	255.0
WORLDWIDE RECAP										
Captive	1.2	.4	1.2	.9	1.1	1.6	1.0	3.0	.9	4.6
	+300.0%	-20.0%	--	+125.0%	-8.3%	+77.8%	-9.1%	+87.5%	-10.0%	+53.3%
PCM/Reseller	8.5	6.1	7.2	22.6	6.2	44.0	5.2	80.0	4.0	140.0
	-7.6%	+369.2%	-15.3%	+270.5%	-13.9%	+94.7%	-16.1%	+81.8%	-23.1%	+75.0%
OEM/Integrator	11.1	9.5	9.5	18.5	8.1	34.8	7.0	65.8	6.2	118.2
	-42.8%	+206.5%	-14.4%	+94.7%	-14.7%	+88.1%	-13.6%	+89.1%	-11.4%	+79.6%
Total Shipments	20.8	16.0	17.9	42.0	15.4	80.4	13.2	148.8	11.1	262.8
	-28.0%	+226.5%	-13.9%	+162.5%	-14.0%	+91.4%	-14.3%	+85.1%	-15.9%	+76.6%
ANNUAL SHARE, BY DIAMETER	56.6%	43.4%	30.0%	70.0%	16.1%	83.9%	8.1%	91.9%	4.1%	95.9%

TABLE 27

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

REWRITABLE DRIVES: BREAKDOWN BY DISK DIAMETER

	1993 Revenues		Forecast 1994			Forecast 1995			Forecast 1996			Forecast 1997		
	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS														
Captive	44.3	6.1	57.3	13.3	--	75.8	20.4	--	86.1	25.5	--	91.8	31.4	--
PCM/Reseller	19.8	24.6	30.7	15.0	--	38.2	17.6	--	46.5	20.8	--	52.3	24.6	--
OEM/Integrator	45.9	2.1	64.5	6.9	--	57.0	7.8	--	58.6	12.0	--	59.7	28.0	--
TOTAL U.S. REVENUES	110.0	32.8	152.5	35.2	--	171.0	45.8	--	191.2	58.3	--	203.8	84.0	--
NON-U.S. MANUFACTURERS														
Captive	23.7	13.4	28.5	15.9	--	32.4	17.1	--	38.1	22.0	--	44.4	30.3	--
PCM/Reseller	49.1	99.6	58.2	97.9	7.7	69.6	93.1	18.9	81.2	103.4	28.6	92.0	163.1	30.6
OEM/Integrator	121.7	56.3	140.0	45.3	.7	180.1	41.5	5.7	203.5	40.7	6.5	222.1	48.0	9.0
TOTAL NON-U.S. REVENUES	194.5	169.3	226.7	159.1	8.4	282.1	151.7	24.6	322.8	166.1	35.1	358.5	241.4	39.6
WORLDWIDE RECAP														
Captive	68.0	19.5	85.8	29.2	--	108.2	37.5	--	124.2	47.5	--	136.2	61.7	--
	-49.6%	-42.1%	+26.2%	+49.7%	--	+26.1%	+28.4%	--	+14.8%	+26.7%	--	+9.7%	+29.9%	--
PCM/Reseller	68.9	124.2	88.9	112.9	7.7	107.8	110.7	18.9	127.7	124.2	28.6	144.3	187.7	30.6
	-23.4%	+84.3%	+29.0%	-9.1%	--	+21.3%	-1.9%	+145.5%	+18.5%	+12.2%	+51.3%	+13.0%	+51.1%	+7.0%
OEM/Integrator	167.6	58.4	204.5	52.2	.7	237.1	49.3	5.7	262.1	52.7	6.5	281.8	76.0	9.0
	-4.4%	-23.7%	+22.0%	-10.6%	--	+15.9%	-5.6%	+714.3%	+10.5%	+6.9%	+14.0%	+7.5%	+44.2%	+38.5%
Total Revenues	304.5	202.1	379.2	194.3	8.4	453.1	197.5	24.6	514.0	224.4	35.1	562.3	325.4	39.6
	-23.9%	+13.8%	+24.5%	-3.9%	--	+19.5%	+1.6%	+192.9%	+13.4%	+13.6%	+42.7%	+9.4%	+45.0%	+12.8%
ANNUAL SHARE, BY DIAMETER	60.2%	39.8%	65.3%	33.4%	1.3%	67.2%	29.3%	3.5%	66.6%	29.0%	4.4%	60.7%	35.1%	4.2%

TABLE 28

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

REWRITABLE DRIVES: BREAKDOWN BY DISK DIAMETER

	1993 Shipments		Forecast 1994			1995			1996			1997		
	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS														
Captive	10.3	3.6	13.6	8.3	--	18.2	13.6	--	21.9	19.6	--	25.1	28.6	--
PCM/Reseller	8.4	16.4	14.1	22.7	--	19.4	31.9	--	26.3	41.4	--	33.3	54.6	--
OEM/Integrator	25.3	3.0	38.7	12.0	--	34.5	15.0	--	36.6	25.0	--	38.5	65.0	--
TOTAL U.S. SHIPMENTS	44.0	23.0	66.4	43.0	--	72.1	60.5	--	84.8	86.0	--	96.9	148.2	--
NON-U.S. MANUFACTURERS														
Captive	9.6	7.8	11.8	9.5	--	13.5	11.0	--	16.2	14.7	--	19.3	20.2	--
PCM/Reseller	30.5	139.5	39.3	160.3	22.0	48.0	179.0	63.0	57.2	235.0	114.0	65.7	429.0	153.0
OEM/Integrator	82.3	83.6	98.3	75.2	2.3	127.8	83.0	19.0	151.7	97.0	26.0	174.0	137.0	45.0
TOTAL NON-U.S. SHIPMENTS	122.4	230.9	149.4	245.0	24.3	189.3	273.0	82.0	225.1	346.7	140.0	259.0	586.2	198.0
WORLDWIDE RECAP														
Captive	19.9	11.4	25.4	17.8	--	31.7	24.6	--	38.1	34.3	--	44.4	48.8	--
	-38.4%	+15.2%	+27.6%	+56.1%	--	+24.8%	+38.2%	--	+20.2%	+39.4%	--	+16.5%	+42.3%	--
PCM/Reseller	38.9	155.9	53.4	183.0	22.0	67.4	210.9	63.0	83.5	276.4	114.0	99.0	483.6	153.0
	-21.4%	+124.3%	+37.3%	+17.4%	--	+26.2%	+15.2%	+186.4%	+23.9%	+31.1%	+81.0%	+18.6%	+75.0%	+34.2%
OEM/Integrator	107.6	86.6	137.0	87.2	2.3	162.3	98.0	19.0	188.3	122.0	26.0	212.5	202.0	45.0
	+9.5%	+.6%	+27.3%	+.7%	--	+18.5%	+12.4%	+726.1%	+16.0%	+24.5%	+36.8%	+12.9%	+65.6%	+73.1%
Total Shipments	166.4	253.9	215.8	288.0	24.3	261.4	333.5	82.0	309.9	432.7	140.0	355.9	734.4	198.0
	-7.6%	+53.4%	+29.7%	+13.4%	--	+21.1%	+15.8%	+237.4%	+18.6%	+29.7%	+70.7%	+14.8%	+69.7%	+41.4%
ANNUAL SHARE, BY DIAMETER	39.7%	60.3%	41.0%	54.5%	4.5%	38.7%	49.3%	12.0%	35.2%	49.0%	15.8%	27.7%	57.0%	15.3%

TABLE 29

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1993 --Shipments--		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	13.9		22.0		32.2		42.9		56.3	
Write-once	--	--	.1	.5%	.4	1.2%	1.4	3.3%	2.6	4.6%
Erasable	13.9	100.0%	21.9	99.5%	31.8	98.8%	41.5	96.7%	53.7	95.4%
OEM/PCM Total	53.5		88.3		101.9		132.3		196.8	
Write-once	.4	.7%	.8	.9%	1.1	1.1%	3.0	2.3%	5.4	2.7%
Erasable	53.1	99.3%	87.5	99.1%	100.8	98.9%	129.3	97.7%	191.4	97.3%
Total U.S.	67.4		110.3		134.1		175.2		253.1	
Write-once	.4	.6%	.9	.8%	1.5	1.1%	4.4	2.5%	8.0	3.2%
Erasable	67.0	99.4%	109.4	99.2%	132.6	98.9%	170.8	97.5%	245.1	96.8%
NON-U.S. MANUFACTURERS										
Captive Total	19.0		23.3		26.8		33.5		42.4	
Write-once	1.6	8.4%	2.0	8.6%	2.3	8.6%	2.6	7.8%	2.9	6.8%
Erasable	17.4	91.6%	21.3	91.4%	24.5	91.4%	30.9	92.2%	39.5	93.2%
OEM/PCM Total	370.7		454.4		611.8		835.9		1,266.7	
Write-once	34.8	9.4%	57.0	12.5%	92.0	15.0%	155.0	18.5%	263.0	20.8%
Erasable	335.9	90.6%	397.4	87.5%	519.8	85.0%	680.9	81.5%	1,003.7	79.2%
Total Non-U.S.	389.7		477.7		638.6		869.4		1,309.1	
Write-once	36.4	9.3%	59.0	12.4%	94.3	14.8%	157.6	18.1%	265.9	20.3%
Erasable	353.3	90.7%	418.7	87.6%	544.3	85.2%	711.8	81.9%	1,043.2	79.7%
WORLDWIDE RECAP										
Total Worldwide Shipments	457.1		588.0		772.7		1,044.6		1,562.2	
	+20.4%		+28.6%		+31.4%		+35.1%		+49.5%	
Write-once	36.8	8.1%	59.9	10.2%	95.8	12.4%	162.0	15.5%	273.9	17.5%
	+8.8%		+62.7%		+59.9%		+69.1%		+69.0%	
Erasable	420.3	91.9%	528.1	89.8%	676.9	87.6%	882.6	84.5%	1,288.3	82.5%
	+21.6%		+25.6%		+28.1%		+30.3%		+45.9%	

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	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	1.2	.3	17.2	1.1
MAINFRAME SYSTEMS General purpose,	13.2	2.9	10.9	.7
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	38.1	8.3	321.8	20.6
PERSONAL COMPUTERS Business and professional, single user	300.7	65.8	578.1	37.0
WORKSTATIONS Engineering and office, single user	89.7	19.6	537.4	34.4
CONSUMER, GAME AND HOBBY COMPUTERS	10.2	2.2	81.2	5.2
OTHER APPLICATIONS	4.0	.9	15.6	1.0
Total	457.2	100.0	1,562.1	100.0

TABLE 31

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 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	
Matsushita Electric	28.3	--	21.0	49.3	27.2	41.3	--	59.0	100.3	23.6
Sony	17.0	.4	6.0	23.4	12.9	40.0	.9	41.1	82.0	19.3
Fujitsu	--	--	18.0	18.0	9.9	.1	--	76.0	76.1	17.9
Ricoh	9.0	.8	3.0	12.8	7.1	20.0	1.6	12.0	33.6	7.9
Olympus Optical	6.9	--	4.0	10.9	6.0	12.4	--	16.0	28.4	6.7
IBM	5.0	--	9.1	14.1	7.8	6.0	--	19.4	25.4	6.0
Other U.S.	17.7	--	--	17.7	9.8	28.1	--	--	28.1	6.7
Other Non-U.S.	10.1	9.3	15.5	34.9	19.3	18.2	13.1	19.0	50.3	11.9
TOTAL	94.0	10.5	76.6	181.1	100.0	166.1	15.6	242.5	424.2	100.0

READ/WRITE OPTICAL DISK DRIVES MORE THAN 1 GIGABYTE

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 Cygnet	GD1002, GD6001, GD9001/S
Hitachi	OD 301A-1, OD 321-1
Philips LMS	LD 4100
NEC	N7913/N6513-23, N6513-20
Nikon	MO-DD121-1A (Erasable)
Sony	WDD 600, WDD 930-01

5.25" disk diameter

Hitachi	OD 152 (Erasable)
Pinnacle Micro	Orray (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. Eastman Kodak produces high capacity 14" drives as well. 5.25" drives entered this product group in 1993 with Hitachi's shipment of its triple capacity rewritable drive. More 5.25" drives in this group are expected to be announced in late 1994. The Pinnacle Micro product is a cluster of four optical drive spindles operating from a single controller and sold as a single drive.

The 12" and 14" drives in this product group are used primarily with networked 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. All but three of the available drives in this group use 12" media, and all but one access a single side of a disk. Philips LMS 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. The high capacity 5.25" drives expected to be widely available in 1995 will extend the range of applications for optical drives in this group.

Market status

After a two year decline, drive shipments in this group leveled out, with unit shipments of 7,100 drives, the same quantity shipped in 1993. Weak economic conditions outside the U.S. prevented growth as firms postponed orders for the larger systems that incorporate these drives. The product group's shipments were also hurt by the effect of competition from optical libraries using 5.25" drives with capacities less than 1 gigabyte. 1993 revenues declined 4.0% to $95.8 million. U.S. manufacturers accounted for 8.9% of worldwide revenues, although 66.9% of worldwide revenue was generated in the U.S. market, up from 62.2% in 1992. 73.9% of revenues were generated by sales to OEMs and integrators.

Almost 96% of units shipped in 1993 were produced by non-U.S. firms, about the same as in 1992. 67.6% of 1993 unit shipments went to the U.S. market, a minor increase, while 32.4% were sold in other parts of the world. 1993's leading noncaptive producers were Sony, and Philips LMS.

Although there are relatively few producers of drives in this product group, with the arrival of high capacity 5.25" drives, the number of producers will increase. 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. Philips LMS, after several difficult years, was able to start ramping production of its double sided drive and increase its market presence.

Government and financial organizations continue as major markets for high capacity disk drives in this group, and system integrators continue to quote on orders of significant magnitude, usually involving optical libraries plus drives. Eastman Kodak's sales of optical drives to replace microfilm equipment for records management have also helped extend the available market. Lower cost 5.25" drives will expand the market for this product group into general industry.

Marketing trends

1994 shipments of 12" and 14" drives will improve slightly, but volume won't really pick up until a new generation of higher capacity drives begins shipping in 1995. The first shipments of 5.25" drives in this group began in 1994 and are expected to eclipse shipments of 12" drives in 1996. 5.25" drives won't have the same capacity per media unit as the 12" drives, but their higher performance, much lower price, rewritability, and multifunctionality and downward compatibility are expected to make them immediately popular. The competition from 5.25" drives may 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 in early 1995. However, they are not expected to have a major impact because most customers will prefer the flexibility of multifunction rewritable drives and media. If significant rewritable drive shipments are delayed beyond 1995 for some unexpected reason, 5.25" write-once drives have a larger opportunity for success.

Because large diameter, optical disk drives are used mostly in specialized applications, shipment growth rates for 12" and 14" drives with more than 1 gigabyte capacity will remain smaller than for other optical disk drive groups. The growth rate for 5.25" drives in this group, however, is expected to exceed 100% in each year of the forecast period. Worldwide unit shipments are expected to grow from 7,100 units in 1993 to 65,600 units in 1997, with 59.0% sold in the U.S. market. 82.8% of 1997 production is expected to be 5.25" drives.

During the forecast period, total revenues are expected to grow from $95.8 million in 1993 (4.3% of the worldwide optical disk drive market) to $273.9 million in 1997 (5.2% of the worldwide optical disk drive market). The U.S. market is expected to generate 63.6% of 1997 worldwide revenues for this product group, with U.S. firms' share of worldwide revenues growing to 18.1%. Most of the U.S. share will come from sales of 5.25" drives. 12" drive sales should be helped by expanding sales of small optical libraries with a single 12" drive and a new generation of higher capacity drives.

Average OEM drive prices for the group are expected to start declining in 1994 due the effect of 5.25" drives on the mix. Prices for 12" and 14" drives are expected to climb, however, as new higher capacity models enter the market, although competitive pressure from 5.25" drives may flatten the rate of increase or even cause a decline in price. A major acceleration in the rate of price decline is expected in 1996 as 5.25" drive shipments in this group ramp up.

IBM has an active optical disk drive development program and introduction of internally produced drives over 1 gigabyte from IBM is anticipated in late 1994 or early 1995. No internal 12" activity is expected from IBM, which prefers 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. Sony, Philips LMS, ATG Cygnet and Hitachi are expected to be the most active 12" drive suppliers, while Nikon will press to establish a market for its 12" MO rewritable drive.

12 centimeter CD-R drives will probably make an appearance in this group late in the forecast period after the next generation high density CD-ROM format is adopted by the industry. Because the format is not completely determined as of mid-1994, and no drives have been announced on even a preliminary basis, it is not yet possible to forecast for this category.

Applications

Networks and multiuser systems, high end personal computers and workstations were major application platforms for drives in this group in 1993, accounting for 93.3% of 1993 unit shipments. This pattern is expected to continue through 1997, 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.

Currently, 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. As 5.25" and 12" MO drives increasingly participate in this product group, archival applications will become less dominant.

Scientific, industrial and defense oriented users of high capacity drives use them to store high volume digitized data from real time inputs 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.
* Hierarchical 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.

Early users of high capacity drives 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 needed 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.

In 1993, about 50% of the drives shipped in this group were attached to optical libraries, but library attachment is expected to gradually decline to 43% in 1997 as 5.25" drives (which are less likely to be used with libraries) form a greater part of this product group.

Automated library systems using large capacity drives usually have two or more drives to improve overall response time, although the single drive, five cartridge Philips LMS 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, which will limit the decline in percentage of drives used with optical libraries.

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 (many of which are microfilm based), concern about hidden perils in new technology and, in some organizations, infighting between MIS managers and records managers. The legal systems of some countries discourage the use of optical storage because only the 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.

12" stand-alone drive applications are being attacked by 5.25" diameter drives used with library units of 10-20 disk capacity. In these small systems, the total cost of the drives, library and media is often less than the price of a single 12" drive, making the small diameter configurations preferable solutions where the longer access time associated with a library is not an objection. The advent of 1.3 gigabyte 5.25" based systems has strengthened the trend toward displacement of 12" systems, and it will be further aggravated by the expected arrival of 2.6 gigabyte 5.25" drives in 1995.

The Philips LMS drive and library announced in 1990, and Sony's 1992 introduction of a somewhat similar product, attempted unsuccessfully to preempt competition from smaller diameter drives in the departmental system market segment. Manufacturers of 12" drives are planning to offer increasingly higher capacities in order to keep their product lines viable, with introductions expected in late 1994 and 1995.

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 12" 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 another year or two before all head positioning times are below 100 milliseconds, Philips LMS and ATG Cygnet have already broken the 100 millisecond barrier for 12" drives, and 5.25" drives in this group are expected to be largely sub-30 millisecond seek time devices. 5.25" drives will probably offer substantially higher rotation rates as a group than the 12" drives.

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 per second.

The 1.3 gigabytes per side 5.25" drives now in the marketing standards bodies will 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: Because various manufacturer's 12" product designs are already established and incompatible, standardization for 12" drives has been limited. 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 versus sampled servo conflict yet remains.

The 5.25" drives now entering this product group are expected to exhibit a far higher degree of standardization that will strengthen the economic performance of the small diameter drives against their larger diameter competitors.

System design: Many large capacity optical disk storage systems will incorporate an automated library. Several firms, including ATG Cygnet, FileNet, Philips LMS, 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. A family of 12" drives expected to start its introduction cycle in late 1994 will offer over 7 to 10 gigabytes per side, much improved from a typical capacity of 1 gigabyte per side in earlier models. Eastman Kodak's 14" drive uses disks with over 5 gigabytes per side and is also expected to upgrade capacity.

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. 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 and manufacturers 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" and the media will, naturally, be rewritable. Fujitsu 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 nonremovable multiple platter drive.

Packaging: The 12" optical disk drives typically have a rack mount configuration. Because these drives are often used with library devices, there is a need to adhere to a standardized mechanical interface that will permit any drive to be used with any library load/unload mechanism.

Through 1995, the 12" form factor will remain the most frequently encountered size in this product group, but in 1996 and thereafter, 5.25" drives are expected to predominate. There is no expectation of any 3.5" drives in this group within the forecast period.

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 Cygnet has done substantial development work with this technique and has incorporated it into the design of the ATG Cygnet 12" drive. ATG Cygnet 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 Cygnet in the preparation of a standard for 12" optical media. Philips LMS 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 size of 12" optical drives favors 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 non-semiconductor 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. However, cost and reliability will have to be traded for performance in such designs. 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 magneto-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. 5.25" media for this product group will also use both glass and plastic.

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. 5.25" drives will be major participants in this product group after 1994.
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 1997.
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 1994, but are expected to have growing impact on shipments after that.
6. Higher capacity 12" drives will stimulate market growth in this category after 1994.
7. CD-R drives will appear in this product group toward the end of the forecast period, but with a degree of uncertainty that precludes a forecast.

TABLE 32

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.0	6.0	5.8	5.8	7.2	8.2	8.7	10.6	13.8	16.9
PCM/Reseller	--	--	--	--	1.8	2.8	3.8	5.6	4.9	7.3
OEM/Integrator	2.5	2.5	2.3	2.3	4.0	5.2	10.0	14.8	16.6	25.2
TOTAL U.S. REVENUES	8.5	8.5	8.1	8.1	13.0	16.2	22.5	31.0	35.3	49.4
Non-U.S. Manufacturers										
Captive	--	7.5	--	4.7	--	5.2	--	10.1	--	13.9
PCM/Reseller	7.5	10.0	8.4	9.6	10.3	14.4	14.8	21.4	23.8	35.5
OEM/Integrator	48.1	69.8	52.5	74.4	64.8	92.3	83.7	123.5	115.1	175.1
TOTAL NON-U.S. REVENUES	55.6	87.3	60.9	88.7	75.1	111.9	98.5	155.0	138.9	224.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	64.1	95.8	69.0	96.8	88.1	128.1	121.0	186.0	174.2	273.9
OEM Average Price ($000)		12.6		11.9		10.1		6.1		4.2

TABLE 33

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.2	.2	.2	.2	.7	1.0	1.3	2.0	2.6	4.0
PCM/Reseller	--	--	--	--	.7	1.1	1.9	2.8	2.9	4.3
OEM/Integrator	.1	.1	.1	.1	1.0	1.6	4.7	7.5	8.3	14.0
TOTAL U.S. SHIPMENTS	.3	.3	.3	.3	2.4	3.7	7.9	12.3	13.8	22.3
Non-U.S. Manufacturers										
Captive	--	.4	--	.5	--	.6	--	1.6	--	2.4
PCM/Reseller	.6	.8	.7	.8	1.0	1.7	2.2	3.5	4.8	7.9
OEM/Integrator	3.9	5.6	4.3	6.3	5.5	8.0	9.5	15.0	20.1	33.0
TOTAL NON-U.S. SHIPMENTS	4.5	6.8	5.0	7.6	6.5	10.3	11.7	20.1	24.9	43.3
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	4.8	7.1	5.3	7.9	8.9	14.0	19.6	32.4	38.7	65.6
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	37.8	80.7	43.1	88.6	52.0	102.6	71.6	135.0	110.3	200.6

TABLE 34

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues	Forecast 1994		1995		1996		1997	
	12"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS									
Captive	6.0	5.8	--	5.6	2.6	5.7	4.9	8.7	8.2
PCM/Reseller	--	--	--	--	2.8	--	5.6	--	7.3
OEM/Integrator	2.5	2.3	--	2.2	3.0	2.2	12.6	4.5	20.7
TOTAL U.S. REVENUES	8.5	8.1	--	7.8	8.4	7.9	23.1	13.2	36.2
NON-U.S. MANUFACTURERS									
Captive	7.5	3.7	1.0	3.8	1.4	5.9	4.2	8.1	5.8
PCM/Reseller	10.0	9.6	--	12.2	2.2	16.1	5.3	23.8	11.7
OEM/Integrator	69.8	73.7	.7	89.9	2.4	110.5	13.0	136.7	38.4
TOTAL NON-U.S. REVENUES	87.3	87.0	1.7	105.9	6.0	132.5	22.5	168.6	55.9
WORLDWIDE RECAP									
Captive	13.5	9.5	1.0	9.4	4.0	11.6	9.1	16.8	14.0
	-46.9%	-29.6%	--	-1.1%	+300.0%	+23.4%	+127.5%	+44.8%	+53.8%
PCM/Reseller	10.0	9.6	--	12.2	5.0	16.1	10.9	23.8	19.0
	+127.3%	-4.0%	--	+27.1%	--	+32.0%	+118.0%	+47.8%	+74.3%
OEM/Integrator	72.3	76.0	.7	92.1	5.4	112.7	25.6	141.2	59.1
	+3.3%	+5.1%	--	+21.2%	+671.4%	+22.4%	+374.1%	+25.3%	+130.9%
Total Revenues	95.8	95.1	1.7	113.7	14.4	140.4	45.6	181.8	92.1
	-4.0%	-.7%	--	+19.6%	+747.1%	+23.5%	+216.7%	+29.5%	+102.0%
ANNUAL SHARE, BY DIAMETER	100.0%	98.3%	1.7%	88.9%	11.1%	75.6%	24.4%	66.5%	33.5%

Note: 12" drives include 14" drives.

TABLE 35

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments	Forecast							
		1994		1995		1996		1997	
	12"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS									
Captive	.2	.2	--	.2	.8	.2	1.8	.3	3.7
PCM/Reseller	--	--	--	--	1.1	--	2.8	--	4.3
OEM/Integrator	.1	.1	--	.1	1.5	.1	7.4	.2	13.8
TOTAL U.S. SHIPMENTS	.3	.3	--	.3	3.4	.3	12.0	.5	21.8
NON-U.S. MANUFACTURERS									
Captive	.4	.2	.3	.2	.4	.3	1.3	.4	2.0
PCM/Reseller	.8	.8	--	.9	.8	1.1	2.4	1.4	6.5
OEM/Integrator	5.6	6.0	.3	6.9	1.1	7.8	7.2	9.0	24.0
TOTAL NON-U.S. SHIPMENTS	6.8	7.0	.6	8.0	2.3	9.2	10.9	10.8	32.5
WORLDWIDE RECAP									
Captive	.6	.4	.3	.4	1.2	.5	3.1	.7	5.7
	-50.0%	-33.3%	--	--	+300.0%	+25.0%	+158.3%	+40.0%	+83.9%
PCM/Reseller	.8	.8	--	.9	1.9	1.1	5.2	1.4	10.8
	+100.0%	--	--	+12.5%	--	+22.2%	+173.7%	+27.3%	+107.7%
OEM/Integrator	5.7	6.1	.3	7.0	2.6	7.9	14.6	9.2	37.8
	+3.6%	+7.0%	--	+14.8%	+766.7%	+12.9%	+461.5%	+16.5%	+158.9%
Total Shipments	7.1	7.3	.6	8.3	5.7	9.5	22.9	11.3	54.3
	--	+2.8%	--	+13.7%	+850.0%	+14.5%	+301.8%	+18.9%	+137.1%
ANNUAL SHARE, BY DIAMETER	100.0%	92.5%	7.5%	59.4%	40.6%	29.3%	70.7%	17.2%	82.8%

Note: 12" drives include 14" drives.

TABLE 36

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	.1	1.9	1.4	2.1
MAINFRAME SYSTEMS General purpose,	.3	4.7	3.9	5.9
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	3.9	54.6	21.9	33.4
PERSONAL COMPUTERS Business and professional, single user	1.5	21.7	13.3	20.3
WORKSTATIONS Engineering and office, single user	1.2	17.0	24.5	37.3
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.1	.1	.6	1.0
Total	7.0	100.1	65.7	100.0

TABLE 37

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	12"	5.25"	Total		12"	5.25"	Total	
Sony	2.1	--	2.1	45.7	2.6	--	2.6	40.0
Philips LMS	1.9	--	1.9	41.3	2.5	--	2.5	38.5
Other U.S.	.1	--	.1	2.2	.1	--	.1	1.5
Other Non-U.S.	.5	--	.5	10.8	1.3	--	1.3	20.0
TOTAL	4.6	--	4.6	100.0	6.5	--	6.5	100.0

CD-ROM OPTICAL LIBRARIES

1994 DISK/TREND REPORT

CD-ROM OPTICAL LIBRARIES

Coverage

Examples of optical disk libraries in this group include:

12 centimeter (4.72") disk diameter

Amber Technology	Rotostar CD
Borett Automation Technologies	VLC
Document Imaging Systems Corp.	D33, D600, D1230
DSM	CDR-1, CDR-2, CDR-4
K&S	CDJ-30
Kubik Enterprises	DDC-240, CDR240M
Logical Engineering	ROMBox 300
Microboards	DataWrite
Nakamichi	MBR-7
NSM	CDR-100
Pioneer	DRM-600, DRM 604, DRM610
TAC Systems	Juke Drive
Todd Enterprises	TAJ-2000
Victor Data Systems (JVC)	DM-5000

CD-ROM optical disk libraries currently make use of CD-ROM drives and/or CD-R drives, 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, although a few high performance models were initially designed for 5.25" optical media and drives.

Market status

The number of CD-ROM library manufacturers has nearly tripled in the past year from 5 to 14, but only Pioneer shipped more than 10,000 units. A few other firms shipped hundreds of units. New manufacturers include Amber Technology, DISC, K&S, Logical Engineering, Microboards, Nakamichi, TAC Systems, Todd Enterprises and Victor Data Systems. CD-ROM libraries range from the 20,000+ disk version of Borett Automation to the integrated drive and six unit capacity of Pioneer, which is derived from the design of a multidisk CD audio player.

The Kubik library, an unusual rotary mechanism that operates much like a carousel-type slide projector, has been joined by a rotary library from TAC systems, which is based upon a Fisher audio mechanism. NSM, Logical Engineering, Todd Enterprises, Microboards, Victor Data Systems, Pioneer and DISC have all announced libraries with 100 disk or greater capacity. 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. Several of these companies are using a karaoke system library to which has been added appropriate controller logic and software support.

91.2% of the units shipped in 1993 held fewer than 40 disks, and this segmentation is expected to be maintained at about the same level throughout the forecast period. About half of the revenues for the group came from the under 40 disk segment, but declining prices and shifts in product mix are expected to result in a revenue share decline for the segment to 41.6% in 1997.

Marketing trends

1993 CD-ROM library revenues jumped 129.1% to $30.7 million, largely as a result of Pioneer's success with its six disk library and an increasing mix of larger libraries with higher prices. Total revenues are expected to reach $72.4 million in 1997. The number of competitors and the complexity of the solutions offered are both expected to further 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, include CD-ROM capability with their file servers, increasing the opportunity for upgrades to a library subsystem.

19,810 units were shipped in 1993, up 72.6% from 1992. 1997 shipments are projected to grow strongly to 52,686 units, with the majority of these shipments being low-end libraries holding no more than ten disks. 66.6% of the total 1993 unit shipments were to the U.S. market, but this percentage will decline slightly to 63.6% in 1997. 43.6% of 1993 unit shipments were sold to OEMs or system integrators. The portion sold to OEM/Integrators is expected to decrease to 29.1% in 1997 as a result of increasing numbers of small libraries sold through distribution.

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 and Nakamichi units, are 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 improved its already strong position in this segment when it began producing an 18 cartridge library in late 1993, but the success of its 500 cartridge unit seems less assured, given the presence of other competitors with high capacity libraries.

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 typical CD-ROM library is an adaptation of an audio player/changer, but a few models derived from high performance 5.25" library designs are also available, notably from Document Imaging Storage Systems and Borett Automation. 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. Libraries based upon audio changer designs may similarly do poorly when subjected to the stress of high use rates on networks. The same deficiency may exist in libraries derived from audio designs, which are typically designed to favor cost considerations over long-term reliability with high exchange rates.

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. CD-ROM library unit shipments will continue to be dominated by low cost, low performance devices, but revenues will increasingly reflect shipments of higher capacity designs.
2. Non-U.S. suppliers will dominate the CD-ROM library market. U.S. firms will concentrate upon lower volume, higher capacity and higher performance designs. IBM will not be a producer.
3. There will be no significant changes in library technology impacting CD-ROM 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 38

CD-ROM FORMAT OPTICAL LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993		Forecast							
	Revenues		1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	--	--	.4	.4	.5	.5	.5	.5	.6	.7
OEM/Integrator	5.0	7.2	7.7	10.4	8.9	12.3	9.2	12.7	9.5	13.0
TOTAL U.S. NONCAPTIVE	5.0	7.2	8.1	10.8	9.4	12.8	9.7	13.2	10.1	13.7
TOTAL U.S. REVENUES	5.0	7.2	8.1	10.8	9.4	12.8	9.7	13.2	10.1	13.7
Non-U.S. Manufacturers										
PCM/Reseller	9.4	13.5	14.2	21.8	22.1	29.8	23.8	34.2	25.0	38.1
OEM/Integrator	6.2	10.0	8.0	12.8	9.2	14.8	10.4	17.5	12.1	20.6
TOTAL NON-U.S. REVENUES	15.6	23.5	22.2	34.6	31.3	44.6	34.2	51.7	37.1	58.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	20.6	30.7	30.3	45.4	40.7	57.4	43.9	64.9	47.2	72.4
OEM Average Price ($000)		2.0		2.3		2.3		2.3		2.2

TABLE 39

CD-ROM FORMAT OPTICAL LIBRARIES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1993 Shipments		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	--	--	96	100	108	119	125	146	141	178
OEM/Integrator	331	475	612	832	755	1,038	854	1,177	968	1,325
TOTAL U.S. NONCAPTIVE	331	475	708	932	863	1,157	979	1,323	1,109	1,503
TOTAL U.S. SHIPMENTS	331	475	708	932	863	1,157	979	1,323	1,109	1,503
Non-U.S. Manufacturers										
PCM/Reseller	7,925	11,181	10,772	17,564	18,042	23,489	21,221	29,825	24,438	37,191
OEM/Integrator	4,938	8,154	5,298	9,228	5,917	10,531	6,761	12,126	7,958	13,992
TOTAL NON-U.S. SHIPMENTS	12,863	19,335	16,070	26,792	23,959	34,020	27,982	41,951	32,396	51,183
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	13,194	19,810	16,778	27,724	24,822	35,177	28,961	43,274	33,505	52,686
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	34	49	51	77	76	112	104	155	138	208

TABLE 40

CD-ROM FORMAT OPTICAL LIBRARIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY LIBRARY SIZE

	1993 Revenues		Forecast 1994		1995		1996		1997	
	1-39	40 up	1-39	40 up	1-39	40 up	1-39	40 up	1-39	40 up
U.S. MANUFACTURERS										
PCM/Reseller	--	--	.2	.2	.3	.2	.3	.2	.4	.3
OEM/Integrator	--	7.2	--	10.4	--	12.3	--	12.7	--	13.0
TOTAL U.S. REVENUES	--	7.2	.2	10.6	.3	12.5	.3	12.9	.4	13.3
NON-U.S. MANUFACTURERS										
PCM/Reseller	9.5	4.0	13.8	8.0	17.6	12.2	19.6	14.6	21.0	17.1
OEM/Integrator	6.0	4.0	6.5	6.3	6.6	8.2	7.5	10.0	8.7	11.9
TOTAL NON-U.S. REVENUES	15.5	8.0	20.3	14.3	24.2	20.4	27.1	24.6	29.7	29.0
WORLDWIDE RECAP										
PCM/Reseller	9.5	4.0	14.0	8.2	17.9	12.4	19.9	14.8	21.4	17.4
	+131.7%	+166.7%	+47.4%	+105.0%	+27.9%	+51.2%	+11.2%	+19.4%	+7.5%	+17.6%
OEM/Integrator	6.0	11.2	6.5	16.7	6.6	20.5	7.5	22.7	8.7	24.9
	+20.0%	+300.0%	+8.3%	+49.1%	+1.5%	+22.8%	+13.6%	+10.7%	+16.0%	+9.7%
Total Revenues	15.5	15.2	20.5	24.9	24.5	32.9	27.4	37.5	30.1	42.3
	+70.3%	+253.5%	+32.3%	+63.8%	+19.5%	+32.1%	+11.8%	+14.0%	+9.9%	+12.8%
ANNUAL SHARE, BY DIAMETER	50.6%	49.4%	45.2%	54.8%	42.7%	57.3%	42.2%	57.8%	41.6%	58.4%

Note: Headings define number of disks stored per library.

TABLE 41

CD-ROM FORMAT OPTICAL LIBRARIES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY LIBRARY SIZE

	1993 Shipments		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	1-39	40 up	1-39	40 up	1-39	40 up	1-39	40 up	1-39	40 up
U.S. MANUFACTURERS										
PCM/Reseller	--	--	96	4	114	5	140	6	170	8
OEM/Integrator	--	475	--	832	11	1,027	21	1,156	34	1,291
TOTAL U.S. SHIPMENTS	--	475	96	836	125	1,032	161	1,162	204	1,299
NON-U.S. MANUFACTURERS										
PCM/Reseller	10,544	637	16,500	1,064	22,000	1,489	28,000	1,825	35,000	2,191
OEM/Integrator	7,501	653	8,422	806	9,500	1,031	10,794	1,332	12,369	1,623
TOTAL NON-U.S. SHIPMENTS	18,045	1,290	24,922	1,870	31,500	2,520	38,794	3,157	47,369	3,814
WORLDWIDE RECAP										
PCM/Reseller	10,544	637	16,596	1,068	22,114	1,494	28,140	1,831	35,170	2,199
	+157.0%	+649.4%	+57.4%	+67.7%	+33.2%	+39.9%	+27.2%	+22.6%	+25.0%	+20.1%
OEM/Integrator	7,501	1,128	8,422	1,638	9,511	2,058	10,815	2,488	12,403	2,914
	+5.6%	+509.7%	+12.3%	+45.2%	+12.9%	+25.6%	+13.7%	+20.9%	+14.7%	+17.1%
Total Shipments	18,045	1,765	25,018	2,706	31,625	3,552	38,955	4,319	47,573	5,113
	+61.1%	+553.7%	+38.6%	+53.3%	+26.4%	+31.2%	+23.2%	+21.6%	+22.1%	+18.4%
ANNUAL SHARE, BY DIAMETER	91.2%	8.8%	90.3%	9.7%	90.0%	10.0%	90.1%	9.9%	90.4%	9.6%

Note: Headings define number of disks stored per library.

READ/WRITE OPTICAL LIBRARIES, 1-39 CARTRIDGES

1994 DISK/TREND REPORT

READ/WRITE OPTICAL LIBRARIES
1 - 39 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

3.5" disk diameter

Advanced Digital Information	VLS-MO

5.25" disk diameter

Aisin Seiki	JC2000
DSM	4000
Fujitsu	M2522/AX
Hewlett-Packard	C1100, C1713T, 20XT
Hitachi	OL101-11, OL112-21
IBM	3995-043
International Data Engineering	7100, 7200, 9000, LG5
K&S	Megastore 1000
NEC	N1137-06
Nikkyo	NOL-102, NOL-161
NKK	N-520
Olympus	OLS 10NSS, OLS S10
Ricoh	RF5210E
Sony	OSL 2000

12" disk diameter

Access	ODSR-2
ATG Cygnet	GF 6910
DSM	28
Hitachi	OL301
Philips LMS	LF 4500
NEC	N7923
Sony	WDA-E330

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, but only a new model from ADIC is available as of mid-1994. 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 others, plus Borett Automation's 8000 disk industrial strength unit.

Also included is the Philips LMS 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 rewritable 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 is currently available only in larger optical libraries. The ADIC 22 disk 3.5" library is the sole 3.5" library in production as of mid-1994.

Market status

Unit shipments for this product group increased only 6.3% to 9,759 units in 1993. The small increase was the result of depressed economic conditions in many parts of the world. Revenues did better, growing 25.8% to $104.3 million and reflecting greater participation by high end libraries in this product group. 60.1% of 1993 revenues and 78% of 1993 shipments were generated by U.S. manufacturers, notably IDE and Hewlett-Packard, which together accounted for nearly 78% of 5.25" unit shipments. Philips LMS was the dominant 12" library supplier. 69.1% of unit shipments were made to U.S. destinations, a slight decrease from 1992 and a reflection of weak non-U.S. markets.

IDE's strong position in 5.25" libraries has come under attack from other manufacturers, including Hewlett-Packard, NKK and Nikkyo, although Japanese companies are having difficulty making immediate inroads into the U.S. market because of the strong yen and steep price declines for U.S. made libraries that occurred in early 1994. Hewlett-Packard and IDE are running a close race for shipment leadership in this product group.

3.5" library shipments 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 to an expected 600+ megabyte level.

Library manufacturers 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 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 can dictate the choice of a drive supplier to reduce development and support costs for captive producers.

Marketing trends

1997 worldwide unit shipments are forecasted to grow to 22,736, and total revenues will increase to $185 million. Shipments at the low capacity end of this product group will be increasingly impacted in the future by anticipated magnetic disk drives such as 5.25" drives capable of storing as much as 18 gigabytes per spindle and 3.5" drives whose capacities are expected to move into the 10 gigabyte per spindle range within the forecast period.

OEMs and system integrators will account for 46.7% of 1997 unit shipments, while 48.1% will be through PCM/Resellers. 5.25" shipments, which were 83.9% of the 1993 total shipments, are expected to improve slightly over the forecast period and hold 85.2% share in 1997. 12" autochangers in this product group held 16.3% share in 1993, and this share is expected to decline to 12.4% in 1997. 3.5" libraries are projected to capture a 2.4% share in 1997.

Total revenues for 1997 are forecasted to reach $185 million, with 57.3% originating from U.S. firms, a moderate percentage decline from 1992 that reflects the effects of expected library introductions from non-U.S. manufacturers. About 65.4% of the worldwide library revenues from this product group are expected to be generated in the U.S. market in 1997.

The number of competitors in this group is expected to increase 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, PCM reseller shipments in this group are running slightly ahead of OEM/Integrator shipments, resulting from the ability of the distributor to effectively handle relatively simple libraries at the low end of the product range. High-end libraries in this group will use distributors to a lesser degree, but 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 optical disk library 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 Philips LMS, Sony and ATG Cygnet 12" libraries occupy a middle ground: While relatively low priced, and having only one drive, they provide on-line capacity so large (especially the dual head Philips design) that throughput may frequently be better than that of multidrive 5.25" units. In cases where re-writable 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 moderate growth through 1997.

Technical trends

For the time being, most libraries in this product group will continue to use 5.25" or 12" drives and media. 3.5" libraries will use 230 megabyte drives and the MOST 384 megabyte drive, but until 3.5" drive capacities above 500 megabytes are available, 3.5" libraries will offer so much less capacity than 5.25" libraries, limited further by single sided recording, that they will be relatively unattractive. They may have some appeal as automated disk writers for software duplication where production requirements are 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 Philips LMS 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 have a chance to 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 1995.
2. The 5.25" format will remain the most commonly used, but it will receive competition from 12" libraries.
3. Rewritable drives will be used in almost all 5.25" libraries in this group, displacing write-once drives.
4. There are no significant changes in anticipated technology 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 in this group will be used mostly with standalone workstations. Single drive 12" units will be used with workstations and also in small multiuser systems. Multidrive libraries will be used in medium to large networked 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.
7. Competition from very high capacity magnetic drives will impact the shipments of libraries at the low end of this group.

TABLE 42

OPTICAL LIBRARIES, 1-39 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	4.3	5.5	5.1	6.5	5.4	7.3	5.9	8.0	6.2	8.6
PCM/Reseller	16.9	23.4	23.4	32.0	30.2	42.5	33.2	46.9	32.6	47.3
OEM/Integrator	25.0	33.8	30.9	43.1	35.7	44.6	36.9	48.6	37.7	50.2
TOTAL U.S. REVENUES	46.2	62.7	59.4	81.6	71.3	94.4	76.0	103.5	76.5	106.1
Non-U.S. Manufacturers										
Captive	--	11.5	--	12.1	--	13.9	--	15.3	--	17.4
PCM/Reseller	5.4	7.1	8.4	11.2	11.0	14.2	13.4	17.3	15.9	20.6
OEM/Integrator	13.8	23.0	16.2	26.5	21.8	31.4	25.4	36.1	28.5	40.9
TOTAL NON-U.S. REVENUES	19.2	41.6	24.6	49.8	32.8	59.5	38.8	68.7	44.4	78.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	65.4	104.3	84.0	131.4	104.1	153.9	114.8	172.2	120.9	185.0
OEM Average Price ($000)		12.4		10.7		9.5		8.9		8.6

TABLE 43

OPTICAL LIBRARIES, 1-39 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1993 Shipments		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	204	262	270	345	302	408	330	448	347	481
PCM/Reseller	2,876	4,054	4,073	5,650	5,037	7,085	6,036	8,526	6,515	9,453
OEM/Integrator	2,495	3,298	3,550	4,854	4,813	5,995	5,572	7,286	6,160	8,145
TOTAL U.S. SHIPMENTS	5,575	7,614	7,893	10,849	10,152	13,488	11,938	16,260	13,022	18,079
Non-U.S. Manufacturers										
Captive	--	370	--	450	--	533	--	614	--	715
PCM/Reseller	382	489	638	866	792	1,059	939	1,267	1,089	1,477
OEM/Integrator	791	1,286	1,016	1,636	1,350	2,007	1,530	2,241	1,660	2,465
TOTAL NON-U.S. SHIPMENTS	1,173	2,145	1,654	2,952	2,142	3,599	2,469	4,122	2,749	4,657
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6,748	9,759	9,547	13,801	12,294	17,087	14,407	20,382	15,771	22,736
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	16	24	25	38	38	55	52	76	68	98

TABLE 44

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues		Forecast 1994			Forecast 1995			Forecast 1996			Forecast 1997		
	12"	5.25"	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"	12"	5.25"	3.5"
U.S. MANUFACTURERS														
Captive	.1	5.4	--	6.5	--	--	7.3	--	--	8.0	--	--	8.6	--
PCM/Reseller	--	23.4	--	32.0	--	--	42.5	--	--	46.9	--	--	47.3	--
OEM/Integrator	.1	33.7	--	42.6	.5	--	43.9	.7	--	47.7	.9	--	49.1	1.1
TOTAL U.S. REVENUES	.2	62.5	--	81.1	.5	--	93.7	.7	--	102.6	.9	--	105.0	1.1
NON-U.S. MANUFACTURERS														
Captive	4.4	7.1	4.5	7.6	--	4.7	9.2	--	4.9	10.4	--	5.0	12.4	--
PCM/Reseller	7.1	--	9.2	2.0	--	11.6	2.6	--	14.5	2.8	--	17.6	3.0	--
OEM/Integrator	18.0	5.0	20.5	6.0	--	25.0	6.4	--	29.8	6.3	--	34.8	6.1	--
TOTAL NON-U.S. REVENUES	29.5	12.1	34.2	15.6	--	41.3	18.2	--	49.2	19.5	--	57.4	21.5	--
WORLDWIDE RECAP														
Captive	4.5	12.5	4.5	14.1	--	4.7	16.5	--	4.9	18.4	--	5.0	21.0	--
	+200.0%	+33.0%	--	+12.8%	--	+4.4%	+17.0%	--	+4.3%	+11.5%	--	+2.0%	+14.1%	--
PCM/Reseller	7.1	23.4	9.2	34.0	--	11.6	45.1	--	14.5	49.7	--	17.6	50.3	--
	+273.7%	+9.9%	+29.6%	+45.3%	--	+26.1%	+32.6%	--	+25.0%	+10.2%	--	+21.4%	+1.2%	--
OEM/Integrator	18.1	38.7	20.5	48.6	.5	25.0	50.3	.7	29.8	54.0	.9	34.8	55.2	1.1
	+22.3%	+32.1%	+13.3%	+25.6%	--	+22.0%	+3.5%	+40.0%	+19.2%	+7.4%	+28.6%	+16.8%	+2.2%	+22.2%
Total Revenues	29.7	74.6	34.2	96.7	.5	41.3	111.9	.7	49.2	122.1	.9	57.4	126.5	1.1
	+63.2%	+24.3%	+15.2%	+29.6%	--	+20.8%	+15.7%	+40.0%	+19.1%	+9.1%	+28.6%	+16.7%	+3.6%	+22.2%
ANNUAL SHARE, BY DIAMETER	28.5%	71.5%	26.0%	73.7%	.3%	26.8%	72.8%	.4%	28.6%	71.0%	.4%	31.0%	68.5%	.5%

TABLE 45

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments			Forecast 1994			1995			1996			1997		
	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	260	--	--	345	--	--	408	--	--	448	--	--	481	--
PCM/Reseller	--	4,054	--	--	5,650	--	--	7,085	--	--	8,526	--	--	9,453	--
OEM/Integrator	8	3,274	16	--	4,630	224	--	5,662	333	--	6,837	449	--	7,580	565
TOTAL U.S. SHIPMENTS	10	7,588	16	--	10,625	224	--	13,155	333	--	15,811	449	--	17,514	565
NON-U.S. MANUFACTURERS															
Captive	88	282	--	90	360	--	93	440	--	94	520	--	95	620	--
PCM/Reseller	489	--	--	616	250	--	730	329	--	855	412	--	980	497	--
OEM/Integrator	981	305	--	1,175	461	--	1,390	617	--	1,570	671	--	1,740	725	--
TOTAL NON-U.S. SHIPMENTS	1,558	587	--	1,881	1,071	--	2,213	1,386	--	2,519	1,603	--	2,815	1,842	--
WORLDWIDE RECAP															
Captive	90	542	--	90	705	--	93	848	--	94	968	--	95	1,101	--
	+181.3%	+38.6%	--	--	+30.1%	--	+3.3%	+20.3%	--	+1.1%	+14.2%	--	+1.1%	+13.7%	--
PCM/Reseller	489	4,054	--	616	5,900	--	730	7,414	--	855	8,938	--	980	9,950	--
	+404.1%	+16.5%	--	+26.0%	+45.5%	--	+18.5%	+25.7%	--	+17.1%	+20.6%	--	+14.6%	+11.3%	--
OEM/Integrator	989	3,579	16	1,175	5,091	224	1,390	6,279	333	1,570	7,508	449	1,740	8,305	565
	+47.6%	-18.2%	-81.4%	+18.8%	+42.2%	--	+18.3%	+23.3%	+48.7%	+12.9%	+19.6%	+34.8%	+10.8%	+10.6%	+25.8%
Total Shipments	1,568	8,175	16	1,881	11,696	224	2,213	14,541	333	2,519	17,414	449	2,815	19,356	565
	+96.2%	-.8%	-81.4%	+20.0%	+43.1%	--	+17.7%	+24.3%	+48.7%	+13.8%	+19.8%	+34.8%	+11.8%	+11.2%	+25.8%
ANNUAL SHARE, BY DIAMETER	16.1%	83.9%	--	13.6%	84.8%	1.6%	13.0%	85.2%	1.8%	12.4%	85.5%	2.1%	12.4%	85.2%	2.4%

TABLE 46

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1993 --Shipments--		Forecast -----1994----		-----1995----		-----1996----		-----1997----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	262.0		345.0		408.0		448.0		481.0	
Write-Once	2.0	.8%	--	--	--	--	--	--	--	--
Erasable	260.0	99.2%	345.0	100.0%	408.0	100.0%	448.0	100.0%	481.0	100.0%
OEM/PCM Total	7,352.0		10,504.0		13,080.0		15,812.0		17,598.0	
Write-Once	248.0	3.4%	195.0	1.9%	162.0	1.2%	141.0	.9%	118.0	.7%
Erasable	7,104.0	96.6%	10,309.0	98.1%	12,918.0	98.8%	15,671.0	99.1%	17,480.0	99.3%
Total U.S.	7,614.0		10,849.0		13,488.0		16,260.0		18,079.0	
Write-Once	250.0	3.3%	195.0	1.8%	162.0	1.2%	141.0	.9%	118.0	.7%
Erasable	7,364.0	96.7%	10,654.0	98.2%	13,326.0	98.8%	16,119.0	99.1%	17,961.0	99.3%
NON-U.S. MANUFACTURERS										
Captive Total	370.0		450.0		533.0		614.0		715.0	
Write-Once	88.0	23.8%	90.0	20.0%	93.0	17.4%	94.0	15.3%	95.0	13.3%
Erasable	282.0	76.2%	360.0	80.0%	440.0	82.6%	520.0	84.7%	620.0	86.7%
OEM/PCM Total	1,775.0		2,502.0		3,066.0		3,508.0		3,942.0	
Write-Once	1,562.0	88.1%	1,879.0	75.2%	2,202.0	71.9%	2,501.0	71.4%	2,790.0	70.9%
Erasable	213.0	11.9%	623.0	24.8%	864.0	28.1%	1,007.0	28.6%	1,152.0	29.1%
Total Non-U.S.	2,145.0		2,952.0		3,599.0		4,122.0		4,657.0	
Write-Once	1,650.0	77.0%	1,969.0	66.8%	2,295.0	63.9%	2,595.0	63.1%	2,885.0	62.0%
Erasable	495.0	23.0%	983.0	33.2%	1,304.0	36.1%	1,527.0	36.9%	1,772.0	38.0%
WORLDWIDE RECAP										
Total Worldwide Shipments	9,759.0		13,801.0		17,087.0		20,382.0		22,736.0	
	+6.8%		+41.4%		+23.8%		+19.2%		+11.5%	
Write-Once	1,900.0	19.5%	2,164.0	15.7%	2,457.0	14.4%	2,736.0	13.4%	3,003.0	13.2%
	+30.5%		+13.8%		+13.5%		+11.3%		+9.7%	
Erasable	7,859.0	80.5%	11,637.0	84.3%	14,630.0	85.6%	17,646.0	86.6%	19,733.0	86.8%
	+2.4%		+48.0%		+25.7%		+20.6%		+11.8%	

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

READ/WRITE OPTICAL LIBRARIES, 40-69 CARTRIDGES

1994 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 Industrial	LF-J5000A, LF-J7000A
International Data Engineering	8100
NEC	N7925-81, ND3605-19, N5817-31
Nikkyo	NOL-642
NKK	N-556ET, N-556MS, N-556MP
Ricoh	RJ5830E

12" disk diameter

DSM	48
Hitachi	OL321-22/32
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 and networked systems because of their high storage capacities. The 5.25" libraries are often found in networked systems also, but many are being used in freestanding document image filing systems used for general office purposes and for technical documentation.

Market status

1993 optical library shipments in this product group increased moderately to 2,837 units, up 7% from 1992. Revenues declined 26% to $47.9 million, reflecting declining prices due to weak economic conditions. Shipments of 5.25" units greatly exceeded shipments of 12" units, capturing 91.6% of worldwide shipments, up slightly from 1992.

19.8% of 1993 revenues were generated by 12" libraries as a result of higher average prices compared to 5.25" libraries, about the same as in 1992. With the increase of 5.25" drive capacities last year, sales of drives in this product group are being diverted to the 1-39 cartridge group, and 5.25" libraries are displacing 12" libraries in this product group. However, next generation high capacity 5.25" drives may help this group capture future share from larger libraries.

Marketing trends

Unit shipments are projected to grow to over 4,900 in 1997 for optical disk libraries in this product group. The 1997 balance between 12" and 5.25" drive usage will tilt even more toward 5.25" as high capacity 5.25" drive shipments ramp up.

The number of manufacturers of 12" libraries in this group decreased last year and may further decline with time, but the number of 5.25" participants is expected to increase somewhat. 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 11.8% of 1993 library shipments in this group involved write-once drives, and in 1997 only 9.2% of the units are projected to be equipped exclusively with write-once drives, almost all of which will be 12" 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 remain the most significant application, followed by general purpose networked systems. Technical applications were third in importance. This pattern is expected to be maintained throughout the forecast period. Libraries attached to networks are expected to increasingly be used in hierarchical storage systems.

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. Single-site video on demand systems may become a future market for some of the larger libraries in this product group, serving as an adjunct to a magnetic disk based video server.

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 12" 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 rates in this product group by optical libraries with fewer or greater numbers of cartridges, although not enough to create negative growth.

TABLE 47

OPTICAL LIBRARIES, 40-69 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.2	.2	.2	.2	.2	.2	.3	.3	.3	.3
PCM/Reseller	.4	.8	.7	1.1	.9	1.3	1.0	1.4	1.0	1.4
OEM/Integrator	8.4	8.7	9.0	9.8	8.1	9.1	7.7	8.8	7.8	9.1
TOTAL U.S. REVENUES	9.0	9.7	9.9	11.1	9.2	10.6	9.0	10.5	9.1	10.8
Non-U.S. Manufacturers										
Captive	--	2.0	--	2.4	--	2.8	--	3.0	--	3.2
PCM/Reseller	3.2	7.9	4.0	7.3	4.7	8.3	5.3	9.3	5.9	10.3
OEM/Integrator	16.9	28.3	19.9	31.5	24.5	36.4	26.4	38.9	28.0	41.9
TOTAL NON-U.S. REVENUES	20.1	38.2	23.9	41.2	29.2	47.5	31.7	51.2	33.9	55.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	29.1	47.9	33.8	52.3	38.4	58.1	40.7	61.7	43.0	66.2
OEM Average Price ($000)		16.6		15.5		14.5		13.5		13.3

TABLE 48

OPTICAL LIBRARIES, 40-69 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1993 Shipments		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	10	10	12	12	14	14	16	16	18	18
PCM/Reseller	45	71	80	112	103	142	124	168	145	202
OEM/Integrator	490	513	580	632	626	701	698	802	775	908
TOTAL U.S. SHIPMENTS	545	594	672	756	743	857	838	986	938	1,128
Non-U.S. Manufacturers										
Captive	--	93	--	100	--	112	--	116	--	122
PCM/Reseller	175	435	260	475	311	549	363	636	422	736
OEM/Integrator	1,004	1,715	1,293	2,036	1,634	2,429	1,891	2,736	2,017	2,940
TOTAL NON-U.S. SHIPMENTS	1,179	2,243	1,553	2,611	1,945	3,090	2,254	3,488	2,439	3,798
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,724	2,837	2,225	3,367	2,688	3,947	3,092	4,474	3,377	4,926
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	4	9	7	13	9	16	12	21	16	26

TABLE 49

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	--	.2	--	.2	--	.2	--	.3	--	.3
PCM/Reseller	--	.8	--	1.1	--	1.3	--	1.4	--	1.4
OEM/Integrator	--	8.7	--	9.8	--	9.1	--	8.8	--	9.1
TOTAL U.S. REVENUES	--	9.7	--	11.1	--	10.6	--	10.5	--	10.8
NON-U.S. MANUFACTURERS										
Captive	.2	1.8	.3	2.1	.4	2.4	.5	2.5	.6	2.6
PCM/Reseller	--	7.9	--	7.3	--	8.3	--	9.3	--	10.3
OEM/Integrator	9.3	19.0	11.7	19.8	13.2	23.2	14.2	24.7	15.6	26.3
TOTAL NON-U.S. REVENUES	9.5	28.7	12.0	29.2	13.6	33.9	14.7	36.5	16.2	39.2
WORLDWIDE RECAP										
Captive	.2	2.0	.3	2.3	.4	2.6	.5	2.8	.6	2.9
	-94.4%	-77.3%	+50.0%	+15.0%	+33.3%	+13.0%	+25.0%	+7.7%	+20.0%	+3.6%
PCM/Reseller	--	8.7	--	8.4	--	9.6	--	10.7	--	11.7
	--	+47.5%	--	-3.4%	--	+14.3%	--	+11.5%	--	+9.3%
OEM/Integrator	9.3	27.7	11.7	29.6	13.2	32.3	14.2	33.5	15.6	35.4
	+3.3%	-25.9%	+25.8%	+6.9%	+12.8%	+9.1%	+7.6%	+3.7%	+9.9%	+5.7%
Total Revenues	9.5	38.4	12.0	40.3	13.6	44.5	14.7	47.0	16.2	50.0
	-24.6%	-26.3%	+26.3%	+4.9%	+13.3%	+10.4%	+8.1%	+5.6%	+10.2%	+6.4%
ANNUAL SHARE, BY DIAMETER	19.8%	80.2%	22.9%	77.1%	23.4%	76.6%	23.8%	76.2%	24.5%	75.5%

Note: 12" libraries includes 14" libraries.

TABLE 50

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	--	10	--	12	--	14	--	16	--	18
PCM/Reseller	--	71	--	112	--	142	--	168	--	202
OEM/Integrator	--	513	--	632	--	701	--	802	--	908
TOTAL U.S. SHIPMENTS	--	594	--	756	--	857	--	986	--	1,128
NON-U.S. MANUFACTURERS										
Captive	4	89	5	95	6	106	8	108	10	112
PCM/Reseller	--	435	--	475	--	549	--	636	--	736
OEM/Integrator	234	1,481	261	1,775	293	2,136	323	2,413	355	2,585
TOTAL NON-U.S. SHIPMENTS	238	2,005	266	2,345	299	2,791	331	3,157	365	3,433
WORLDWIDE RECAP										
Captive	4	99	5	107	6	120	8	124	10	130
	-93.3%	-59.3%	+25.0%	+8.1%	+20.0%	+12.1%	+33.3%	+3.3%	+25.0%	+4.8%
PCM/Reseller	--	506	--	587	--	691	--	804	--	938
	--	+99.2%	--	+16.0%	--	+17.7%	--	+16.4%	--	+16.7%
OEM/Integrator	234	1,994	261	2,407	293	2,837	323	3,215	355	3,493
	+4.0%	+6.7%	+11.5%	+20.7%	+12.3%	+17.9%	+10.2%	+13.3%	+9.9%	+8.6%
Total Shipments	238	2,599	266	3,101	299	3,648	331	4,143	365	4,561
	-16.5%	+9.8%	+11.8%	+19.3%	+12.4%	+17.6%	+10.7%	+13.6%	+10.3%	+10.1%
ANNUAL SHARE, BY DIAMETER	8.4%	91.6%	7.9%	92.1%	7.6%	92.4%	7.4%	92.6%	7.4%	92.6%

Note: 12" libraries includes 14" libraries.

TABLE 51

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1993 --Shipments--		Forecast -----1994----		-----1995----		-----1996----		-----1997----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	10.0		12.0		14.0		16.0		18.0	
Rewritable	10.0	100.0%	12.0	100.0%	14.0	100.0%	16.0	100.0%	18.0	100.0%
OEM/PCM Total	584.0		744.0		843.0		970.0		1,110.0	
Rewritable	584.0	100.0%	744.0	100.0%	843.0	100.0%	970.0	100.0%	1,110.0	100.0%
Total U.S.	594.0		756.0		857.0		986.0		1,128.0	
Rewritable	594.0	100.0%	756.0	100.0%	857.0	100.0%	986.0	100.0%	1,128.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	93.0		100.0		112.0		116.0		122.0	
Write-Once	91.0	97.9%	85.0	85.1%	81.0	72.4%	78.0	67.3%	75.0	61.6%
Rewritable	2.0	2.1%	15.0	14.9%	31.0	27.6%	38.0	32.7%	47.0	38.4%
OEM/PCM Total	2,150.0		2,511.0		2,978.0		3,372.0		3,676.0	
Write-Once	244.0	11.3%	291.0	11.6%	339.0	11.4%	356.0	10.6%	380.0	10.3%
Rewritable	1,906.0	88.7%	2,220.0	88.4%	2,639.0	88.6%	3,016.0	89.4%	3,296.0	89.7%
Total Non-U.S.	2,243.0		2,611.0		3,090.0		3,488.0		3,798.0	
Write-Once	335.0	14.9%	376.0	14.4%	420.0	13.6%	434.0	12.4%	455.0	12.0%
Rewritable	1,908.0	85.1%	2,235.0	85.6%	2,670.0	86.4%	3,054.0	87.6%	3,343.0	88.0%
WORLDWIDE RECAP										
Total Worldwide Shipments	2,837.0		3,367.0		3,947.0		4,474.0		4,926.0	
	+7.0%		+18.6%		+17.2%		+13.3%		+10.1%	
Write-Once	335.0	11.8%	376.0	11.2%	420.0	10.6%	434.0	9.7%	455.0	9.2%
	-56.3%		+12.2%		+11.7%		+3.3%		+4.8%	
Rewritable	2,502.0	88.2%	2,991.0	88.8%	3,527.0	89.4%	4,040.0	90.3%	4,471.0	90.8%
	+32.8%		+19.5%		+17.9%		+14.5%		+10.6%	

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

READ/WRITE OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

1994 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 (5.25")
Document Imaging Systems	D75-1, D255-1, D510-2, D1050-2
DSM	5100, 6300
Fujitsu	F6445/A1, F6445/A2, F6445/A2X2
Hewlett-Packard	C1705T, C1709T
IBM	3995-142, 3995-133
K&S	Megastore
NKK	N-5160ET, N-5160MP, N-5160MS
Sigma Designs	DP 520

12" and 14" disk diameter

ATG Cygnet	1800
Borett Automation Technology	VLC (12")
Eastman Kodak	6800 ADL, 2000 ADL
FileNet	OSAR models 151, 170, Model 0150
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 ATG 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

In 1993, unit shipments increased to 1,830 units, a 38.8% increase. Both 12" and 5.25" libraries had healthy growth, but 5.25" systems grew faster and captured 72.4% of the units shipped. Shipments of 5.25" units grew 40.8%, while shipments of 12" units rose almost 34%. Worldwide revenues in 1993 declined to $79.8 million, a decline reflecting lowering prices intended to stimulate a weakening world market and an increasing PCM/Reseller market segment with its lower prices. 76.9% of this product group's revenues were generated from sales in the U.S., and 71.9% of worldwide revenues were generated by U.S. manufacturers, still the highest U.S. manufacturer revenue percentage among the library product groups, but down considerably from 1992. Much of this shift reflects the change in classification of Cygnet from U.S. to non-U.S. as a result of its acquisition by ATG Gigadisc.

Hewlett-Packard repeated as the shipment leader for the group in 1993, followed distantly by ATG Cygnet. IBM, which uses Hewlett-Packard mechanisms in its library products was a substantial market presence. Had IBM been manufacturing its own library mechanisms, it would have been the second largest manufacturer of libraries in this group. IBM's use of 5.25" drives 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.

69.7% of 1993 shipments went through the OEM/Integrator channel, about the same as in 1992. Captive shipments dropped to 17.3%, while PCM/Reseller activity for the libraries in this group increased to account for 13% of shipments. 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 in the 5.25" optical library segment, is from NKK, which began shipments in 1992 in this group, and from ATG Cygnet in the 12" segment.

It is likely that the number of competitors in this product group will gradually increase as makers of smaller systems gain experience and scale up. The new entrants are most likely to specialize in libraries handling 5.25" disk cartridges. Newcomers may find the system integration and support activities that must be mastered in this product group a larger challenge than expected.

Marketing trends

1997 shipments of 3,782 units are expected 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 1997.

Total 1997 revenue is expected to exceed $146 million, with 69.7% expected 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 fluctuate throughout the forecast period, reflecting the increasing presence of the less expensive 5.25" systems in the product group versus an expected trend to more expensive 12" systems.

12" libraries should be able to retain 19.2% of the unit shipments in 1997, but will account for 47.3% of 1997 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 72.2% in 1993 to 80.6% in 1997. Most of the rewritable drives will be 5.25" diameter drives, but Nikon's rewritable 12" drives are also available for libraries in this product group.

By the end of 1997, the vast majority of libraries in this group will be attached to network servers or mainframes acting in that role.

Applications

Financial and government institutions are, and will remain, the major users of optical disk drive libraries in this product group. It is possible that towards the end of the forecast period, optical disk drive 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 support for the 3995 as a virtual 3390 disk subsystem under System Managed Storage increased 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. About four fifths of the model 3995 libraries in this product group are attached to mainframes.

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 Imaging Systems 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, 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, Sigma Designs, 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.

TABLE 52

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	20.5	25.6	19.8	26.1	21.3	27.5	21.6	28.1	22.0	29.4
PCM/Reseller	4.7	5.7	6.2	7.7	9.2	11.1	10.6	12.9	12.0	14.7
OEM/Integrator	21.5	26.1	25.1	31.6	28.4	36.4	32.1	42.2	36.1	48.8
TOTAL U.S. REVENUES	46.7	57.4	51.1	65.4	58.9	75.0	64.3	83.2	70.1	92.9
Non-U.S. Manufacturers										
Captive	--	.8	--	1.3	--	1.9	--	2.5	--	3.1
PCM/Reseller	1.5	2.4	2.2	3.3	2.8	4.1	3.7	5.3	4.5	6.4
OEM/Integrator	13.2	19.2	16.6	25.1	19.2	30.1	23.5	37.3	27.3	43.7
TOTAL NON-U.S. REVENUES	14.7	22.4	18.8	29.7	22.0	36.1	27.2	45.1	31.8	53.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	61.4	79.8	69.9	95.1	80.9	111.1	91.5	128.3	101.9	146.1
OEM Average Price ($000)		35.5		35.1		35.0		35.7		36.1

TABLE 53

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1993 Shipments		Forecast							
			1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	239	302	240	322	270	353	285	385	304	425
PCM/Reseller	142	174	193	242	294	357	349	428	409	507
OEM/Integrator	749	936	926	1,187	1,101	1,383	1,233	1,587	1,396	1,845
TOTAL U.S. SHIPMENTS	1,130	1,412	1,359	1,751	1,665	2,093	1,867	2,400	2,109	2,777
Non-U.S. Manufacturers										
Captive	--	14	--	23	--	33	--	44	--	56
PCM/Reseller	39	65	64	105	85	133	124	189	153	232
OEM/Integrator	226	339	283	430	325	515	400	639	442	717
TOTAL NON-U.S. SHIPMENTS	265	418	347	558	410	681	524	872	595	1,005
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,395	1,830	1,706	2,309	2,075	2,774	2,391	3,272	2,704	3,782
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	3	4	4	6	7	9	9	12	12	16

TABLE 54

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	16.1	9.5	15.2	10.9	14.4	13.1	13.1	15.0	12.5	16.9
PCM/Reseller	.2	5.5	.3	7.4	.5	10.6	.6	12.3	.7	14.0
OEM/Integrator	7.2	18.9	9.1	22.5	10.7	25.7	12.7	29.5	14.5	34.3
TOTAL U.S. REVENUES	23.5	33.9	24.6	40.8	25.6	49.4	26.4	56.8	27.7	65.2
NON-U.S. MANUFACTURERS										
Captive	--	.8	--	1.3	--	1.9	--	2.5	--	3.1
PCM/Reseller	.7	1.7	.9	2.4	1.3	2.8	1.6	3.7	2.0	4.4
OEM/Integrator	17.9	1.3	23.2	1.9	27.4	2.7	33.2	4.1	39.4	4.3
TOTAL NON-U.S. REVENUES	18.6	3.8	24.1	5.6	28.7	7.4	34.8	10.3	41.4	11.8
WORLDWIDE RECAP										
Captive	16.1	10.3	15.2	12.2	14.4	15.0	13.1	17.5	12.5	20.0
	-34.0%	+27.2%	-5.6%	+18.4%	-5.3%	+23.0%	-9.0%	+16.7%	-4.6%	+14.3%
PCM/Reseller	.9	7.2	1.2	9.8	1.8	13.4	2.2	16.0	2.7	18.4
	--	-5.3%	+33.3%	+36.1%	+50.0%	+36.7%	+22.2%	+19.4%	+22.7%	+15.0%
OEM/Integrator	25.1	20.2	32.3	24.4	38.1	28.4	45.9	33.6	53.9	38.6
	+50.3%	-35.7%	+28.7%	+20.8%	+18.0%	+16.4%	+20.5%	+18.3%	+17.4%	+14.9%
Total Revenues	42.1	37.7	48.7	46.4	54.3	56.8	61.2	67.1	69.1	77.0
	+2.4%	-20.0%	+15.7%	+23.1%	+11.5%	+22.4%	+12.7%	+18.1%	+12.9%	+14.8%
ANNUAL SHARE, BY DIAMETER	52.9%	47.1%	51.3%	48.7%	48.9%	51.1%	47.7%	52.3%	47.3%	52.7%

Note: 12" libraries include 14" libraries.

TABLE 55

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments		Forecast 1994		Forecast 1995		Forecast 1996		Forecast 1997	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	138	164	127	195	115	238	103	282	94	331
PCM/Reseller	2	172	3	239	4	353	5	423	6	501
OEM/Integrator	78	858	93	1,094	108	1,275	124	1,463	138	1,707
TOTAL U.S. SHIPMENTS	218	1,194	223	1,528	227	1,866	232	2,168	238	2,539
NON-U.S. MANUFACTURERS										
Captive	--	14	--	23	--	33	--	44	--	56
PCM/Reseller	10	55	14	91	18	115	21	168	25	207
OEM/Integrator	277	62	331	99	365	150	414	225	464	253
TOTAL NON-U.S. SHIPMENTS	287	131	345	213	383	298	435	437	489	516
WORLDWIDE RECAP										
Captive	138	178	127	218	115	271	103	326	94	387
	-4.8%	+69.5%	-8.0%	+22.5%	-9.4%	+24.3%	-10.4%	+20.3%	-8.7%	+18.7%
PCM/Reseller	12	227	17	330	22	468	26	591	31	708
	--	+59.9%	+41.7%	+45.4%	+29.4%	+41.8%	+18.2%	+26.3%	+19.2%	+19.8%
OEM/Integrator	355	920	424	1,193	473	1,425	538	1,688	602	1,960
	+53.0%	+32.6%	+19.4%	+29.7%	+11.6%	+19.4%	+13.7%	+18.5%	+11.9%	+16.1%
Total Shipments	505	1,325	568	1,741	610	2,164	667	2,605	727	3,055
	+34.0%	+40.8%	+12.5%	+31.4%	+7.4%	+24.3%	+9.3%	+20.4%	+9.0%	+17.3%
ANNUAL SHARE, BY DIAMETER	27.6%	72.4%	24.6%	75.4%	22.0%	78.0%	20.4%	79.6%	19.2%	80.8%

Note: 12" libraries include 14" libraries.

TABLE 56

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1993 --Shipments--		Forecast -----1994----		-----1995----		-----1996----		-----1997----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	302.0		322.0		353.0		385.0		425.0	
Write-Once	138.0	45.7%	127.0	39.4%	115.0	32.6%	103.0	26.8%	94.0	22.1%
Rewritable	164.0	54.3%	195.0	60.6%	238.0	67.4%	282.0	73.2%	331.0	77.9%
OEM/PCM Total	1,110.0		1,429.0		1,740.0		2,015.0		2,352.0	
Write-Once	83.0	7.5%	99.0	6.9%	116.0	6.7%	134.0	6.7%	149.0	6.3%
Rewritable	1,027.0	92.5%	1,330.0	93.1%	1,624.0	93.3%	1,881.0	93.3%	2,203.0	93.7%
Total U.S.	1,412.0		1,751.0		2,093.0		2,400.0		2,777.0	
Write-Once	221.0	15.7%	226.0	12.9%	231.0	11.0%	237.0	9.9%	243.0	8.8%
Rewritable	1,191.0	84.3%	1,525.0	87.1%	1,862.0	89.0%	2,163.0	90.1%	2,534.0	91.2%
NON-U.S. MANUFACTURERS										
Captive Total	14.0		23.0		33.0		44.0		56.0	
Rewritable	14.0	100.0%	23.0	100.0%	33.0	100.0%	44.0	100.0%	56.0	100.0%
OEM/PCM Total	404.0		535.0		648.0		828.0		949.0	
Write-Once	287.0	71.1%	345.0	64.6%	383.0	59.2%	435.0	52.6%	489.0	51.6%
Rewritable	117.0	28.9%	190.0	35.4%	265.0	40.8%	393.0	47.4%	460.0	48.4%
Total Non-U.S.	418.0		558.0		681.0		872.0		1,005.0	
Write-Once	287.0	68.8%	345.0	61.9%	383.0	56.3%	435.0	49.9%	489.0	48.7%
Rewritable	131.0	31.2%	213.0	38.1%	298.0	43.7%	437.0	50.1%	516.0	51.3%
WORLDWIDE RECAP										
Total Worldwide Shipments	1,830.0		2,309.0		2,774.0		3,272.0		3,782.0	
	+38.8%		+26.1%		+20.1%		+17.9%		+15.5%	
Write-Once	508.0	27.8%	571.0	24.7%	614.0	22.1%	672.0	20.5%	732.0	19.4%
	+34.0%		+12.4%		+7.5%		+9.4%		+8.9%	
Rewritable	1,322.0	72.2%	1,738.0	75.3%	2,160.0	77.9%	2,600.0	79.5%	3,050.0	80.6%
	+40.7%		+31.4%		+24.2%		+20.3%		+17.3%	

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

OPTICAL DISK DRIVE SPECIFICATIONS

1994 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/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 unless otherwise stated.

Rotational speed: If more than one speed range exists, as for CD-ROM drives, only the highest performance range is given.

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. When 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.

1994 DISK/TREND optical disk product groups

For the 1994 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 specification section following this one for optical library data.

MANUFACTURER	AIWA	ALCO DIGITAL DEVICES	ALCO DIGITAL DEVICES	ALPS ELECTRIC	ASACA
DRIVE	ACD-300	CDR 931	CDR 938	DC52	AMD-1341NS
DISK/TREND GROUP	10	10	10	10	11
MARKET	PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Rewritable-(MO)
Interface	Various			IDE/ATAPI	SCSI-2
Speed control	CLV	CLV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 598
Capacity per track (Bytes)	F: N/A	N/A	N/A	N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20800
Track density (TPI)	15875	15875	15875	15875	16933
Maximum linear density (BPI)	27600	27600	27600	27600	34795
Rotational speed (RPM)	1060-400	530-200	1060-400	1000-400	3000
PERFORMANCE					
Positioner type	Crs: Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Dual Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	275	890	325		160
Average rotational delay (msec)	55	110	55		10
Average access time (msec)	330	1000	380	320	170
Data transfer rate (KBytes/sec)	300	150	300	307.2	12240/10000*
SIZE (mm: H x W x D)	63.2 x 175 x 296			41.5 x 146.3 x 191	430 x 312 x 600
FIRST CUSTOMER SHIPMENT	1994	1993	1994	3Q94	3/93
COMMENTS	External mount	Top loading Purchased mechanism	MPC-2 compliant Tray loading Purchased mechanism		Proprietary format *Maximum SCSI rate

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
DRIVE	GD 1002	GD 6000	GD 6001	GD 9001	GD 9001/S
DISK/TREND GROUP	12	12	12	12	12
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	300 mm	300 mm	300 mm	300 mm	300 mm
Recording medium	Au-Cr-Polymer	Au-Cr-Polymer	Au-Cr-Polymer	Au-Cr-Polymer	Au-Cr-Polymer
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Write Once	Write Once	Write Once	Write Once
Interface	SCSI	SCSI	SCSI	SCSI, SCSI-2	SCSI, SCSI-2
Speed control	CAV	CAV	CAV	MCAV	MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 1,000	F: 3,200	F: 3,200	F: 4,500	F: 5,100
Capacity per track (Bytes)	F: 25,600	F: 52,428	F: 52,428	*	*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	40000	62500	62500	82000	82000
Track density (TPI)	15200	25400	25400	25400	25400
Maximum linear density (BPI)	14514	28200	28200	25400	25400
Rotational speed (RPM)	1121.5	1143	1143	914	914
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.	Crs: Linear Motor Fine: Galvonom.
Servo type	Sampled	Sampled	Sampled	Sampled	Sampled
Average positioning time (msec)	110	90	90	90	90
Average rotational delay (msec)	26.7	26.2	26.2	33	33
Average access time (msec)	136.7	116.2	116.2	123	123
Data transfer rate (KBytes/sec)	480	1000	1000	1000	1000
SIZE (mm: H x W x D)	174 x 440 x 530	174 x 440 x 530	174 x 440 x 530	177 x 482 x 532.5	177 x 482 x 532.5
FIRST CUSTOMER SHIPMENT	2Q88	3Q89	4Q90	1991	2Q92
COMMENTS			Differs from GD 6000 in the cartridge (single operation loading)	*Varies by zone Can read GD 6000 disks	*Varies by zone Can read GD 6000 disks and read/write GD 9001

MANUFACTURER	AZTECH SYSTEMS	AZTECH SYSTEMS	BEHAVIOR TECH COMPUTER	CANON	CANON
DRIVE	CDA 268-01A Zeta	CDA 268-031	CDD-110	MO-5001S	OM-500D
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	130 mm	130 mm
Recording medium	Aluminum	Aluminum	Aluminum	Tb-Fe-Co	Bilayer RE-TM
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Rewritable-(MO)	Rewritable-(MO)
Interface	PC AT	IDE	Sony CDU 31A	SCSI	Modified ESDI
Speed control	CLV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	F: 256	F: 256
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 16,384	F: 16,384
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	15728	15728
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	21082	21082
Rotational speed (RPM)	1060-400	1060-400	1060-400	3000	3000
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: DC Motor 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)	350	350	335	80	80
Average rotational delay (msec)	55	55	55	10	10
Average access time (msec)	405	405	380	90	90
Data transfer rate (KBytes/sec)	307.2	307.2	307.2	1138	1138
SIZE (mm: H x W x D)	41.3 x 146.1 x 201	41.3 x 146.1 x 201	41.5 x 146 x 208	137 x 185 x 365	82.6 x 146.1 x 203
FIRST CUSTOMER SHIPMENT	1Q94	2Q94	3Q94	3/90	4Q88
COMMENTS	Photo CD. MPC-2 compliant Multisession. Tray loading. Audio output.	Photo CD. MPC-2 compliant Multisession. Tray loading. Audio output.	64 KB buffer. MPC-2 compliant Multisession. Tray loading. Wearnes mechanism.	SCSI controller available. Exchange coupled MO media. External mount	SCSI controller available Exchange coupled MO media

MANUFACTURER	CD-ROM, INC.	CD-ROM, INC.	CD-ROM, INC.	CD-ROM, INC.	CHINON
DRIVE	CRI 100/SCSIi	CRI 1100/ATe	CRI 1100/ATi	CRI 1100/SCSIe	CDA-435 CDC-435 CDS-435 CDX-435
DISK/TREND GROUP	10	10	10	10	10
MARKET	PCM	PCM	PCM	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
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	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)	1060-400	1060-400	1060-400	1060-400	200-530
PERFORMANCE					
Positioner type	Crs: Lead Screw Fine: Lens Actuator	Crs: Lead Screw Fine: Lens Actuator	Crs: Lead Screw Fine: Lens Actuator	Crs: Lead Screw Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	365	365	365	365	240
Average rotational delay (msec)	110	110	110	110	110
Average access time (msec)	475	475	475	475	350
Data transfer rate (KBytes/sec)	307	307	307	307	153.6
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2		41.3 x 146.1 x 203.2		41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1994	1994	1994	1994	1Q92
COMMENTS	64 KB buffer	64 KB buffer External mount		64 KB buffer External mount	64 KB buffer Motorized loading

MANUFACTURER	CHINON	CHINON	CHINON	CHINON	CHINON
DRIVE	CDA-535 CDC-535 CDS-535 CDX-535	CDS-525I	CDS-525S	CDS-545	MO300 MOA300 MOD300 MOX300
DISK/TREND GROUP	10	10	10	10	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	86 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	RE-TM Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Rewritable-(MO)
Interface	SCSI-2	IDE/ATAPI	SCSI-2	SCSI-2	SCSI-2
Speed control	CLV	CLV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 650	F: 650	F: 650	F: 128
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F:
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	10000
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	24440
Rotational speed (RPM)	400-1060	200-1060	200-1060	200-2120	3000
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)	165	265	265	293	45
Average rotational delay (msec)	55	55	55	27	10
Average access time (msec)	220	320	320	320	55
Data transfer rate (KBytes/sec)	307.2	307.2	307.2	614.4	625
SIZE (mm: H x W x D)	41.3 x 146.1 x 202.2	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q93	2Q94	2Q94	4Q94	1Q93
COMMENTS	256 KB buffer. Multisession. CDA is for Mac. CDX is external mount	64 KB buffer Multisession	64 KB buffer Multisession	64 KB buffer Multisession	256 KB buffer

MANUFACTURER	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	ELITEGROUP COMPUTER SYSTEMS
DRIVE	PCD Writer 600	PCD Writer 200 PCD Writer 200+ PCD Writer 225	6800	System 2000	VERTOS 100
DISK/TREND GROUP	11	11	12	12	10
MARKET	OEM, PCM	OEM, PCM	Captive, OEM	Captive, OEM	PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	356 mm	356 mm	120 mm/80 mm
Recording medium	Dye Polymer	Dye Polymer	Phase Change	Phase Change	Aluminum
Track format	Spiral	Spiral	Spiral (Zone)	Spiral (5 zone)	Spiral
DRIVE: Operating mode	Write Once	Write Once	Write Once	Write Once	Read Only
Interface	SCSI	SCSI	SCSI	SCSI	Prop. PC AT
Speed control	CLV	CLV	MCAV	MCAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680/780	F: 600	F: 5,100	F: 13,000	F: 660
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	87354		20750
Track density (TPI)	15875	15875	21160	25400	15875
Maximum linear density (BPI)	27600	27600	21000	25000	27600
Rotational speed (RPM)	3000-1200	1000-400	1632-786	1632-786	1060-400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Sampled	Sampled	Continuous
Average positioning time (msec)	978	945	500	500	295
Average rotational delay (msec)	18.3	55	27	28	55
Average access time (msec)	1000	1000	527	527	350
Data transfer rate (KBytes/sec)	921.6	307.2	1000	1000	300
SIZE (mm: H x W x D)	118 x 420 x 334	118 x 420 x 334	800 x 455 x 714*	800 x 455 x 714*	41.3 x 146.1 x 208
FIRST CUSTOMER SHIPMENT	2Q94		4Q88	3Q94	1Q94
COMMENTS	75 disk loader option 1 MB buffer, 8 MB option. Tray loading	256 KB buffer Tray loading	*Includes the controller	*Includes controller Preliminary specification	64 KB buffer. MPC-2 compliant Multisession. Tray loading. Matsushita mechanism.

MANUFACTURER	ELITEGROUP COMPUTER SYSTEMS	ELITEGROUP COMPUTER SYSTEMS	ELITEGROUP COMPUTER SYSTEMS	FUJITSU	FUJITSU
DRIVE	VERTOS 200	VERTOS 300SSA	VERTOS 300SSD	M2507B	M2511A DynaMO 128
DISK/TREND GROUP	10	10	10	11	11
MARKET	PCM	PCM	PCM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	130 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	SCSI-2	Prop. PC AT	IDE/ATAPI	SCSI-2	SCSI-2
Speed control	CLV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 660	F: 660	F: 660	F: 326.4	F: 128
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 17,408	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	18751	10000
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	24923	24400
Rotational speed (RPM)	1060-400	1060-400	1060-400	5400	3600
PERFORMANCE					
Positioner type	Crs: Stepping Motor 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	Continuous
Average positioning time (msec)	295	295	295	35	30
Average rotational delay (msec)	55	55	55	5.6	8.3
Average access time (msec)	350	350	350	40.6	38.3
Data transfer rate (KBytes/sec)	300	300	300	2080 4100 synch.	1090 4000 synch.
SIZE (mm: H x W x D)	41.3 x 146.1 x 208	41.3 x 146 x 208	41.3 x 146 x 208	82 x 146.1 x 208	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q94	3Q94	3Q94	6/92	1992
COMMENTS	64 KB buffer. MPC-2 compliant Multisession. Tray loading. Matsushita mechanism.	256 KB buffer. MPC-2 compliant Multisession. Tray loading. Sony mechanism.	256 KB buffer. MPC-2 compliant Multisession. Tray loading. Sony mechanism.	Direct overwrite, 3 beam head. Sold in Japan	256 KB read cache DynaMO is external subsystem

MANUFACTURER	FUJITSU	FUNAI ELECTRIC	FUNAI ELECTRIC	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.
DRIVE	M2512A DynaMO	E2450UA	PL1345	CD-i Portable	GCD-R320B
DISK/TREND GROUP	11	10	10	10	10
MARKET	OEM, PCM	OEM	OEM	PCM	OEM, PCM
MEDIA: Nominal disk diameter	86 mm	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm/80 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-2	Sony CXD 1186	IDE	Serial	SCSI-2
Speed control	CAV/ZCAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128/230	F: 540	F: 540	F: 680	F: 680
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	1000/17940	20750	20750	20750	20750
Track density (TPI)	15875/18273	15875	15875	15875	15875
Maximum linear density (BPI)	24400/29296	27600	27600	27600	27600
Rotational speed (RPM)	3600	1000-400	1000-400	1060-400	1060-400
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)	35	320	320	800	250
Average rotational delay (msec)	8.3	55	55	110	55
Average access time (msec)	43.3	375	375	910	305
Data transfer rate (KBytes/sec)	1300-2100 5000 synch.	307.2	307.2	330	300
SIZE (mm: H x W x D)	25.4 x 101.6 x 146	41.3 x 146.1 x 193	41.3 x 146.1 x 193	68.5 x 185.4 x 160	41.3 x 146.1 x 180
FIRST CUSTOMER SHIPMENT	3/94	4Q93	9/94	1994	1Q94
COMMENTS	256 KB read/write cache DynaMO is external subsystem	64 KB buffer. Photo CD. MPC-2 compliant Multisession. Spin up:2.5 sec	256 KB buffer. Photo CD. MPC-2 compliant Multisession. Spin up:2.5 sec		Photo CD. Multisession. MPC-2 compliant Tray loading.

MANUFACTURER	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.	GROUP SENSE	GROUP SENSE	GROUP SENSE
DRIVE	GCD-R420B	GDI-11	CDAT-300I	CDAT-301A	CDSI-100X CDAT-300X
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	PCM
MEDIA: Nominal disk diameter	120 mm/80 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	PC AT	Serial	Sony	Sony	PC AT
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680	F: 680	F: 630	F: 630	F: 630
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: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	250	800	595	245	745
Average rotational delay (msec)	55	110	55	55	55
Average access time (msec)	305	910	650	300	800
Data transfer rate (KBytes/sec)	300	330	300	300	300
SIZE (mm: H x W x D)	41.3 x 146.1 x 180	90 x 430 x 380	42.2 x 148 x 214	42.2 x 148 x 214	46.5 x 202 x 144.5
FIRST CUSTOMER SHIPMENT	1Q94	1994	6/94	1994	7/94
COMMENTS	Photo CD. Multisession. MPC-2 compliant Tray loading.	CD-I player	64 KB buffer. MPC-2 compliant Multisession. Tray loading. Purchased mechanism.	64 KB buffer. MPC-2 compliant Multisession. Tray loading. Purchased mechanism.	64 KB buffer. MPC-2 compliant Multisession. Top loading. Purchased mechanism.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI
DRIVE	C1716T	C2550A Model 1300T	CDR 1900S	CDR 1950S	CDR 5150
DISK/TREND GROUP	11	11	10	10	10
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co	Tb-Fe-Co	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MF)	Rewritable-(MF)	Read Only	Read Only	Read Only
Interface	SCSI-2	SCSI-2	Proprietary	SCSI	SCSI-2
Speed control	CAV	CAV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 650	F: 682	F: 682	F: 682
Capacity per track (Bytes)	F: 17,408	F: 17,408	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	21600*	20750	20750	20750
Track density (TPI)	18273	18273	15875	15875	15875
Maximum linear density (BPI)	29540	29540	27600	27600	27600
Rotational speed (RPM)	2400	2400	1060-400	1060-400	530-200
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: NS	Crs: Linear, Voice Coil Fine: NS	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	23.5	190	190	300
Average rotational delay (msec)	12.5	12.5	55	55	110
Average access time (msec)	36	36	245	245	410
Data transfer rate (KBytes/sec)	5000 synch. 1600 asynch.	5000 synch. 1600 asynch.	307.2	307.2 5000 synch.	153.6
SIZE (mm: H x W x D)	82.5 x 146.1 x 203.2	146.1 x 174 x 280	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	65 x 360 x 360
FIRST CUSTOMER SHIPMENT	2Q93	2Q93	1Q93	1Q94	3Q92
COMMENTS	MO-WORM. DSP servo. Backward compat *37600 logical tracks. 512 KB buffer.	External version of C1716T *37600 logical tracks	Photo CD Multisession MPC-2 compliant	Photo CD Multisession MPC-2 compliant	Can expand compressed data Internal Kanji ROM

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	CDR 6700	CDR 6750	OD 101-1	OD 112-1	OD 152 OU 152
DISK/TREND GROUP	10	10	11	11	12
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive, OEM	Captive, OEM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	130 mm
Recording medium	Aluminum	Aluminum	Te Alloy	Tb-Fe-Co	RE-TM Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Write Once	Rewritable-(MO)	Rewritable-(MF)
Interface	Proprietary	SCSI	SCSI	SCSI	SCSI-2
Speed control	CLV	CLV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 682	F: 300	F: 322	F: 1,012
Capacity per track (Bytes)	F: N/A	F: N/A	F: 16,400	F: 17,408	*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	18624	18751	22440
Track density (TPI)	15875	15875	16000	16000	18947
Maximum linear density (BPI)	27600	27600	24000	24000	45340
Rotational speed (RPM)	1060-400	1060-400	1800	2400	3000
PERFORMANCE					
Positioner type	Crs: Linear Motor Fine: Lens Actuator	Crs: Linear Motor Fine: Lens Actuator	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	190	190	93	62.5	40
Average rotational delay (msec)	55	55	16.7	12.5	10
Average access time (msec)	245	245	109.7	75	50
Data transfer rate (KBytes/sec)	307.2 1000 asynch.	307.2 5000 asynch.	690	925	1540-3020
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	83 x 146.1 x 213	107 x 146.1 x 220	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	2Q87	7/89	4Q93
COMMENTS	Photo CD Multisession MPC-2 compliant	Photo CD Multisession MPC-2 compliant		ISO standard	OU 152 is external *Varies by zone 1,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HONEYWELL	HOPAX INDUSTRIES
DRIVE	OD 301A-1	OD 321-1 OD 321-2	OL F152	AN/MU-928	520/E
DISK/TREND GROUP	12	12	12	11	10
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	300 mm	300 mm	130 mm	130 mm	120 mm
Recording medium	Te Alloy	Te Alloy	RE-TM Alloy	Te Alloy	Aluminum
Track format	Spiral	Spiral	Spiral	Concentric	Spiral
DRIVE: Operating mode	Write Once	Write Once	Rewritable-(MF)	Write Once	Read Only
Interface	SCSI, GPIB, SMD	SCSI	SCSI-2	Modified SCSI	IDE
Speed control	CAV	MCAV	ZCAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 1,310	F: 3,500	F: 1,012	F: 260	F: 635 Mode 2 553 Mode 1
Capacity per track (Bytes)	F: 31,700	F: N/A	*	F: 20,480	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	41300	48035	22440	12695	20750
Track density (TPI)	16000	17000	18947	NS	15875
Maximum linear density (BPI)	19500	33200	45340	NS	27600
Rotational speed (RPM)	600	1000	3000	1800	1060-400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Stepping Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Sector	Continuous
Average positioning time (msec)	200	120	40	125	245
Average rotational delay (msec)	50	30	10	17	55
Average access time (msec)	250	150	50	142	300
Data transfer rate (KBytes/sec)	440	1160-2220	1540-3020	562	302
SIZE (mm: H x W x D)	160 x 380 x 650	160 x 430 x 660	82.3 x 146.1 x 203.2		41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	3Q85	1Q91	1Q94	2Q89	3Q94
COMMENTS		Pit edge recording. Glass substrate 321-2 used in libraries	For Hitachi libraries *Varies by zone	Embedded controller Militarized	64 KB buffer. MPC-2 compliant Photo CD. Tray loading. Purchased mechanism.

MANUFACTURER	HOPAX INDUSTRIES	IBM	IBM	IBM	IBM
DRIVE	520A/AI	0632-C1X	0632-C2X MCC51300	0632-CBX	0632-CHA 0632-CHX
DISK/TREND GROUP	10	11	11	11	11
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Aluminum	RE-TM Alloy	RE-TM Alloy	*	RE-TM Alloy
Track format	Spiral	Spiral	Banded Spiral	Spiral	Banded Spiral
DRIVE: Operating mode	Read Only	Rewritable-(MO)	Rewritable-(MO)	Wr.Once,Rewrit.	Rewritable-(MF)
Interface	PC AT	SCSI	SCSI	SCSI	SCSI
Speed control	CLV	CAV	ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	F: 297.5/325	F: 595/650*	F: 595/650	F: 595/650*
Capacity per track (Bytes)	F: N/A	F: 17,408	F: 17,408	F: N/A	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	18751	21600**	21600/37600**	21600**
Track density (TPI)	15875	15900	18273	18273	18273
Maximum linear density (BPI)	27600	24900	29540	29540	29540
Rotational speed (RPM)	1060-400	2400	2400	2400	3500
PERFORMANCE					
Positioner type	Crs: DC Motor 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)	245	70	55	65/55	29
Average rotational delay (msec)	55	12.5	12.5	12.5	8.6
Average access time (msec)	300	82.5	67.5	77.5/67.5	37.6
Data transfer rate (KBytes/sec)	302	620/680* 4000 synch.	1561* 4000 synch.	1561 5000 synch.	2079/2280 5000 synch.
SIZE (mm: H x W x D)	41.5 x 146 x 208	82.5 x 146 x 205.5	82.5 x 146 x 205.5	82.5 x 146 x 205.5	41.3 x 146 x 205.2
FIRST CUSTOMER SHIPMENT	3Q94	3Q92	2Q93	3Q93	2Q94
COMMENTS	64 KB buffer. MPC-2 compliant Photo CD. Tray loading. Purchased mechanism.	*512/1024 bytes per sector	*512/1024 bytes per sector. **37600 logical tracks. MCC51300 is external mount	*Uses MO or ablative WORM media **Logical tracks	*512/1024 bytes per sector. **37600 logical tracks. 1 MB cache 4 MB option

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	3431	7209-001	7209-002	MD 3125B	MTA-3127 MTAS-3127
DISK/TREND GROUP	11	11	11	11	11
MARKET	Captive, OEM	Captive, OEM	Captive	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	86 mm	86 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rd.Only,Rewrit.	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
Speed control	CAV	CAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 595/650*	F: 595	F: 595	F: 127/122	F: 127
Capacity per track (Bytes)	F: 17,408	F: 17,408	F: 17,408	F:12,700/12,200	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18751	18751	21600*	10000	9994
Track density (TPI)	15900	15900	18273	15900	15900
Maximum linear density (BPI)	24900	24900	29540	24400	24400
Rotational speed (RPM)	2400	2400	3500	3000	3000
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)	70	70	29	40	40
Average rotational delay (msec)	12.5	12.5	8.6	10	10
Average access time (msec)	82.5	82.5	37.6	50	50
Data transfer rate (KBytes/sec)	620/680* 4000 synch.	620 4000 synch.	1079 4000 synch.	625 4000 synch.	625
SIZE (mm: H x W x D)	41.3 x 146.1 x 205.2	41.3 x 146.1 x 205.2	122.3 x 280 x 290	41.3 x 101.6 x 169	25.4 x 101.6 x 169
FIRST CUSTOMER SHIPMENT	1Q93	4Q92	3Q93	3Q92	4Q93
COMMENTS	*512/1024 bytes per sector For Micro-channel systems	For RS/6000 External mount	For RS/6000 External mount *Logical tracks	122 MB with read only media P-ROM support	122 MB with read only media P-RPM support

MANUFACTURER	IBM	JUKO ELECTRONICS	JVC	LASERBYTE	LION OPTICS
DRIVE	MTA-3230	JOCD-5X	XR-W1001	LB3230	XC 200IE XC 200II
DISK/TREND GROUP	11	10	11	11	10
MARKET	Captive,OEM,PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	86 mm	120 mm/80 mm	120 mm	86 mm	120 mm/80 mm
Recording medium	RE-TM Alloy	Aluminum	Organic Dye	RE-TM Alloy	Aluminum
Track format	Banded Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Read Only	Write Once	Rewritable-(MO)	Read Only
Interface	SCSI-2	SCSI-2	SCSI	SCSI, SCSI-2	Sony
Speed control	ZCAV	CLV	CLV	ZCAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 230	F: 540 Mode 1	F: 580	F: 229.1	F: 540/680
Capacity per track (Bytes)	F: 12,800*	F: N/A	F: N/A	F: 12,800	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11510/17853*	20750	20750	17900	20750
Track density (TPI)	18273	15875	15875	18273	15875
Maximum linear density (BPI)	29540	27600	27600	24300	27600
Rotational speed (RPM)	3600	1080-420	530-200	3600	1060-400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: Linear, Voice Coil Fine:	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	40	325	300	28	288
Average rotational delay (msec)	8.3	55	110	8.3	55
Average access time (msec)	48.3	380	410	36.3	343
Data transfer rate (KBytes/sec)	1475 max. 5000 synch.	150/300	153.6	920-1470	307.2 2700 asynch.
SIZE (mm: H x W x D)	25.4 x 101.6 x 169	48 x 140 x 260	41.3 x 146 x 205	41.3 x 101.6 x 146	41.5 x 146 x 206
FIRST CUSTOMER SHIPMENT	5/94	1994	4/92	2Q94	2Q94
COMMENTS	*Logical tracks Read only and partial read only modes	Top loading Sanyo mechanism	Embedded SCSI	256 KB buffer Read only and partial read only modes	64 KB buffer. Photo CD. Multisession. Tray loading. IE is external mount

MANUFACTURER	LION OPTICS	LONGSHINE ELECTRONICS	LONGSHINE ELECTRONICS	LONGSHINE ELECTRONICS	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	XC 200SE XC 200SI	LCS 7260	LCS 7260I	LCS 7260S	CR-503
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	120 mm/80 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	PC AT	Enhanced IDE	SCSI-2	SCSI-2
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540/680	F: 540	F: 540	F: 540	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	1060-400	1060-400	1060-400	1060-400
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: DC Motor, Lead Screw Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	288	330	300	300	265
Average rotational delay (msec)	55	60	50	50	55
Average access time (msec)	343	390	350	350	320
Data transfer rate (KBytes/sec)	307.2 2700 asynch.	150/300	150/300	150/300	307.2
SIZE (mm: H x W x D)	41.5 x 146 x 206	42. 3 x 148.5 x 205	42. 3 x 148.5 x 205	42. 3 x 148.5 x 205	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q94	1Q94	3Q94	3Q94	2Q90
COMMENTS	64 KB buffer. Photo CD. Multisession. Tray loading. SE is external mount	64 KB buffer MPC-2 compliant Tray loading. Audio output	64 KB buffer MPC-2 compliant Tray loading. Audio output	64 KB buffer MPC-2 compliant Tray loading. Audio output	256 KB buffer. Photo CD, XA. MPC-2 compliant Multisession.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	CR-533	CR-562	CR-563	CR-571B	LK-RC562AB LK-RC562NM
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 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-2	PC AT	PC AT	IDE, ATAPI	Proprietary
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 682	F: 682	F: 682	F: 540/180
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	27900	27600	27900	27600
Rotational speed (RPM)	1060-400	1060-400	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	Crs: DC Motor, Rack & Pinion Fine: Lens Actuator	Crs: DC Motor, Lead Screw Fine: Lens Actuator	Crs: DC Motor, Lead Screw Fine: Lens Actuator	Crs: DC Motor, Lead Screw Fine: Lens Actuator	Crs: DC Motor, Lead Screw Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	290	265	265	265	265
Average rotational delay (msec)	55	55	55	55	55
Average access time (msec)	345	320	320	320	320
Data transfer rate (KBytes/sec)	307.2	307.2	307.2	307.2	307.2
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 190	41.3 x 146 x 190	41.3 x 146 x 203	57 x 158 x 314
FIRST CUSTOMER SHIPMENT	2Q93	5/93	2Q93	3Q94	4Q93
COMMENTS	128 KB buffer. 256 KB option. MPC-2 compliant Multisession. Photo CD, XA.	64 KB buffer. Tray loading. Photo CD, XA. MPC-2 compliant Multisession.	64 KB buffer. Tray loading. Photo CD, XA. MPC-2 compliant Multisession.	256 KB buffer. Tray loading. Photo CD, XA. MPC-2 compliant Multisession.	64 KB buffer. Photo CD, XA. Multisession. MPC-2,Tray load External models Sold in Japan.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LF-3000E LF-3002 LF-3004 LF-3090	LF-3100 LF-3104	LF-3200JA	LF-3200JD	LF-3294
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	86 mm	86 mm	86 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	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI-2	SCSI-2	SCSI	SCSI	SCSI
Speed control	CAV	CAV	ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 128	F: 229.1	F: 229.1	F: 229.1
Capacity per track (Bytes)	F: 12,800	F: 12,800	F: 12,800*	F: 12,800*	F: 12,800*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	10000	11510/17853*	11510/17853*	11510/17853*
Track density (TPI)	15875	15875	18273	18273	18273
Maximum linear density (BPI)	24440	24440	29540	29540	29540
Rotational speed (RPM)	3000	3000	3600	3600	3600
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine:	Crs: Linear, Voice Coil Fine:	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	35	35	35
Average rotational delay (msec)	10	10	8.3	8.3	8.3
Average access time (msec)	50	50	43.3	43.3	43.3
Data transfer rate (KBytes/sec)	937.5	906 1500 avg.	2100 5000 synch.	2100 5000 synch.	2100 5000 synch.
SIZE (mm: H x W x D)	41.3 x 101.6 x 146	41.3 x 101.6 x 146	56 x 168 x 240	56 x 168 x 240	41.3 x 101.6 x 151.5
FIRST CUSTOMER SHIPMENT	4Q91	3Q91	3Q94	3Q94	2Q94
COMMENTS	LF-3090 is external mount	LF-3100 is external mount Sold in Japan	256 KB buffer. *Logical tracks For use with Macintosh. External mount	256 KB buffer. *Logical tracks For use w/DOS, PC-9800 and Panacom systems External mount	256 KB buffer *Logical tracks

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LF-5300A	LF-7010 LF-7014A LF-7110	LF-7012 LF-7090	LF-7300A	LF-7304
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	130 mm
Recording medium	Te-Ox	Ge-Tb-Se	Ge-Tb-Se	Ge-Tb-Se	Ge-Tb-Se
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Rewritable-(PC)	Rewritable-(PC)	Multifunct-(PC)	Multifunct-(PC)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	MCAV	MCAV	MCAV	MCAV	MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 700	F: 500/470*	F: 500/470*	F: 750	F: 750
Capacity per track (Bytes)	F:	F: NS	F: NS	F:	F:
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	25920	19968/18360*	19968/18360*	25920	25920
Track density (TPI)	21770	16925	16925	21770	21770
Maximum linear density (BPI)		30480	30480		
Rotational speed (RPM)	2400	1800	1800	2400	2400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, 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)	45	90	90	45	45
Average rotational delay (msec)	12.5	16.7	16.7	12.5	12.5
Average access time (msec)	57.5	106.7	106.7	57.5	57.5
Data transfer rate (KBytes/sec)	740-1440 5000 synch.	990	752 avg. 983 max.	780-1560 5000 synch.	780-1560 5000 synch.
SIZE (mm: H x W x D)	74 x 220 x 323	85.7 x 149.2 x 212.7	41.3 x 146.1 x 203.2	74 x 220 x 323	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	4Q93	4Q90	1991	4Q93	4Q93
COMMENTS	External mount	*Will operate with WORM media: 470 MB capacity. LF-7110 sold in Japan.	*Will operate with WORM media: 470 MB capacity. LF-7090 is external mount.	External mount	

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS
DRIVE	LF-7394	EBP-201	EBP-401	EBP-504	EBP-506
DISK/TREND GROUP	11	10	10	10	10
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Ge-Tb-Se	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Multifunct-(PC)	Read Only	Read Only	Read Only	Read Only
Interface	SCSI-2	Centronics	Proprietary	Proprietary	Proprietary
Speed control	MCAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 750/700*	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: NA	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	25920	20750	20750	20750	20750
Track density (TPI)	21700	15875	15875	15875	15875
Maximum linear density (BPI)		27600	27600	27600	27600
Rotational speed (RPM)	2400	530-200	530-200	1060-400	1060-400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	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
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	45	1590	1590	320	320
Average rotational delay (msec)	12.5	110	110	55	55
Average access time (msec)	57.5	1700	1700	375	375
Data transfer rate (KBytes/sec)	780-1560 740-1440*	153.6	153.6	307.2	307.2
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2			29 x 130 x 223.5	29 x 130 x 203.5
FIRST CUSTOMER SHIPMENT	4Q93	1Q89	2Q91	3Q93	1Q94
COMMENTS	*With WORM media	Stand-alone model	For automobile use	Tray loading model	Tray loading model

MANUFACTURER	MATSUSHITA ELECTRONIC COMPONENTS	MAXOPTIX	MAXOPTIX	MEDIA VISION	MITSUMI ELECTRIC
DRIVE	EBP-602	T3-1300	Tahiti IIM	Reno	CRMC-FX001D
DISK/TREND GROUP	10	11	11	10	10
MARKET	OEM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	Aluminum	RE-TM Alloy	RE-TM Alloy	Aluminum	Aluminum
Track format	Spiral	Spiral (Zone)	Spiral (Zone)	Spiral	Spiral
DRIVE: Operating mode	Read Only	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Read Only	Read Only
Interface	Proprietary	SCSI-2	SCSI-2	SCSI-2	PC AT
Speed control	CLV	CAV	CAV/MCAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 650/512/326	F: 512/326.4	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F:	F:25,000/17,408	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	37600/25000	25000	20750	20750
Track density (TPI)	15875	18273/16933	16933	15875	15875
Maximum linear density (BPI)	27600	29540*	25000*	27600	27600
Rotational speed (RPM)	1060-400	3375/4000/4800	2200	1060-400	1000-400
PERFORMANCE					
Positioner type	Crs: Stepping Motor Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Motor, Lead Screw Fine: Lens Positioner
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	320	19	35	180	250
Average rotational delay (msec)	55	6.25/7.5/8.9	13.6	55	55
Average access time (msec)	375	25.25	48.6	235	305
Data transfer rate (KBytes/sec)	307.2	2200/1100	1200/840	300	300
SIZE (mm: H x W x D)	23 x 96 x 151	82.6 x 146 x 203	82.6 x 146 x 208.3		42 x 148 x 201
FIRST CUSTOMER SHIPMENT	1Q94	5/93	5/92	4/94	1Q94
COMMENTS	For pop-up model CD ROM module	*2,7 RLL Code	*2,7 RLL Code CCW WORM media per DIS 11560	64 KB buffer MPC-2 compliant External mount	Photo CD. MPC-2 compliant Multisession. Auto tray loading.

MANUFACTURER	MITSUMI ELECTRIC	MOST	MOST	MOUNTAINGATE DATA SYSTEMS	MOUNTAINGATE DATA SYSTEMS
DRIVE	CRMC-FX001DE	RMD 5200-S	RMD 5300-S	CR6000 CR6120 CR6221/22 CR6300	CR6800 CR6822 CR6835/36 CR6841/42/44 CR6880
DISK/TREND GROUP	10	11	11	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	86 mm	86 mm	130 mm	130 mm
Recording medium	Aluminum	RE-TM Alloy	RE-TM Alloy	Te-Ox	Te-Ox
Track format	Spiral	Spiral	Spiral	Spiral	Concentric
DRIVE: Operating mode	Read Only	Rewritable-(MO)	Rewritable-(MO)	Write Once	Write Once
Interface	IDE/ATAPI	SCSI-1/2	SCSI-2	SCSI	SCSI
Speed control	CLV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 128/256*	F: 230*/256/384	F: 320	F: 320
Capacity per track (Bytes)	F: N/A	F: 12,800/**	**	F: 17,408	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	12900	18750	18750
Track density (TPI)	15875	15875	18273	15875	15875
Maximum linear density (BPI)	27600	15875/39625	42900	24924	24924
Rotational speed (RPM)	1000-400	2400	2400	1800	1800
PERFORMANCE					
Positioner type	Crs: Motor, Lead Screw Fine: Lens Positioner	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	250	35.2	35.2	112	112
Average rotational delay (msec)	55	12.5	12	16.5	16.5
Average access time (msec)	305	47.7	47.2	128.5	128.5
Data transfer rate (KBytes/sec)	300	512/820-1228	512/860-1500	522	522
SIZE (mm: H x W x D)	42 x 148 x 201	41.3 x 146 x 203.2	41.3 x 146 x 203.2		
FIRST CUSTOMER SHIPMENT	2Q94	2Q92	3Q94	3/89	1989
COMMENTS	Photo CD. MPC-2 compliant Multisession. Auto tray loading.	*Zoned record. **Varies by zone. OROM support. 128 KB buffer.	*Also operates with 128 MB media **Varies by format		For use in harsh environments

MANUFACTURER	MOUNTAIN OPTECH	MOUNTAIN OPTECH	MOUNTAIN OPTECH	NEC	NEC
DRIVE	SE-250 R/W SI-250 R/W	CS-1000 M/F SE-1000 M/F SS-1000 M/F ST-1000 M/F	RM-2000 M/F	CDR-260	CDR-400 MultiSpin 3Xp
DISK/TREND GROUP	11	11	11	10	10
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Nominal disk diameter	86 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	Aluminum	Aluminum
Track format	Spiral	Spiral (Zone)	Spiral (Zone)	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Read Only	Read Only
Interface	SCSI	SCSI	SCSI	IDE	SCSI-2
Speed control	CAV	ZCAV	ZCAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 512/326.4	F: 512/326.4	F: 680	F: 540/680
Capacity per track (Bytes)	F: 12,800	F:25,000/17,408	F:25,000/17,408	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	25000	25000	20750	20750
Track density (TPI)	15900	16933	16933	15875	15875
Maximum linear density (BPI)	24400	25000	25000	27600	27600
Rotational speed (RPM)	1800	2200	2200	1060-400	1500-600
PERFORMANCE					
Positioner type	Crs: NS Fine: Lens Actuator	Crs: Voice Coil 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)	60	35	35	320	250
Average rotational delay (msec)	16.6	13.6	13.6	55	37
Average access time (msec)	76.6	48.6	48.6	375	287
Data transfer rate (KBytes/sec)	543.8	1250/880	1250/880	307.2	460.8 2500 asynch.
SIZE (mm: H x W x D)				41.3 x 149 x 208	56 x 154 x 257
FIRST CUSTOMER SHIPMENT	4Q92	2Q91	1993	1992	10/93
COMMENTS	Ruggedized Preliminary specification	Ruggedized version of Maxtor Tahiti SE-1000 is for military use	2 ruggedized drives in 19" rack	Internal	256 KB buffer. Photo CD. MPC-2 compliant Multisession.

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	CDR-500 CDR-600 MultiSpin 3Xe MultiSpin 3Xi	CDR-900 MultiSpin 4Xpro	PC-CD 160S	PC-CD 170S	N1137-04 N7915-11 N7915-84 PC-OD102
DISK/TREND GROUP	10	10	10	10	11
MARKET	PCM	PCM	Captive	Captive	Captive
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Recording medium	Aluminum	Aluminum	Aluminum	Aluminum	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Rewritable-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Speed control	CLV	CLV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540/680	F: 540/680	F: 540	F: 540	F: 305
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	18751
Track density (TPI)	15875	15875	15875	15875	15375
Maximum linear density (BPI)	27600	27600	27600	27600	25000
Rotational speed (RPM)	1500-600	2000-800	1060-400	1060-400	3000
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: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	195	180	225	225	60
Average rotational delay (msec)	37	37	55	55	10
Average access time (msec)	232	207	280	280	70
Data transfer rate (KBytes/sec)	460.8 2500 asynch.	614.4 2500 asynch.	307.2	460.8	1500
SIZE (mm: H x W x D)	42.8 x 149 x 220	79 x 185 x 371	77 x 178 x 321	177 x 178 x 324	130 x 170 x 280
FIRST CUSTOMER SHIPMENT	10/93	1Q94	1Q94	1Q94	1Q91
COMMENTS	256 KB buffer. Photo CD. MPC-2 compliant Multisession. 3Xe is external	256 KB buffer. Photo CD. MPC-2 compliant Multisession.	Tray loading		

MANUFACTURER	NEC	NEC	NEC	NEC	NIKON
DRIVE	N1137-57 N7915-85 ODD-155 PC-OD502	PC-OD301 PC-OD301R	N6513-20	N6513-23 N7913	MO-DD121-1A
DISK/TREND GROUP	11	11	12	12	12
MARKET	Captive	Captive	Captive	Captive	OEM
MEDIA: Nominal disk diameter	130 mm	86 mm	300 mm	300 mm	300 mm
Recording medium	Tb-Fe-Co	Tb-Fe-Co	Te Alloy	Te Alloy	Tb-Fe,Gd-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Write Once	Write Once	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI, Prop.	Prop., SCSI	SCSI
Speed control	ZCAV	CAV	Zone CLV	MCAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680/325	F: 128	F: 1,800	F: 2,500	F: 3,400/4,000*
Capacity per track (Bytes)	F: N/A	F: 12,800	F:29,500-56,500	F: NS	F:102442/108222
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	10000	41000	49000	41331/41196
Track density (TPI)	18273	15375	15875	16940	15875
Maximum linear density (BPI)	29540	24500	20000	25000	30600
Rotational speed (RPM)	3000/4200	3000	600-330	600	1500
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: Galvonom.
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	32	40	650	150	73
Average rotational delay (msec)	10/7	10	70	50	30
Average access time (msec)	42/39	50	720	200	93
Data transfer rate (KBytes/sec)	1940	1500	452	900	1770/2010
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	100 x 170 x 280			400 x 588 x 170
FIRST CUSTOMER SHIPMENT	3Q93	1992	1Q87	6/90	1Q94
COMMENTS	*37600 logical tracks				*Sector size 512B/1024B

MANUFACTURER	NIPPON STEEL	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
DRIVE	DD5211	128MO	MOS300E MOS300S	MOS320E MOS320S MOS321S*	MOS500E MOS500D
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	86 mm	86 mm	86 mm	130 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MF)
Interface	SCSI-2	SCSI	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV	CAV	CAV	CAV/ZCAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 654	F: 128	F: 128	F: 230/128	F: 650
Capacity per track (Bytes)	F: 17,408	F: 10,000	F: 12,800	F: 12,800	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	10000	10000	11500**	18751
Track density (TPI)	18273	15875	15875	18273	15875
Maximum linear density (BPI)	29540	24440	24440	29300	24902
Rotational speed (RPM)	3000	3600	3600	4200	3000
PERFORMANCE					
Positioner type	Crs: 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)	30	38	38	28	--
Average rotational delay (msec)	10	8.3	8.3	7.1	10
Average access time (msec)	40	46.3	46.3	35.1	--
Data transfer rate (KBytes/sec)	2000 5000 synch.	768	3000 synch. 768	1075-1720/896	
SIZE (mm: H x W x D)	82.5 x 146 x 210	41.3 x 101.6 x 171.9	41.3 x 101.6 x 171.9	41.3 x 101.6 x 160	82.6 x 146.1 x 205
FIRST CUSTOMER SHIPMENT	1994	1993	10/92	2Q94	1993
COMMENTS	256 KB buffer. *37600 log.trks 1 MB option. Dir. overwrite Single sided. Prelim. spec.	External mount, DOS & Macintosh versions Similar to MOS300S	S version is external mount	*256 KB buffer, 1 MB optional. **17900 logical tracks.	D version less controller Sold only in Japan

MANUFACTURER	OLYMPUS	OLYMPUS	OPTICS STORAGE	PHILIPS LMS	PHILIPS LMS
DRIVE	MOS520E MOS520S	MOS525E	Dolphin 8000	CM 206	CM 207
DISK/TREND GROUP	11	11	10	10	10
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm/80 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co	Tb-Fe-Co	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MF)	Wr.Once,Rewrit.	Read Only	Read Only	Read Only
Interface	SCSI-2	SCSI-2	PC AT	PC AT	IDE/ATAPI
Speed control	CAV/ZCAV	ZCAV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650/325	F: 595/650*	F: 635	F: 553 Mode 1 F: 635 Mode 2	F: 553 Mode 1 F: 635 Mode 2
Capacity per track (Bytes)	F: 17,408	F: 17,408	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18750*	21600**	20750	20750	20750
Track density (TPI)	18273/15875	18273	15875	15875	15875
Maximum linear density (BPI)	31005/27597	29540	27600	27600	27600
Rotational speed (RPM)	3000/4500	3500	1060-400	1000-400	1000-400
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:Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	56/54	29	310	325	270
Average rotational delay (msec)	10/6.67	8.57	55	55	55
Average access time (msec)	66/60.67	37.57	365	380	325
Data transfer rate (KBytes/sec)	1200-2300/1000	1750	300	307.2 Mode 1 352.8 Mode 2	307.2 Mode 1 352.8 Mode 2
SIZE (mm: H x W x D)	82.6 x 146.1 X 205	41.3 x 146.1 x 205	41.3 x 146 x 210	41.5 x 146 x 208	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	11/93	5/94	4Q93	1993	1Q94
COMMENTS	*37600 log.trks 1 MB buffer. 4 MB optional. S version is external mount. Sld. only Japan	1 MB cache, 4 MB option *512/1024 byte sector. **37600 logical tracks	64 KB buffer Purchased mechanism	64 KB buffer. Photo CD. Multisession. Tray loading.	64 KB buffer. Photo CD. Multisession. Tray loading.

MANUFACTURER	PHILIPS LMS	PHILIPS LMS	PHILIPS LMS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS
DRIVE	CDD 521	CDD 522	LD 4100	CDF 100	CDF 200
DISK/TREND GROUP	11	11	12	10	10
MARKET	OEM, PCM	OEM, PCM	Captive,OEM,PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	300 mm	120 mm	120 mm
Recording medium	Dye Polymer	Dye Polymer	Te Alloy	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Write Once	Write Once	Read Only	Read Only
Interface	SCSI-2	SCSI-2	SCSI-2	Video/Audio	RF, Video/Audio
Speed control	CLV	CLV	CAV		
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540/645	F: 553 Mode 1 F: 635 Mode 2	F: 5,600	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: 49,808	F: N/A	F: N/A
Data surfaces per spindle	1	1	2	1	1
Tracks per surface	20750	20750	57301	20750	20750
Track density (TPI)	15875	15875	16925-23132	15875	15875
Maximum linear density (BPI)	27600	27600	NS	27600	27600
Rotational speed (RPM)	1000-400*		855	500-200	500-200
PERFORMANCE					
Positioner type	Crs: Linear Motor Fine: Lens Actuator	Crs: Fine:	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Rotary Galvonometer Fine:	Crs: Rotary Galvonometer Fine:
Servo type	Continuous	Continuous	Sampled	Continuous	Continuous
Average positioning time (msec)	1000		90	1000	1000
Average rotational delay (msec)	110		35	110	110
Average access time (msec)	1110		125*	1110	1110
Data transfer rate (KBytes/sec)	307.2/153.6		700	153.6/175.2	153.6/175.2
SIZE (mm: H x W x D)	118 x 420 x 334		118 x 475 x 653	154.6 x 220 x 46	121 x 435 x 300
FIRST CUSTOMER SHIPMENT	3/92	3Q94	2Q90	4Q92	2Q92
COMMENTS	External mount Tray loading. *500-200 with 153.6 KB data rate	Preliminary specification	*Includes command latency Has Direct Read During Write	Portable Multisession Photo CD player	Desktop Multisession Photo CD player

MANUFACTURER	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS	PHILIPS CONSUMER ELECTRONICS
DRIVE	CDI 210 CDI 220	CDI 350	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)	1000	800	800	265	1000
Average rotational delay (msec)	110	110	110	55	110
Average access time (msec)	1110	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
SIZE (mm: H x W x D)	90 x 420 x 400	52 x 190 x 292	90 x 420 x 400		118 x 420 x 334
FIRST CUSTOMER SHIPMENT	3Q92	4/93	1990	2Q93	3/92
COMMENTS	Desktop CDI player "Thumbstick" remote control	Portable CDI player with LCD screen	Desktop CDI player	64 KB buffer. Photo CD. Multisession. 425ABK is external mount	External mount Tray loading. *500-200 with 153.6 KB data rate

MANUFACTURER	PINNACLE MICRO	PINNACLE MICRO	PINNACLE MICRO	PIONEER	PIONEER
DRIVE	PMO-650	Sierra	ORRAY	DR-S104X DR-U104X	DRM-1804X
DISK/TREND GROUP	11	11	12	10	10
MARKET	OEM, PCM	PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	RE-TM Alloy	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Read Only	Read Only
Interface	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI
Speed control	CAV	CAV/ZCAV	CAV/ZCAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 326.4	F: 325/650	F: 1,300/2,600	F: 540	F: 540
Capacity per track (Bytes)	F: 17,408	F: 17,408/NA	F: 17,408/NA	F: N/A	F: N/A
Data surfaces per spindle	1	1	4	1	1
Tracks per surface	18751	37600/21600	37600/21600	20750	20750
Track density (TPI)	15875	18273	18273	15875	15875
Maximum linear density (BPI)	24902	28540	28540	27600	27600
Rotational speed (RPM)	3600	4500/3000	4500/3000	2120-800	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	NA	NA	190	300
Average rotational delay (msec)	8.3	6.6/10	6.6/10	55	28
Average access time (msec)	NA	NA	NA	245	328
Data transfer rate (KBytes/sec)	1400 4200 synch.	2000 5000 synch.	8000	600	614.4
SIZE (mm: H x W x D)	93 x 186 x 254.2	93 x 186 x 254.2		41.3 x 146 x 202	198 x 262 x 422
FIRST CUSTOMER SHIPMENT	1992	1993	2Q94	3Q94	1994
COMMENTS	Purchased mechanism	Purchased mechanism 4 MB cache	Purchased mechanism 8-64 MB cache	DR-S104X is external model	256 KB buffer. Photo CD. Multisession. Integral with 18 disk changer

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
DRIVE	DRM-602X	DRM-604X	DD-M5101	DD-S5101 DD-U5101	DDJ-U5101
DISK/TREND GROUP	10	10	11	11	11
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	130 mm
Recording medium	Aluminum	Aluminum	Cyanine Dye	Cyanine Dye	Cyanine Dye
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Write Once	Write Once	Write Once
Interface	SCSI-2	SCSI, SCSI-2	Proprietary	SCSI, Prop.	SCSI, Prop.
Speed control	CLV	CLV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 327	F: 327	F: 327
Capacity per track (Bytes)	F: N/A	F: N/A	F: 16,384	F: 16,384	F: 16,384
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	19958	19958	19958
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	15875	15875	15875
Rotational speed (RPM)	1060-200	2120-200	1800	1800	1800
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Galvonom.
Servo type	Continuous	Continuous	Sampled	Sampled	Sampled
Average positioning time (msec)	300	300	60	60	60
Average rotational delay (msec)	55	28	16.7	16.7	16.7
Average access time (msec)	355	328	76.7	76.7	76.7
Data transfer rate (KBytes/sec)	307.2	614.4	742.5	742.5	491
SIZE (mm: H x W x D)	104 x 211 x 371	104 x 211 x 371	41.3 x 146 x 206	82 x 146 x 206	41.3 x 146 x 206
FIRST CUSTOMER SHIPMENT	3Q93	3Q92	2Q88	2Q88	4/91
COMMENTS	256 KB buffer. Photo CD. Multisession. Integral with 6 disk changer	128 KB buffer. Photo CD. Multisession. Includes 6 disk changer	Mechanism only External SCSI controller board available	DD-S5101 is external mount	For use with optical libraries

MANUFACTURER	PIONEER	PIONEER	PIONEER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
DRIVE	DE-S7001 DE-U7001	DE-SH7101 DE-UH7101	DEJ-U7001	DM-3028 DM-5028	PX 43CH 4 Plex
DISK/TREND GROUP	11	11	11	10	10
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co/Dye	Tb-Fe-Co/Dye	Tb-Fe-Co/Dye	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Read Only	Read Only
Interface	SCSI	SCSI	SCSI	SCSI	SCSI-2
Speed control	CAV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 327	F: 327	F: 327	F: 599	F: 540
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 16,384	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	19958	19958	19958	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	15875	15875	15875	25400	27600
Rotational speed (RPM)	1800	1800	1800	1182-486	2120-800
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Galvonom.	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Galvonom.	Crs: Voice Coil Fine: Lens Actuator	Crs: Voice Coil Fine: Lens Actuator
Servo type	Sampled	Sampled	Sampled		Continuous
Average positioning time (msec)	53.3	53.3	53.3	185	193
Average rotational delay (msec)	16.7	16.7	16.7	55	27
Average access time (msec)	70	70	70	240	220
Data transfer rate (KBytes/sec)	491	635	491	335	600
SIZE (mm: H x W x D)	82 x 146 x 205.5	41.3 x 146 x 203.2	41.3 x 146 x 203.2	41.3 x 146 x 202	41.3 x 146 x 202
FIRST CUSTOMER SHIPMENT	6/90	2Q93	4/91	3Q93	6/94
COMMENTS	DE-S7001 is external mount Multifunction	Multifunction	For use with optical libraries Multifunction	64 KB buffer Photo CD mount. Multisession. DM-5028 is external mount	1 MB buffer Photo CD Multisession

MANUFACTURER	RICOH	RICOH	RICOH	RICOH	RICOH
DRIVE	RI-600M/S	RO-3012E RS-3102E Transporter 2	RO-5031E RS-9200EX	RO-5043 RS-8200 RS-9100H	RO-5060E RS-5060E
DISK/TREND GROUP	11	11	11	11	11
MARKET	PCM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	86 mm	130 mm	130 mm	130 mm
Recording medium	Dye Polymer	RE-TM Alloy	Tb-Fe-Co	Cyanine Dye	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Rewritable-(MO)	Rewritable-(MO)	Write Once	Rewritable-(MO)
Interface	SCSI-2	SCSI-2	SCSI	SCSI	SCSI-2
Speed control	CLV	CAV	CAV	CLV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680	F: 127.4	F: 297/326	F: 393	F: 326.2/652.3
Capacity per track (Bytes)	F: N/A	F: 12,740	F:15,872/17,408	F: N/A	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	18750	18750	18751/21600*
Track density (TPI)	15875	15875	15875	15900	15900/18273
Maximum linear density (BPI)	27600	24440	24923	32200	24900/29540
Rotational speed (RPM)	530-200	3000	3600	668-334	4500/3000
PERFORMANCE					
Positioner type	Crs: Fine:	Crs: Linear, Voice Coil Fine: Lens Actuator	Linear, Voice Coil	Crs: Voice Coil Fine: Voice Coil	Crs: Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	390	45	29	108	29
Average rotational delay (msec)	110	10	8.3	60	6.7/10
Average access time (msec)	500	55	37.3	168	35.4/39
Data transfer rate (KBytes/sec)	150	640	1250	312.5	5000 synch. 3300 asynch.
SIZE (mm: H x W x D)	335 x 220 x 325*	41.3 x 101.6 x 149.8	82.6 x 146.1 x 203.2	41.3 x 146.1 x 208	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	4/94	3/93	4Q91	2Q90	1Q94
COMMENTS	Subsystem-has 1 CD ROM and 1-21 CD-R drives. *Minimum configuration	256 KB buffer RS-3012E is external version	480 KB buffer. Embedded SCSI controller. Split optics. RS-9200EX is external vers.	SCSI controller included. RS-8200 & 9100H are external versions.	512 KB buffer *37600 logical tracks

MANUFACTURER	RICOH	RICOH	SAMSUNG ELECTRONICS	SANYO ELECTRIC	SANYO ELECTRIC
DRIVE	RO-5061E	RS-9200CD	SCDR-300	CDR 93 CRD 400I	CDR H93 CRD 400E
DISK/TREND GROUP	11	11	10	10	10
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm/80 mm	120 mm/80 mm
Recording medium	RE-TM Alloy	Dye Polymer	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Write Once	Read Only	Read Only	Read Only
Interface	SCSI-2	SCSI-2	SCSI	SCSI-2	SCSI-2
Speed control	CAV/ZCAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 326/652	F: 650	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	18751/21600*	20750	20750	20750	20750
Track density (TPI)	15900/18273	15875	15875	15875	15875
Maximum linear density (BPI)	24900/29540	27600	27600	27600	27600
Rotational speed (RPM)	4500/3000	530-200	500-200	1060-400	1060-400
PERFORMANCE					
Positioner type	Crs: Voice Coil Fine: Lens Actuator	Crs: Fine:	Crs: Fine:	Crs: Fine: Lens Actuator	Crs: Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35.4	390	340	265	295
Average rotational delay (msec)	10	110	110	55	55
Average access time (msec)	45.4	500	450	320	350
Data transfer rate (KBytes/sec)	5000 synch. 3300 asynch.	150	153.6	307.2	307.2
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	125 x 210 x 310	41.3 x 146.1 x 203.2	41.5 x 146 x 210.3	48 x 140 x 255
FIRST CUSTOMER SHIPMENT	2Q94	1Q93	3Q93	2Q94	3Q94
COMMENTS	512 KB buffer *37600 logical tracks	Multisession CD format		256 KB buffer Photo CD Multisession. Tray loading	256 KB buffer Photo CD Multisession. Tray loading

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SHARP	SHARP	SHARP
DRIVE	OMD 5010	OMF 5000	PU-CDI	JY-750 JY-7500	JY-800 JY-8000
DISK/TREND GROUP	11	11	10	11	11
MARKET	OEM	OEM	PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	86 mm	86 mm	80 mm	130 mm	130 mm
Recording medium	RE-TM Alloy	RE-TM Alloy	Aluminum	RE-TM(Tb-Fe-Co)	RE-TM Alloy
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Read Only	Rewritable(MO)*	Rewritable-(MF)
Interface	SCSI, SCSI-2	SCSI, SCSI-2	Proprietary	SCSI, SCSI-2	SCSI, SCSI-2
Speed control	CAV	CAV	CLV	CAV	CAV/MCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 128	F: 200	F: 326	F: 595/650*
Capacity per track (Bytes)	F: 12,800	F: 12,800	F: N/A	F: 17,408	F: 17,408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	10000	8750	18751	21600**
Track density (TPI)	15875	15875	15875	15875	18273
Maximum linear density (BPI)	24440	24440	27600	33200**	29540
Rotational speed (RPM)	3600	3600	500-300	3000	3000
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: NS Fine: NS	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)	38	38	NS	40	39
Average rotational delay (msec)	8.3	8.3	NS	10	10
Average access time (msec)	46.3	46.3	NS	50	49
Data transfer rate (KBytes/sec)	768	768	NS	870 4000 synch.	870.4/2000
SIZE (mm: H x W x D)	41.3 x 101.6 x 171.9	142 x 66 x 284		41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q92	2Q93	1993	10/92	1Q94
COMMENTS		Subsystem	Sold only in Japan for Electronic Organizer	*CCW compatible **2,7 RLL Code JY-7500 is external mount	*512/1024 bytes per sector. **37600 logical tracks. JY-8000 is external mount

MANUFACTURER	SIERRA TECHNOLOGIES	SONY	SONY	SONY	SONY
DRIVE	525 GB+ 525 GBX2+	CDU-33A	CDU-561	CDU-6811	CDU-7811
DISK/TREND GROUP	11	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	Te Alloy	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Concentric	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Read Only	Read Only	Read Only	Read Only
Interface	SCSI-2	Proprietary	SCSI	SCSI	SCSI-2
Speed control	CAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 640	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: 20,000	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	32000	20750	20750	20750	20750
Track density (TPI)	35000	15875	15875	15875	15875
Maximum linear density (BPI)	32000	27600	27600	27600	27600
Rotational speed (RPM)	1800	1160-460	1160-460	*	400-1000
PERFORMANCE					
Positioner type	Crs: Stepping Motor Fine: Lens Actuator	Crs: DC Motor, Gear 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	Sector	Continuous	Continuous	Continuous	
Average positioning time (msec)	90	265	240	240	235
Average rotational delay (msec)	16.7	55/110	55/110	55/110	55
Average access time (msec)	106.7	320/375	295/350	295/350	290
Data transfer rate (KBytes/sec)	812.5	300/150	300/150	300/150	300
SIZE (mm: H x W x D)	82.6 x 146.1 x 208.2	41 x 146 x 178	41.4 x 146.1 x 203.2	58 x 177.5 x 325.5	58 x 177.5 x 325.5
FIRST CUSTOMER SHIPMENT	4/88	2Q94	1992	2Q93	2Q93
COMMENTS	525 GBX2+ is external mount; dual drive available	64 KB buffer. Photo CD. MPC-2. Tray loading.		External mount	256 KB buffer Multisession Embedded SCSI-2

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	CDU55E	CDU55S	DD-10BZ Data Discman	DD-1EX DD-10X Data Discman	DD-20 DD-22 Data Discman
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	Captive	Captive	Captive
MEDIA: Nominal disk diameter	120 mm	120 mm	80 mm	80 mm	80 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	IDE/ATAPI	SCSI-2	Proprietary	Proprietary	--
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 184	F: 184	F: 184
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	9062	9062	9062
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	1060-400	500-300	500-300	500-300
PERFORMANCE					
Positioner type	Crs: DC Motor, Gear Fine: Lens Actuator	Crs: DC Motor, Gear Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	250	250	NS	NS	NS
Average rotational delay (msec)	55	55	65	65	65
Average access time (msec)	305	305	NS	NS	NS
Data transfer rate (KBytes/sec)	300	300	9.4	9.4	9.4
SIZE (mm: H x W x D)	41.3 x 146 x 178	41.3 x 146 x 178	35 x 110 x 157	35 x 110 x 157	40 x 166 x 113
FIRST CUSTOMER SHIPMENT	3Q94	3Q94		7/90	1993
COMMENTS					

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	DD-30 DD-30DB2 Data Discman	DD-8 Data Discman	DD-DR1 Data Discman	PIX-100	CDW-900E
DISK/TREND GROUP	10	10	10	10	11
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Nominal disk diameter	80 mm	80 mm	80 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	RS232C	Proprietary	RS232C	Proprietary	SCSI
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 184	F: 184	F: 184	F: 600	F: 680
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	20750	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		1000-200
PERFORMANCE					
Positioner type	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor, Lead Screw Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	NS	NS	--	NS
Average rotational delay (msec)	65	65	65	--	NS
Average access time (msec)	NS	NS	NS	--	NS
Data transfer rate (KBytes/sec)	9.4	9.4	9.4	--	150-300
SIZE (mm: H x W x D)	34 x 160 x 111	39 x 110 x 180	35 x 110 x 173	48 x 180 x 148	88 x 424 x 411
FIRST CUSTOMER SHIPMENT	1993	1993		1992	1992
COMMENTS				XA format. Portable multimedia player. Preliminary specification.	Sold only with mastering system

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	MDM-111	RMO-S310PR	RMO-S310SC	RMO-S330	RMO-S350 SMO-S301
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	PCM	PCM	PCM	OEM, PCM
MEDIA: Nominal disk diameter	64 mm	86 mm	86 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	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rd.Only,Rewrit.	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Interface		Printer Port	SCSI-2	SCSI	SCSI
Speed control	CLV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 140	F: 128	F: 128	F: 128	F: 128
Capacity per track (Bytes)	F: NA	F: 12,800	F: 12,800	F: 12,800	F: 12,800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface		10000	10000	10000	10000
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)		24440	24440	24440	24440
Rotational speed (RPM)	990-420	1800	1800	1800	3000
PERFORMANCE					
Positioner type	Crs: Fine:	Crs: Voice Coil Fine: Lens Acuator	Crs: Voice Coil Fine: Lens Acuator	Crs: Linear, Voice Coil Fine: Lens Acuator	Crs: Linear, Voice Coil Fine: Lens Acuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		120	120	120	40
Average rotational delay (msec)	42.5	16.6	16.6	16.6	10
Average access time (msec)		136.6	136.6	136.6	50
Data transfer rate (KBytes/sec)	150 2500 synch.	375	375	375	625
SIZE (mm: H x W x D)	25.4 x 101.6 x 149			52.4 x 160 x 240	74 x 290 x 285
FIRST CUSTOMER SHIPMENT	2Q94	3Q94	3Q94	7/94	6/91
COMMENTS		128 KB buffer. Portable. Intern. battery and charger. Preliminary specification	128 KB buffer. Portable. Intern. battery and charger. Preliminary specification	External subsystem	External subsystems

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	RMO-S360 SMO-S303	RMO-S550 SMO-S501A	RMO-S570 SMO-S521	SMO-E301 SMO-E301F	SMO-E501
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	86 mm	130 mm	130 mm	86 mm	130 mm
Recording medium	Tb-Fe-Co	Tb-Fe-Co	RE-TM Alloy	Tb-Fe-Co	Tb-Fe-Co
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MF)	Rewritable-(MO)	Rewritable-(MO)
Interface	SCSI	SCSI	SCSI, SCSI-2	SCSI, SCSI-2	SCSI
Speed control	CAV	CAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 326.4	F: 650	F: 128	F: 325
Capacity per track (Bytes)	F: 12,800	F: 17,408	F: N/A	F: 12,800	F: 17,332
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	18751	21600*	10000	18751
Track density (TPI)	15875	15875	18273	15875	15875
Maximum linear density (BPI)	24440	24902	29540	24440	24902
Rotational speed (RPM)	3000	2400	3000	3000	2400
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine: Lens Acuator	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)	40	70	40	38	70
Average rotational delay (msec)	10	12.5	10	10	12.5
Average access time (msec)	50	82.5	50	48	82.5
Data transfer rate (KBytes/sec)	625	680	1000-2000	625	680
SIZE (mm: H x W x D)	69 x 160 x 261	106.5 x 221 x 290.5	70 x 211 x 293	41.3 x 101.6 x 146	82.5 x 146 x 203.2
FIRST CUSTOMER SHIPMENT	1992	2Q88	2Q94	8/92	3Q90
COMMENTS	External subsystems	ISO standard RMO-S550 is external subsystem	*37600 logical tracks	Embedded SCSI controller Internal fan on E301F. (164.7 mm long).	Embedded SCSI controller

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	SMO-E502	SMO-E511	SMO-F521	SMO-P301	WDD-600
DISK/TREND GROUP	11	11	11	11	12
MARKET	Captive, OEM	Captive, OEM	OEM, PCM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	86 mm	300 mm
Recording medium	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co	Tb-Fe-Co	SbSe-BiTe
Track format	Spiral	Spiral	Banded Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MO)	Write Once
Interface	SCSI, SCSI-2	SCSI	SCSI, SCSI-2	SCSI	SCSI
Speed control	CAV	CAV	ZCAV	CAV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 325	F: 325	F: 650	F: 128	F: 2,182/3,276
Capacity per track (Bytes)	F: 17,332	F: 17,332	F: N/A	F: 12,800	F: NS
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18751	18751	21600*	10000	43750
Track density (TPI)	15875	15875	18273	15875	15875
Maximum linear density (BPI)	24902	24902	29540	24440	49874
Rotational speed (RPM)	2400	2400	3000	3000	360-1440
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 Motor Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	60	70	40	40	180/600
Average rotational delay (msec)	12.5	12.5	10	10	41/55
Average access time (msec)	72.5	82.5	50	50	221/455
Data transfer rate (KBytes/sec)	680	680	1000-2000	625	600
SIZE (mm: H x W x D)	82.5 mm 146 x 203.2	82.5 x 146 x 203.2	41.3 x 146 x 203.2	41.3 x 101.6 x 195.5	180 x 375 x 520*
FIRST CUSTOMER SHIPMENT	1Q92	1991	3Q93	1991	3Q89
COMMENTS	Embedded SCSI controller	Embedded SCSI controller	*37600 logical tracks	Integrated controller	Downward compatible with WDD 3000 *Drive unit only

MANUFACTURER	SONY	TEAC	TEAC	TEAC	TEAC
DRIVE	WDD-930-01 WDD-931	CD-50	CD-100H	CD-505	CD-55A
DISK/TREND GROUP	12	10	10	10	10
MARKET	Captive, OEM	OEM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	300 mm	120 mm	120 mm	120 mm	120 mm
Recording medium	SbSe-BiTe	Aluminum	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Write Once	Read Only	Read Only	Read Only	Read Only
Interface	SCSI-2	SCSI-2		PC AT	PC AT
Speed control	CAV/CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 2,182/3,276	F: 680	F: 680	F: 680	F: 680
Capacity per track (Bytes)	F: NS	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	43750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	49874	27600	27600	27600	27600
Rotational speed (RPM)	540-2160	400-1060	1000-400	2120-800	2120-800
PERFORMANCE					
Positioner type	Crs: Linear Motor 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)	180/600	265	295	195	195
Average rotational delay (msec)	27/36.7	55	55	27	27
Average access time (msec)	207/637	320	350	222	222
Data transfer rate (KBytes/sec)	900	335	300	600	600
SIZE (mm: H x W x D)	180 x 480 x 540	41.3 x 146 x 202	60 x 170 x 290	41.3 x 146 x 203	25.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q92	1994	1993	3Q94	2Q94
COMMENTS	Downward compatible with WDD-600 & WDD-3000	64 KB buffer XA compatible	External mount	Photo CD Multisession Includes 3.5" 2 MB FDD	Photo CD Multisession

MANUFACTURER	TEAC	TEAC	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	OD-3000	OD-5000	TXM-3401E TXM-3401P XM-3400A XM-3401B	TXM-4101L XM-4101B	XM-4100A
DISK/TREND GROUP	11	11	10	10	10
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	86 mm	86 mm	120 mm	120 mm	120 mm
Recording medium	Tb-Fe-Co	RE-TM Alloy	Aluminum	Aluminum	Aluminum
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Rewritable-(MO)	Rewritable-(MO)	Read Only	Read Only	Read Only
Interface	SCSI-2	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV	CAV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 127.4	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: 12,800	F: 12,740	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	10000	21250	21250	21250
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	24440	24440	25400	25400	25400
Rotational speed (RPM)	3000	3000	1170-400	1060-400	1060-400
PERFORMANCE					
Positioner type	Crs: Linear, Voice Coil Fine:	Crs: Linear, Voice Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Rack & Pinion Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	42	42	150	330	330
Average rotational delay (msec)	10	10	50	50	55
Average access time (msec)	52	52	200	385	385
Data transfer rate (KBytes/sec)	640	5300 synch.	330 4200 synch.	307.2	307.2
SIZE (mm: H x W x D)	41.3 x 101.6 x 146	41.3 x 146 x 153.5	41.3 x 146.1 x 203.2	25.4 x 146 x 195	30.4 x 140 x 210
FIRST CUSTOMER SHIPMENT	4Q91	1993	1Q94	4Q93	1Q94
COMMENTS	128 KB buffer	P-ROM, O-ROM compatible Mounts in 5.25" form factor	256 KB buffer. Photo CD. MPC-2 compliant Multisession.	TXM-4101L is external mount Photo CD MPC-2 compliant	64 KB buffer. Photo CD. Multisession. MPC-2 compliant Portable.

MANUFACTURER	TXC	TXC	WEARNES TECHNOLOGY	WEARNES TECHNOLOGY	YAMAHA
DRIVE	TXCD-A4	TXCD-I1	CDD-110	CDD-120	CDE-100 CDE-100 H10
DISK/TREND GROUP	10	10	10	10	11
MARKET	OEM, 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	Dye Polymer
Track format	Spiral	Spiral	Spiral	Spiral	Spiral
DRIVE: Operating mode	Read Only	Read Only	Read Only	Read Only	Write Once
Interface	PC AT	IDE	PC AT	IDE	SCSI-2
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	F: 635	F: 635	F: 661 Mode 2 F: 580 Mode 1
Capacity per track (Bytes)	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	29870
Rotational speed (RPM)	1060-400	1060-400	1000-400	1000-400	2000-800
PERFORMANCE					
Positioner type	Crs: DC Motor Fine: Lens Actuator	Crs: DC Motor 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	Continuous
Average positioning time (msec)	195	195	325	325	NS
Average rotational delay (msec)	55	55	55	55	NS
Average access time (msec)	250	250	380	380	500
Data transfer rate (KBytes/sec)	307.2	307.2	307.2	307.2	614/307/153 3000 asynch.
SIZE (mm: H x W x D)	42.5 x 146 x 216.5	42.5 x 146 x 216.5	41.3 x 146 x 208	41.3 x 146 x 208	114 x 180 x 333
FIRST CUSTOMER SHIPMENT	1Q94	3Q94	3Q93	3Q93	1Q94
COMMENTS	64 KB buffer. Photo CD. Multisession. Tray loading. Philips mechanism.	64 KB buffer. Photo CD. Multisession. Tray loading. Philips mechanism.	64 KB buffer. Photo CD. Multisession. Tray loading.	64 KB buffer. Photo CD. Multisession. Tray loading.	512 KB buffer. External mount. CDE-100 H10 includes 1 GB HDD. Caddy loading.

MANUFACTURER	YAMAHA	YAMAHA			
DRIVE	CDR-100	YPR-301			
DISK/TREND GROUP	11	11			
MARKET	OEM, PCM	OEM, PCM			
MEDIA: Nominal disk diameter	120 mm	120 mm			
Recording medium	Dye Polymer	Dye Polymer			
Track format	Spiral	Spiral			
DRIVE: Operating mode	Write Once	Write Once			
Interface	SCSI-2	SCSI, Propriet.			
Speed control	CLV	CLV			
CAPACITY/RECORDING DENSITY Total capacity (Mbytes)	F: 661 Mode 2 F: 580 Mode 1	F: 620			
Capacity per track (Bytes)	F: N/A	F: N/A			
Data surfaces per spindle	1	1			
Tracks per surface	20750	20750			
Track density (TPI)	15875	15875			
Maximum linear density (BPI)	29870	29870			
Rotational speed (RPM)	2000-800	1060-400			
PERFORMANCE Positioner type	Crs: Linear, Voice Coil Fine: Lens Actuator	Crs: Linear, Voice Coil Fine: Lens Actuator			
Servo type	Continuous	Continuous			
Average positioning time (msec)	NS	NS			
Average rotational delay (msec)	NS	55			
Average access time (msec)	500	NS			
Data transfer rate (KBytes/sec)	3000 asynch.	307.2			
SIZE (mm: H x W x D)	41.3 x 146 x 203	130 x 435 x 382			
FIRST CUSTOMER SHIPMENT	1Q94	1993			
COMMENTS	512 KB buffer Caddy loading	Sold only as part of PDS system. Tray loading. Multiple recording speed			

1994 DISK/TREND REPORT

OPTICAL LIBRARY SPECIFICATIONS

1994 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.

1994 DISK/TREND optical disk product groups

For the 1994 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	ADVANCED DIGITAL INFORMATION	AISIN SEIKI	AMBER TECHNOLOGY	AMBER TECHNOLOGY
LIBRARY	ODSR-2	VLS-MO	JC2000	Rotostar 452	Rotostar 742
DISK/TREND GROUP	51	51	51	50	50
MARKET	Captive	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	12"	86 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	9000	128/256	600-650	540	540
Cartridge type	ATG	ISO	ANSI/ISO	Caddy	Caddy
DRIVE: Type	Write Once	Rewritable-(MO)	Wr.Once,Rewrit.	Read Only	Read Only
Drive models	ATG	Most 5200-S*	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	16*	22	20	52	42
Maximum disk capacity (units)	20	22	20	52	42
Number of drives: Maximum	2	2	2	4	7
Interface: Library Drive	RS232C SCSI	SCSI-2 SCSI-2	SCSI, RS232C Drive dependent	RS232 SCSI	RS232 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	180	5.6	12-13	28.1	22.7
Import/export module (disks)	1	22	1	1	1
PERFORMANCE					
Positioner type	Y axis	X axis tray	Y axis	Rotary	Rotary
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	9	8	5	8	8
Spin-up + drive ready time (sec)	3	7	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	3	4	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	123	47.7	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	12	11	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	1000	512	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	2	1	1 or 2	2	2
FIRST CUSTOMER SHIPMENT	--	4Q93	2Q88	2Q94	2Q94
COMMENTS	*With 2 drives	*Available with other drives on custom basis		Mini silo Can be expanded to 104 disks	Mini silo Can be expanded to 84 disks

MANUFACTURER	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY
LIBRARY	Rotostar CD 252 Rotostar CD 262	Rotostar CD 462	Rotostar 242	Rotostar 252	Rotostar 262
DISK/TREND GROUP	50	50	52	52	52
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	540	540	512	650/1000/1300	1300
Cartridge type	Caddy	Caddy	ISO	ISO	ISO
DRIVE: Type	Write Once	Read Only	Rewritable	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	JVC, Yamaha, Ricoh	Various	Canon	Panasonic, H-P	Sony SMO F521
LIBRARY MECHANISM					
Minimum disk capacity (units)	52	62	42	52	62
Maximum disk capacity (units)	62	62	42	52	62
Number of drives: Maximum	2	4	2	2	2
Interface: Library Drive	RS232 SCSI	RS232 SCSI	RS232 SCSI	RS232 SCSI	RS232 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	33.5	33.5	21.5	Drive dependent	80.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Rotary	Rotary	Rotary	Rotary	Rotary
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	8	8	8	8
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	2.5	Drive dependent	2.5
Spin-down time (sec)	Drive dependent	Drive dependent	2	Drive dependent	2
Average drive access time (msec)	Drive dependent	Drive dependent	90	Drive dependent	50
Non-queued access time (sec)	Drive dependent	Drive dependent	6.5	Drive dependent	6.5
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	1138	Drive dependent	2000
Number of drive data paths: Max.	2	2	2	2	2
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q94	1993	2Q94
COMMENTS	Mini silo Can be expanded to 124 disks	Mini silo Can be expanded to 124 disks	Mini silo Can be expanded to 84 disks	Mini silo Can be expanded to 104 disks	Mini silo Can be expanded to 124 disks

MANUFACTURER	ASACA	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
LIBRARY	ADL-450	1602	ASM	ASM-L1	ASM-N1
DISK/TREND GROUP	53	51	51	51	51
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	12"	12"	12"	12"
Nominal disk capacity (MB)	1200*/1300	Drive dependent	10200	5600	8000
Cartridge type	ANSI/ISO	Drive dependent	ATG Cygnet	LMSI	Nikon
DRIVE: Type	Rewritable-(MO)	Write Once	Write Once	Write Once	Rewritable-(MO)
Drive models	AMD-1341NS* H-P C1716T	ATG, LMS, Sony	G9 9001/5	LD 4100	DD121-1AJ
LIBRARY MECHANISM					
Minimum disk capacity (units)	450	29	22	22	22
Maximum disk capacity (units)	626	29	22	22	22
Number of drives: Maximum	24/4*	2	2	2	2
Interface: Library Drive	RS232C, SCSI-2 SCSI-2	RS232C, SCSI-2 SCSI	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	814	295*	224.4	123.2	176
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	15	6.5	7.2	7.2	8
Spin-up + drive ready time (sec)	6*/2.8	Drive dependent	2.6	3.5	4
Spin-down time (sec)	3*/1.4	Drive dependent	2	1.5	2.2
Average drive access time (msec)	130*/31.8	Drive dependent	116	115	76
Non-queued access time (sec)	13.5*/10.3	Drive dependent	7.1	7.1	8
Drive data transfer rate (KB/s)	12240*/1600	Drive dependent	1500	1000	1100
Number of drive data paths: Max.	4*/24	2	2 (1 per drive)	2 (1 per drive)	2 (1 per drive)
FIRST CUSTOMER SHIPMENT	2Q94	10/91	2Q94	2Q94	2Q94
COMMENTS	*With Asaca 1341NS drive	*With ATG drive			

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
LIBRARY	GF 6910	1800/A2	1800/H1	1800/L2	1800/N1
DISK/TREND GROUP	51	53	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	10200	10200	7000	5600	8000
Cartridge type	Proprietary	ATG	Hitachi	LMSI	Nikon
DRIVE: Type	Write Once	Write Once	Write Once	Write Once	Rewritable-(MO)
Drive models	GD 6001 GD 9001 GD 9001S	ATG GD 9001S	Hitachi OD 321	LMSI 4100	Nikon DD121-1AJ
LIBRARY MECHANISM					
Minimum disk capacity (units)	6	61	61	61	29
Maximum disk capacity (units)	6	141	141	141	141
Number of drives: Maximum	1	5	5	5	5
Interface: Library Drive	SCSI SCSI-2	RS232C, SCSI-2 SCSI	RS232C SCSI-2	RS232C, SCSI SCSI	RS-232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	30.6	1438	987	789.6	1128
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	2	2	2
Average media exchange time (sec)	2.5	7.2	8	7.2	9
Spin-up + drive ready time (sec)	3	2.6	3.5	3.5	5.8
Spin-down time (sec)	2	2.0	3.5	1.5	3.2
Average drive access time (msec)	Drive dependent	116	150	115	137
Non-queued access time (sec)	5.5	7.1	7.5	7.1	8
Drive data transfer rate (KB/s)	1000	1500	1116-2220	1000	1500
Number of drive data paths: Max.	1	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)
FIRST CUSTOMER SHIPMENT	1992	10/91	3Q93	7/91	1Q94
COMMENTS		Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies	Includes model 1602, 1802, 1803

MANUFACTURER	ATG CYGNET	ATG CYGNET	BORETT AUTOMATION TECHNOLOGIES	BORETT AUTOMATION TECHNOLOGIES	BORETT AUTOMATION TECHNOLOGIES
LIBRARY	1800/S	1800/S2	VLC (CD)	VLC (12")	VLC (5.25")
DISK/TREND GROUP	53	53	50	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	120 mm	12"	130 mm
Nominal disk capacity (MB)	6550	6550	600	Drive dependent	1300
Cartridge type	Sony	Sony	Caddy/None	Any	Any
DRIVE: Type	Write Once	Write Once	Wr.Once,Rd.Only	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Sony WDD 600	Sony WDD 930	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	61	61	340	128	288
Maximum disk capacity (units)	141	141	7616*/24640	1792	8064
Number of drives: Maximum	5	5	100	28	100
Interface: Library Drive	RS232C, SCSI SCSI	RS232C SCSI-2	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	923.55	923	4570*/14784	17920	16934
Import/export module (disks)	1	1	40	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Rotary Industrial Robot	Rotary Industrial Robot	Rotary Industrial Robot
Pickers per positioner	2	2	1, 2	1, 2	1, 2
Average media exchange time (sec)	8	8	10	10	10
Spin-up + drive ready time (sec)	3.8	2.4	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	2.1	1.2	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	221	207	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	9	6.4	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	1000	900	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	5 (1 per drive)	5 (1 per drive)	NS	NS	NS
FIRST CUSTOMER SHIPMENT	2Q89	3Q93	--	--	--
COMMENTS	Includes model 1802 and 1803 assemblies	Includes model 1802 and 1803 assemblies	Can mix media types *With caddy	Can mix media types	Can mix media types

MANUFACTURER	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.
LIBRARY	D300	D600	D630	D1230	D75-1
DISK/TREND GROUP	50	50	50	50	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (MB)	540	540	540	540	650/1300
Cartridge type	Caddy	Caddy	Caddy	Caddy	Drive dependent
DRIVE: Type	Wr.Once,Rd.Only	Wr.Once,Rd.Only	Wr.Once,Rd.Only	Wr.Once,Rd.Only	Wr.Once,Rewrit.
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)					47
Maximum disk capacity (units)	309	618	633	1266	77
Number of drives: Maximum	12	24	16	32	3
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI, RS232
Interface: Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	167	334	342	684	61-100
Import/export module (disks)	1	2	1	2	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)	7	7	7	7	7
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.	1-12	1-24	1-16	1-32	1
FIRST CUSTOMER SHIPMENT	7/94	7/94	7/94	7/94	12/91
COMMENTS	Can mix CD ROM and 5.25" drives plus media in 1 library	Can mix CD ROM and 5.25" drives plus media in 1 library	Can mix CD ROM and 5.25" drives plus media in 1 library	Can mix CD ROM and 5.25" drives plus media in 1 library	

MANUFACTURER	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.	DOCUMENT IMAGING SYSTEMS CORP.
LIBRARY	D255-1	D510-2	D525-1	D1050-2	D170
DISK/TREND GROUP	53	53	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650/1300	650/1300	650/1300	650/1300	650/1300
Cartridge type	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	227	444	457	994	150
Maximum disk capacity (units)	257	514	527	1054	170
Number of drives: Maximum	4	8	8	16	4
Interface: Library Drive	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2	SCSI, RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	117-334	117-668	343-686	312-1370	110-221
Import/export module (disks)	1	2	1	2	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)	7	7	7	7	7
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.	1-4	1-8	1-8	1-16	1-4
FIRST CUSTOMER SHIPMENT	12/91	5/92	5/92	5/92	5/92
COMMENTS	Depopulated versions available	Depopulated versions available	Depopulated versions available	Depopulated versions available	Depopulated versions available

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	CDR-1	CDR-2	CDR-3	CDR-4	28 28-U
DISK/TREND GROUP	50	50	50	50	51
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	12"
Nominal disk capacity (MB)	600 (Mode 1)	600 (Mode 1)	600 (Mode 1)	600 (Mode 1)	Drive dependent
Cartridge type	Caddy	Caddy	Caddy	Caddy	Proprietary
DRIVE: Type	Read Only	Read Only	Read Only	Read Only	Write Once
Drive models	NEC CDR 83	NEC CDR 83	NEC CDR 83	NEC CDR 83	ATG, Optimem Sony, Toshiba, LMSI 4100
LIBRARY MECHANISM					
Minimum disk capacity (units)	85	151	411	549	28
Maximum disk capacity (units)	105	191	480	687	28
Number of drives: Maximum	6	14	28	42	2
Interface: Library Drive	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	63	114.6	288	412.2	Drive dependent
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	9	10	11	12	6
Spin-up + drive ready time (sec)	4.0	4.0	4.0	4.0	Drive dependent
Spin-down time (sec)	2.7	2.7	2.7	2.7	Drive dependent
Average drive access time (msec)	280	280	280	280	Drive dependent
Non-queued access time (sec)	6.5	7	7.5	8	Drive dependent
Drive data transfer rate (KB/s)	307.2	307.2	307.2	307.2	Drive dependent
Number of drive data paths: Max.	1	2	4	6	2
FIRST CUSTOMER SHIPMENT	4Q92	4Q92	4Q92	4Q92	11/89
COMMENTS	2 drives minimum	6 drives minimum	14 drives minimum	14 drives minimum	Model 28-U is upgradable to model 48

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	4000	48	100-2000	5100 5300 5500	6300 6400
DISK/TREND GROUP	51	52	53	53	53
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	130 mm	12"	12"	130 mm	130 mm
Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Cartridge type	ANSI/ISO	Proprietary	Proprietary	ANSI/ISO	ANSI/ISO
DRIVE: Type	Wr.Once,Rewrit.	Write Once	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Various	ATG Gigadisc, Optim.,LMSI4100 Sony WDD600	ATG, Optimem, Sony, Hitachi, LMSI, Toshiba	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	18	48	54	24 (5100)	274 (6300)
Maximum disk capacity (units)	28	48	2380	179 (5500)	458 (6400)
Number of drives: Maximum	4	2	120	6 (5300-5500)	16
Interface: Library Drive	RS232C SCSI	RS232C SCSI	RS232C SCSI	RS232C SCSI	RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Import/export module (disks)	1	1	Up to 119*	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	5	7	8-12	6.5	8
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.	1-2	2	Variable	2 to 8	Various
FIRST CUSTOMER SHIPMENT	4/92	11/89	9/87	11/89	6/92
COMMENTS			*Custom configured		

MANUFACTURER	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	FILENET
LIBRARY	560E	2000 ADL	2000 ADL+	6800 ADL	Model 0140 OSAR GTX
DISK/TREND GROUP	52	53	53	53	53
MARKET	Captive,OEM,PCM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	14"	14"	14"	12"
Nominal disk capacity (MB)	654/1300	10200	10200	10200	7000
Cartridge type	Various	ANSI/ISO	ANSI/ISO	ANSI/ISO	Hitachi
DRIVE: Type	Wr.Once,Rewrit.	Write Once	Write Once	Write Once	Write Once
Drive models	Various	6800	2000	6800	Hitachi OD 301
LIBRARY MECHANISM					
Minimum disk capacity (units)	18	15	15	50	96
Maximum disk capacity (units)	60(with 1 drv.)	100/134	100/134	100	125
Number of drives: Maximum	5	1/2	1/2	2	6
Interface: Library	RS232C, SCSI-2	SCSI-2, RS232	SCSI-2, RS232	RS232C, SCSI	RS232, RS422
Interface: Drive	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	78	1366/1020	1742/1300	1020	875
Import/export module (disks)	1	1	1	1	1
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)	6-8	6.5	6.5	6.5	4.0
Spin-up + drive ready time (sec)	Drive dependent	2.4	2.4	2.4	3.0
Spin-down time (sec)	Drive dependent	1.4	1.4	1.4	2.5
Average drive access time (msec)	Drive dependent	700	700	700	150
Non-queued access time (sec)	Drive dependent	5.5	5.5	7	6.0
Drive data transfer rate (KB/s)	Drive dependent	1000	1000	1000	4000
Number of drive data paths: Max.	5	1/2	1/2	2	6
FIRST CUSTOMER SHIPMENT	3Q92	4Q93	3Q94	4Q88	6/91
COMMENTS		Expandable in modules of 25 disks Depopulated versions available	Expandable in modules of 25 disks Depopulated versions available	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)	5600	7000	5600	10200	10200
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	FUJITSU	FUJITSU
LIBRARY	M2522/AX	F6445/A1 M255X/A1	F6445/A2 M255X/A2	F6445/A2X2 M255X/A2X2	M2522/BX
DISK/TREND GROUP	51	53	53	53	53
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	644	644	644	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Drive models	M2504B	M2507L	M2507L	M2507L	M2504B
LIBRARY MECHANISM					
Minimum disk capacity (units)	24	390	780	1560	78
Maximum disk capacity (units)	24	390	780	1560	78
Number of drives: Maximum	2	6	11	10	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	31	251.2	502.3	1004.6	101
Import/export module (disks)	1	10/10	10/10	10/10	1*
PERFORMANCE					
Positioner type	Y axis picker	Rotary Drum Y axis picker	Rotary Drum (2) 2 Y axis picker	Rotary Drum (4) 4 Y axis picker	Rotary Drum Y axis picker
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	10	10	10	9
Spin-up + drive ready time (sec)	5.5	5.5	5.5	5.5	5.5
Spin-down time (sec)	3.5	4.5	4.5	4.5	3.5
Average drive access time (msec)	40	40.6	40.6	40.6	40
Non-queued access time (sec)	9.5	10.5	10.5	10.5	10
Drive data transfer rate (KB/s)	1000-2000	2080	2080	2080	1000-2000
Number of drive data paths: Max.	1	2	2	2	1
FIRST CUSTOMER SHIPMENT	4Q94	4Q91	4Q91	4Q91	3Q94
COMMENTS		Single pass write *With DIR (M109X/F1785)	Single pass write *With DIR (M109X/F1785)	Single pass write *With DIR (M109X/F1785)	*20 cartridges Available with DEF option

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	C1100A C1101A	C1100B C1103 Model 20XT	C1700T C1710T Model 40T	C1708T C1718T Model 20LT	C1713T Model 20T
DISK/TREND GROUP	51	51	51	51	51
MARKET	Captive, PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive, OEM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	1300	1300	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MF)
Drive models	H-P C1716T	H-P C1716T	H-P C1716T	H-P C1716T	H-P C1716T
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	16	32	16	16
Maximum disk capacity (units)	16	16	32	16	16
Number of drives: Maximum	1	1	2	1	1
Interface: Library Drive	SCSI-2* SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	20.8	20.8	41.6	20.8	20.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-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	7	8	7
Spin-up + drive ready time (sec)	2.5	2.5	2.5	2.5	2.5
Spin-down time (sec)	2.0	2.0	2.0	2.0	2.0
Average drive access time (msec)	36	36	36	36	36
Non-queued access time (sec)	6.5	6.5	6.0	6.5	6.0
Drive data transfer rate (KB/s)	1600	1600	1600	1600	1600
Number of drive data paths: Max.	1	1	2	1	1
FIRST CUSTOMER SHIPMENT	4/94	4/94	5/93	5/93	5/93
COMMENTS	*C1100A is single ended. C1101A is differential	C1103 is OEM version			

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI
LIBRARY	C1705T C1715T Model 200T	C1709T C1714T Model 120T	OL101-11 OL101-21	OL112-11 OL112-21	OL301-11 OL301-21
DISK/TREND GROUP	53	53	51	51	51
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	12"
Nominal disk capacity (MB)	1300	1300	600	644	2620
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	Proprietary
DRIVE: Type	Rewritable-(MF)	Rewritable-(MF)	Write Once	Rewritable-(MO)	Write Once
Drive models	H-P C1716T	H-P C1716T	Hitachi OD101	Hitachi OD112-1	Hitachi OD301A1
LIBRARY MECHANISM					
Minimum disk capacity (units)	144	88	24	24	16
Maximum disk capacity (units)	144	88	24	24	16
Number of drives: Maximum	4	4	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)	187	114	14.4	15	42
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	8	7.7	7.7	8.7
Spin-up + drive ready time (sec)	2.5	2.5	2.5	4.0	4.3
Spin-down time (sec)	2.0	2.0	2.5	3.5	3.5
Average drive access time (msec)	36	36	110	70	250
Non-queued access time (sec)	6.5	6.5	7.8	7.8	8.8
Drive data transfer rate (KB/s)	1600	1600	1500	1500	1500
Number of drive data paths: Max.	4	4	1	1	1
FIRST CUSTOMER SHIPMENT	5/93	5/93	1987	1989	1985
COMMENTS			-11 has single ended interface -21 has differential interface	-11 has single ended interface -21 has differential interface	-11 has single ended interface -21 has differential interface. IEEE-488 interface avail

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
LIBRARY	OL301-12 OL301-22	OL101-12 OL101-22	OL112-12 OL112-22	OL114-12 OL114-22	OL152-48 OL152-60
DISK/TREND GROUP	51	52	52	52	52
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	12"	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2620	600	644	644	2022
Cartridge type	Proprietary	ANSI/ISO	ANSI/ISO	ANSI/ISO	Hitachi
DRIVE: Type	Write Once	Write Once	Rewritable-(MO)	Wr.Once,Rewrit.	Rewritable-(MF)
Drive models	Hitachi OD301A1	Hitachi OD101	Hitachi OD112-1	Hitachi	Hitachi OLF152
LIBRARY MECHANISM					
Minimum disk capacity (units)	32	48	48	48	48*
Maximum disk capacity (units)	32	48	48	48	60
Number of drives: Maximum	2	4	4	4	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	83.9	28.8	30	30	121
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8.7	7.7	7.7	7.7	5.8
Spin-up + drive ready time (sec)	4.3	2.5	3.7	4.0	5
Spin-down time (sec)	3.5	2.5	2.7	3.5	3
Average drive access time (msec)	250	110	70	70	50
Non-queued access time (sec)	8.8	7.8	7.8	7.8	7.9
Drive data transfer rate (KB/s)	1500	1500	1500	1500	1540-3020
Number of drive data paths: Max.	1	2	1	4	4
FIRST CUSTOMER SHIPMENT	1985	1987	1989	1991	1Q94
COMMENTS	-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	*With 4 drives Available with single-ended or differential SCSI

MANUFACTURER	HITACHI	HITACHI	HITACHI	IBM	IBM
LIBRARY	OL321-22	OL321-32	OL152-180 OL152-192	3995-022	3995-023
DISK/TREND GROUP	52	52	53	51	51
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)	7000	7000	2022	650	1300
Cartridge type	Proprietary	Proprietary	Hitachi	ISO	ISO
DRIVE: Type	Write Once	Write Once	Rewritable-(MF)	Write Once	Rewritable-(MF)
Drive models	Hitachi OD321	Hitachi OD321	Hitachi OLF152	NS	IBM 0632-CBX
LIBRARY MECHANISM					
Minimum disk capacity (units)	47	64	180*	32	32
Maximum disk capacity (units)	47/127*	64/144*	192	32	32
Number of drives: Maximum	4	2	2	2	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	LAN SCSI	LAN SCSI
Library capacity (Gbytes) (with maximum disk capacity)	329/889*	448/1008*	388	20.8	40
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	6	7	7
Spin-up + drive ready time (sec)	3	3	5	2.5	3
Spin-down time (sec)	3	3	3	1.3	1.3
Average drive access time (msec)	150	150	50	62	67.5
Non-queued access time (sec)	8.5	8.5	8	6.1	6.5
Drive data transfer rate (KB/s)	1500/4000	1500/4000	1540-3020	680	1561
Number of drive data paths: Max.	2	2	4	2	2
FIRST CUSTOMER SHIPMENT	1Q91	1Q91	1Q94	2Q92	8/93
COMMENTS	Dual picker *With expansion unit	Dual picker *With expansion unit	*With 4 drives Available with single-ended or differential SCSI	For LAN Hewlett-Packard mechanism	For LAN Hewlett-Packard mechanism MF version available 5/94

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-042	3995-043	3995-063	3995-A23	3995-A43
DISK/TREND GROUP	51	51	51	51	51
MARKET	Captive	Captive	Captive, OEM	Captive, OEM	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	1300	1300	1300	1300
Cartridge type	ISO	ANSI/ISO	ISO	ISO	ANSI/ISO
DRIVE: Type	Write Once	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MF)	Rewritable-(MF)
Drive models	NS	IBM 0632-CBX	IBM 0632-C2X	IBM 0632-CBX	IBM 0632-CBX
LIBRARY MECHANISM					
Minimum disk capacity (units)	32	32	32	16	16
Maximum disk capacity (units)	32	32	32	16	16
Number of drives: Maximum	2	2	2	1	1
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	20.8	40	40	20	20
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)	7	7	7	7	7
Spin-up + drive ready time (sec)	2.5	3	3	3	3
Spin-down time (sec)	1.3	1.3	1.3	1.3	1.3
Average drive access time (msec)	62	67.5	67.5	67.5	67.5
Non-queued access time (sec)	6.1	6.5	6.5	6.5	6.5
Drive data transfer rate (KB/s)	680	1561	1561	1561	1561
Number of drive data paths: Max.	2	2	2	1	1
FIRST CUSTOMER SHIPMENT	2Q92	6/94	8/93	10/93	6/94
COMMENTS	For AS/400 Hewlett-Packard mechanism	For AS/400 Hewlett-Packard mechanism	For RS/6000 Hewlett-Packard mechanism MF version available 1Q94	For PS/2 with OS/2, AS/400 Hewlett-Packard mechanism. MF version available 1Q94	For AS/400 Hewlett-Packard mechanism

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-A63	3995-112	3995-113	3995-122	3995-123
DISK/TREND GROUP	51	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	1300	650	1300
Cartridge type	ANSI/ISO	ISO	ISO	ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MF)	Write Once	Rewritable-(MF)	Write Once	Rewritable-(MF)
Drive models	IBM 0632-CBX	NS	IBM 0632-C2X	NS	IBM 0632-CBX
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	144	144	144	144
Maximum disk capacity (units)	16	144	144	144	144
Number of drives: Maximum	1	4	4	5	5
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	LAN SCSI	LAN SCSI
Library capacity (Gbytes) (with maximum disk capacity)	20	93.6	188	93.6	188
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)	7	8	8	8	8
Spin-up + drive ready time (sec)	3	2.5	3.1	2.5	3.1
Spin-down time (sec)	1.3	1.3	1.3	1.3	1.3
Average drive access time (msec)	67.5	62	67.5	62	67.5
Non-queued access time (sec)	6.5	6.1	7.1	6.1	7.1
Drive data transfer rate (KB/s)	1561	680	1272	680	1561
Number of drive data paths: Max.	1	4	4	5	5
FIRST CUSTOMER SHIPMENT	6/94	4Q91	6/93	2Q92	8/93
COMMENTS	For RS/6000 Hewlett-Packard mechanism	Expansion unit for Write Once libraries Hewlett-Packard mechanism	Expansion unit for Rewritable libraries. Hewlett-Packard mechanism. MF version available 1Q94	For LAN Hewlett-Packard mechanism	For LAN Hewlett-Packard mechanism MF version available 5/94

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-133	3995-142	3995-143	3995-153	3995-163
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive, OEM	Captive	Captive	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	650	1300	1300	1300
Cartridge type	ANSI/ISO	ISO	ANSI/ISO	ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MF)	Write Once	Rewritable-(MF)	Rewritable-(MO)	Rewritable-(MF)
Drive models	IBM 0632-CBX	NS	IBM 0632-CBX	IBM 0632-C2X	IBM 0632-CBX
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	4	5	4
Interface: Library Drive	S/370* SCSI	SCSI SCSI	SCSI SCSI	S/370* SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	188	93.6	188	178	188
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)	3.1	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)	67.5	62	67.5	67.5	67.5
Non-queued access time (sec)	7.1	6.1	7.1	7.1	7.1
Drive data transfer rate (KB/s)	1561	680	1561	1272	1561
Number of drive data paths: Max.	4	4	4	5	4
FIRST CUSTOMER SHIPMENT	1Q94	12/93	6/94	3Q93	1Q94
COMMENTS	For MVS/ES systems Hewlett-Packard mechanism *OEMI channel	For AS/400 Hewlett-Packard mechanism	For AS/400 Hewlett-Packard mechanism	*OEMI channel Hewlett-Packard mechanism	For 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	8100
DISK/TREND GROUP	51	51	51	51	52
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	654	654	654	650	Drive dependent
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO	ANSI/ISO
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	10	20	20	5	26
Maximum disk capacity (units)	10*	20	25	5	53
Number of drives: Maximum	1	1	2	1	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	6.5/10.3	30 max.	30 max.	6.5 max.	79.5 max.
Import/export module (disks)	1	1	1	5	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	5.5	7	7	5.2
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	12/93
COMMENTS	*11 with Panasonic drive Ruggedized version		105 MB Winchester buffer is optional		

MANUFACTURER	K&S	K&S	K&S	KUBIK ENTERPRISES	KUBIK ENTERPRISES
LIBRARY	CDJ-30	Megastore 1000	Megastore 1000/M	CDR240M	DDC-240
DISK/TREND GROUP	50	51	53	50	50
MARKET	OEM	OEM, PCM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm/80 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	540/600	654/1024*	650/1500*	550	550
Cartridge type	Caddy	ISO, ZCAV*	ANSI	N/A	N/A
DRIVE: Type	Write Once	Rewritable-(MO)	Rewritable	Read Only	Read Only
Drive models	Philips, other	Various	Sony, Maxoptix, Matsushita LF7300Z, Ricoh	Toshiba, others on request	LMSI, Sony
LIBRARY MECHANISM					
Minimum disk capacity (units)	30	10	10	240	240
Maximum disk capacity (units)	30	10	80	240	240
Number of drives: Maximum	1	1	4	4	1
Interface: Library Drive	SCSI-2 SCSI, SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI, SCSI-2	RS232C SCSI	RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	18	6.5/10.2*	120*	132	132
Import/export module (disks)	1/15	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	Rotary	Rotary
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	30	18	18	7	7
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	1	1
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	1	1
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	NS	NS
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	307.2	307.2
Number of drive data paths: Max.	1	1	1	4	1
FIRST CUSTOMER SHIPMENT	1994	9/91	1994	1992	1990
COMMENTS		*With Maxoptix drive	*With LF7300Z Available with 10, 20, 40 or 80 cartridges	Rack mount available	Rack mount available

MANUFACTURER	LOGICAL ENGINEERING	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
LIBRARY	ROMBOX 300	LF-J7000A	LF-J7324A LF-J7324AN	LF-J7328A LF-J7328AN	LF-J7350A
DISK/TREND GROUP	50	52	52	52	52
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	1000	1500	1500	1500
Cartridge type	None	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Wr.Once,Rd.Only	Rewritable-(MO)	Rewritable-(PC)	Rewritable-(PC)	Rewritable-(PC)
Drive models	Toshiba, Kodak, Philips, Yamaha	MEI LF-7012Z	MEI LF-7394	MEI LF-7394	MEI LF-7394
LIBRARY MECHANISM					
Minimum disk capacity (units)	300	50	24	28	50
Maximum disk capacity (units)	300	50	24	28	50
Number of drives: Maximum	2	2	2	1	2
Interface: Library Drive	RS232C/RS422	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	162	50	36	42	75
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	20	8	6.5	6.5	7
Spin-up + drive ready time (sec)	2	4	6	6	6
Spin-down time (sec)	2	2.5	2.5	2.5	2.5
Average drive access time (msec)	200	107	57.5	57.5	57.5
Non-queued access time (sec)	12	8	9.25	9.25	9.5
Drive data transfer rate (KB/s)	Drive dependent	1500/4000*	1500/5000*	1500/5000*	1500/5000*
Number of drive data paths: Max.	2	1/2	1/2	1	1/2
FIRST CUSTOMER SHIPMENT	1993	7/91	3/94	1/94	2/94
COMMENTS	Can have 2 CD-ROM or 1 CD-ROM and 1 CD-R drive	*SCSI synchronous mode	*SCSI synchronous mode Also available with 1400 MB WORM drive	*SCSI synchronous mode Also available with 1400 MB WORM drive	*SCSI synchronous mode Also available with 1400 MB WORM drive

MANUFACTURER	MICROBOARDS	MOST	MOST	MOST	NAKAMICHI
LIBRARY	DataWrite	MODL	ODL-5600	ODL-8400	MBR-7
DISK/TREND GROUP	50	51	51	51	50
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	86 mm	86 mm	86 mm	120 mm/80 mm
Nominal disk capacity (MB)	600	384	128/256/384	128/230/256/384	600
Cartridge type	None	ANSI/ISO	ISO		None
DRIVE: Type	Read Only	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Read Only
Drive models	Sony	Most RMD 5300S	Most RMD 5200	Most RMD 5300	Nakamichi
LIBRARY MECHANISM					
Minimum disk capacity (units)	360	22	22	22	7
Maximum disk capacity (units)	360	22	22	22	7
Number of drives: Maximum	2	2	2	2	1
Interface: Library Drive	RS232/SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI, SCSI-2	SCSI-2 SCSI, SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	216	8.45	5.6	8.4	4.2
Import/export module (disks)	1	22	22	22	1
PERFORMANCE					
Positioner type	Y axis	X axis tray	X axis	X axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	11	8	6	6	2.1
Spin-up + drive ready time (sec)	2	7	6	6	Included
Spin-down time (sec)	1	4	3.5	3.5	Included
Average drive access time (msec)	350	47	35	35	435
Non-queued access time (sec)	7.5	11	9	9	NA
Drive data transfer rate (KB/s)	300	860-1500	512-1228	1024-1500	300
Number of drive data paths: Max.	1/2	1	2	2	1
FIRST CUSTOMER SHIPMENT	2Q94	1Q94	2Q94	3Q94	3Q94
COMMENTS	Sony mechanism	ADIC mechanism Operates with 128, 256 and 384 MB disks	Purchased mechanism	Purchased mechanism	64 KB buffer 256 KB option Photo CD Multisession

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
LIBRARY	N1137-06	N1137-58	N7923	N5817-31/32 N7925-82	N7925-83
DISK/TREND GROUP	51	51	51	52	52
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	12"	130 mm	130 mm
Nominal disk capacity (MB)	610	1300	5000	610	1300
Cartridge type	ANSI/ISO	ANSI/ISO	Proprietary	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable-(MO)	Rewritable-(MO)	Write Once	Rewritable-(MO)	Rewritable-(MO)
Drive models	NEC N1137-04	NEC N1137-57	NEC N7913	NEC N7915 NEC N5817-11	NEC N7915-85
LIBRARY MECHANISM					
Minimum disk capacity (units)	4	4	36	46	46
Maximum disk capacity (units)	4	4	36	67	67
Number of drives: Maximum	1	1	2	4	4
Interface: Library Drive	SCSI SCSI	SCSI SCSI	NEC Proprietary	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	2.4	5.2	180	40	78
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	2	1	2
Average media exchange time (sec)	10	6	14	10	10
Spin-up + drive ready time (sec)	4	8	8	4	8
Spin-down time (sec)	4	5	8	4	5
Average drive access time (msec)	60	42	200	60	42
Non-queued access time (sec)	8	11	15	9	13
Drive data transfer rate (KB/s)	1500	3000	900	1500	3000
Number of drive data paths: Max.	1	1	2	1	1
FIRST CUSTOMER SHIPMENT	1991	1993	6/90	1992	1993
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)	1300	1300	1300	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-F521, IBM 0632-C2D	Sony SMO-F521, IBM 0632-C2D	Sony SMO-F521 IBM 0632-C2D	Sony, Pioneer, Maxoptix, IBM	Maxoptix
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)	10.3	20.8	83.2	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	Sony	Maxoptix	Pioneer	Sony
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 Drive	SCSI-2 SCSI	SCSI-2 SCSI	SCSI-2 SCSI	SCSI-2 SCSI	SCSI-2 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	NSM	OLYMPUS	PHILIPS LMS	PHILIPS LMS
LIBRARY	CDR 100 Recordable	CDR 100 XA	OLS 10NSS OLS S10	LF 4500	LF 4502
DISK/TREND GROUP	50	50	51	51	51
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	12"	12"
Nominal disk capacity (MB)	600	600	1300	5600	5600
Cartridge type	NSM	NSM	ANSI/ISO	LMSI	LMSI
DRIVE: Type	Write Once	Read Only	Rewritable-(MF)	Write Once	Write Once
Drive models	JVC	Toshiba	Olympus MOS 525E	LMSI LD 4100	LMSI LD 4100
LIBRARY MECHANISM					
Minimum disk capacity (units)	100	100	10	5	10
Maximum disk capacity (units)	100	100	10	5	10
Number of drives: Maximum	1	1	1	1	2
Interface: Library Drive	SCSI-2, RS232 SCSI	SCSI-2, RS232 SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	60	60	13	28	56
Import/export module (disks)	50/1	50/1	1	5	5
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	Moving Magazine	Moving Magazine
Pickers per positioner	2	2	1	N/A	N/A
Average media exchange time (sec)	4.5	4.5	6	3	3
Spin-up + drive ready time (sec)	1.5	1.5	4	2.5	2.5
Spin-down time (sec)	1.0	1.0	3	1.5	1.5
Average drive access time (msec)	200	200	33.5	130*	130
Non-queued access time (sec)	4.3	4.3	7	5.5	5.5
Drive data transfer rate (KB/s)	307.2	307.2	1200-2300	700/1800**	700/1800*
Number of drive data paths: Max.	1	1	1	1	2
FIRST CUSTOMER SHIPMENT	3/94	1/94	2Q94	4Q91	1Q92
COMMENTS				*Includes command overhead **Asynchronous mode. Dual head drive	2 LF 4500 in single cabinet *Asynchronous mode Dual head drive

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	RICOH
LIBRARY	DRJ-5004X	DRM-1804X	DRM-602X	DRM-604X	RF5210E
DISK/TREND GROUP	50	50	50	50	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (MB)	540	540	540	540	1300
Cartridge type	N/A	N/A	N/A	N/A	ANSI/ISO
DRIVE: Type	Read Only	Read Only	Read Only	Read Only	Rewritable-(MO)
Drive models	Pioneer 4X	Pioneer (integrated with drive)	Pioneer (integrated with drive)	Pioneer (integrated with drive)	Ricoh RO-5060E
LIBRARY MECHANISM					
Minimum disk capacity (units)	100	18	6	6	16
Maximum disk capacity (units)	500	18	6	6	16
Number of drives: Maximum	4	1	1	1	1
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	270	9.72	3.24	3.24	20.9
Import/export module (disks)	100	18	6	6	1
PERFORMANCE					
Positioner type	Y axis	NS	NS	NS	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	19	5	5	5	5
Spin-up + drive ready time (sec)	3	3	NS	NS	5.5
Spin-down time (sec)	2	2	NS	NS	5
Average drive access time (msec)	300	300	300	300	40.7
Non-queued access time (sec)	13	NS	NS	NS	8
Drive data transfer rate (KB/s)	614	614.4/153.6	307.2/153.6	614.4/153.6	5000 synch.
Number of drive data paths: Max.	4	1	1	1	1
FIRST CUSTOMER SHIPMENT	3Q94	4Q93	4Q93	3Q92	2Q94
COMMENTS	Photo CD Multisession	Photo CD Multisession	Photo CD Multisession	Photo CD Multisession	

MANUFACTURER	RICOH	SIGMA DESIGNS IMAGING SYSTEMS	SONY	SONY	SONY
LIBRARY	RJ5830E	DP 520	OSL 2000	WDA-E330	WDA-610
DISK/TREND GROUP	52	53	51	51	52
MARKET	OEM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	12"	12"
Nominal disk capacity (MB)	1300	650/1300	650/1300	6552	6552
Cartridge type	ANSI/ISO	ISO	ANSI/ISO	Proprietary	Proprietary
DRIVE: Type	Rewritable-(MO)	Wr.Once,Rewrit.	Rewritable-(MF)	Write Once	Write Once
Drive models	Ricoh RO-5060E	IBM multifunction	Sony E521	Sony WDD 930-01	Sony WDD 600-01
LIBRARY MECHANISM					
Minimum disk capacity (units)	64	108	20	12	50
Maximum disk capacity (units)	64	288	20	12	50
Number of drives: Maximum	2	10	2	1	2
Interface: Library	SCSI-2	RS232	RS232	SCSI-2	SCSI
Interface: Drive	SCSI-2	SCSI	SCSI-2	SCSI-2	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	83.5	187/374	26	78.6	327.6
Import/export module (disks)	16/1	1	1, 10	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	2	1	1	1
Average media exchange time (sec)	5	4*/6	5.5	3.0	5
Spin-up + drive ready time (sec)	5.5	Drive dependent	2.5	2.4	2.4
Spin-down time (sec)	5	Drive dependent	2	2.5	1.1
Average drive access time (msec)	40.7	Drive dependent	50	208/637	221/455
Non-queued access time (sec)	8	Drive dependent	5.25	4	5
Drive data transfer rate (KB/s)	5000 synch.	Drive dependent	2000	900	600
Number of drive data paths: Max.	1/2	4	2	1	1
FIRST CUSTOMER SHIPMENT	2Q94	3Q93	2Q94	3Q92	9/89
COMMENTS		*With 2 drives installed			Can attach 7 units to 1 SCSI port

MANUFACTURER	SONY	TAC SYSTEMS	TODD ENTERPRISES	VICTOR DATA SYSTEMS (JVC)	
LIBRARY	WDA-E930	Juke Drive	TAJ-2000	DM-5000	
DISK/TREND GROUP	53	50	50	50	
MARKET	OEM	OEM	OEM	OEM	
MEDIA: Nominal disk diameter	12"	120 mm	120 mm	120 mm	
Nominal disk capacity (MB)	6552	600	680	600	
Cartridge type	Proprietary	None	Caddy	None	
DRIVE: Type	Write Once	Read Only	Read Only	Read Only	
Drive models	Sony WDD 930-01	Hitachi CDR-6750	Hitachi CDR-6750	JVC	
LIBRARY MECHANISM					
Minimum disk capacity (units)	47	24	174	360	
Maximum disk capacity (units)	77	24	203	360	
Number of drives: Maximum	4	1	14	2	
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	Ethernet SCSI	SCSI-2 SCSI-2	
Library capacity (Gbytes) (with maximum disk capacity)	504.5	14.4	132	216	
Import/export module (disks)	1	1	--	1	
PERFORMANCE					
Positioner type	Y axis	Rotary	X-Y axis	Y axis	
Pickers per positioner	1	1	1	1	
Average media exchange time (sec)	5	7	12	30	
Spin-up + drive ready time (sec)	2.4	2	8-9		
Spin-down time (sec)	1.2	1	2		
Average drive access time (msec)	208/637	245	235	360	
Non-queued access time (sec)	5	5.5	14		
Drive data transfer rate (KB/s)	900	300	307.2	150	
Number of drive data paths: Max.	1	1		1	
FIRST CUSTOMER SHIPMENT	4Q92	1/94	1994	3Q94	
COMMENTS		Purchased mechanism	Photo CD Multisession UNIX server	Preliminary specification	

MANUFACTURER PROFILES

1994 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 1993, this figure is reported explicitly only for firms with major 1993 sales. "1993 total net sales" covers the fiscal year ending in 1993 for each firm unless noted otherwise, or for the parent company if the manufacturer is a subsidiary. Fiscal years end on December 31, 1993, 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 1993 is used, as cited by the Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
France	French franc	5.67
Germany	Deutschmark	1.65
Hong Kong	Hong Kong dollar	7.74
Japan	Yen	111.0
Malaysia	Ringgit	2.57
Netherlands	Guilder	1.86
Singapore	Singapore dollar	1.62
South Korea	Won	806.0
Taiwan	Taiwan dollar	26.4
United Kingdom	Pound	.667

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 supplies the library in limited quantities to its own end users and, until late 1994, for resale through ATG Cygnet.

ADVANCED DIGITAL INFORMATION CORPORATION (ADIC)
14737 NE 87th Street
Redmond, WA 98073

ADIC is a supplier of backup subsystems and controller boards for personal computers. The firm developed a tabletop library for 3.5" drives and announced the product in late 1993. Several manufacturers of 3.5" drives were actively evaluating the library as of mid-1994, but only MOST had begun production of a library incorporating its 3.5" drive family with the ADIC mechanism.

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 several improvements to the basic design. Borett libraries can handle disks in CD-ROM caddies, and 5.25" and 12" optical disk cartridges, as well as various tape cartridges.

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

CD-ROM, founded in 1988, is a U.S. owned and headquartered manufacturer of CD-ROM drives (using purchased mechanisms). 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.

CYGNET SYSTEMS, INC. (See ATG Cygnet, in European manufacturers section)

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1993 total net sales: $14,371,369,000 (FY ending 6/27/93) Net income: ($251,330,000)

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 buy drives and libraries externally.

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. A library capable of handling CD-ROM media was introduced at the 1994 AIIM conference.

DOCUPOINT CORPORATION (See Sigma Designs Imaging Systems)

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1993 total net sales: $16,364,000,000 Net income: ($1,515,000)

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 the now defunct Literal Corporation, in which Eastman Kodak had 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, are supplied by Philips to attach to consumer TV sets for playback of the images. Philips is also supplying the CD recorders used by participating photo processors, although Kodak expects to be in production of its own CD-R drive late in 1994 using a purchased mechanism. 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. A 6.5 gigabyte per side version was announced in 1994. The drive is used in Eastman Kodak's image storage product lines and is also offered on an OEM basis as a computer peripheral.

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

1993 total net sales: $158,808,000 (FY ending 1/2/94) Net income: $7,767,000

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 deemphasizing 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 340 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 700 systems, mostly 12", as of mid-1994. 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

1993 total net sales: $20,317,000,000 Net income: $1,777,000,000
(FY ending 10/31/93)

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 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 stand-alone and jukebox configurations. The new H-P optical drives have 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, went into production status in 1993. The mechanical mechanism is made for H-P by a contract manufacturer.

Write-once technology using magneto-optic media (Continuous Composite WORM) 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. Despite large increases in production, as of mid-1994, Hewlett-Packard was moving towards a view of internal optical drive manufacturing as nonstrategic and is considered more likely to be a drive purchaser than a drive manufacturer for future generations of drives.

H-P is the leading revenue producer in the 5.25" optical library market, 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 and through resellers.

H-P was one of the earliest users of CD-ROM for distribution of documentation and software. 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, later 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. Capacity per side will probably be in the 400 to 600 megabyte range.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1993 total net sales: $62,716,000,000 Net income: ($7,987,000,000)

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 is a very active participant in the optical drive and media standards committees and has also become a major distributor of software and documentation on CD-ROM disks.

IBM's optical program is directed from Tucson, Arizona, but some IBM optical products are made in locations other than Tucson, including Southeast Asia. The 5.25" optical drive development staff and laboratories remain in Tucson, but development of 3.5" drives is under way in Fujisawa, Japan. Some advanced development is done at the Almaden research facilities, including work on short wavelength lasers and a stacked disk design announced in 1994.

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. IBM is actively involved in the design of systems using multimedia techniques involving a variety of optical drive types, including CD-ROM and magneto-optic drives.

In 1987, IBM announced the model 3363 5.25" write-once drive for use with its personal computers. The mechanism for this drive was obtained from Matsushita Electric, with IBM supplying the electronics, software, and performing final assembly and test. The product was unsuccessful and was finally withdrawn from marketing in 1991.

IBM's own 5.25" magneto-optic drive was shown at the 1991 COMDEX show and formally announced in 1992. It has since been replaced by the double capacity 654 megabyte per side drive introduced by IBM in March, 1993. A more recent half high multifunction version can use ablative or MO media. The new drive is used in IBM system libraries and also sold to OEMs. IBM is very active in standards work aimed at 1.3 gigabyte per side 5.25" drives and high capacity 3.5" drives.

In 1991, IBM announced a 3.5" 128 megabyte MO drive that had been designed at its Fujisawa facilities. The drive was 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, pushed for a 230 megabyte standard for the next generation of 3.5" drives. IBM did introduce such a drive, though Sony did not. In October of 1993, IBM announced a 1 inch high 3.5" lower power MO drive developed in conjunction with Philips Key Module Group, and indicated that there would be additional joint developments in the future.

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 were used with the libraries until IBM put its own 5.25" multifunction drive into production. IBM now uses its own 650 megabyte per side magneto-optic and multifunction drives to provide storage for its libraries. 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 its 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
Subsidiary of Plasmon Data Systems
727 Washington Avenue South
Edina, MN 55439

Founded in 1987, IDE was originally 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 remarketed by many 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. A 26 cartridge 5.25" drive library was introduced in late 1993, and a 53 cartridge model was first shipped in December of 1993. As of mid-1994, IDE remained the leading supplier of small 5.25" optical libraries, closely pursued by Hewlett-Packard. The firm was purchased by Plasmon Data Systems in 1994, but continues to operate under its original name for recognition in the OEM market it serves.

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. The 240 disk 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 is expected to explore contract manufacturing arrangements as volume increases.

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. Kawatetsu is a subsidiary of Kawasaki Steel, which later had an investment 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 held about 26% of Literal, and Kawasaki Steel owned about 21%. The remainder was held by earlier ISI investors. The initial ISI product was a 122 megabyte 5.25" write-once drive, 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 used a technique called track compression to achieve the higher capacity.

Literal's later efforts were 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 was suspended and the firm concentrated its development efforts on higher capacity write-once 5.25" drives. Due to the demise of Optical Storage Corporation, the sole supplier of Literal's media, and increasing competition from higher capacity MO drives, customer interest in Literal waned and the firm discontinued operations in 1993, selling its optical drive product line to Sierra Technologies.

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 drive's original supplier, but the operation was sold to Martin Marietta 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 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 remained at low levels, mostly to existing customers, and in late 1993 the firm disbanded, turning over its optical drive customer base to Sierra Technologies.

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 63% 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 historically 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, but its current strategy emphasizes optical subsystem integration and reduces the firm's reliance upon drive sales for growth.

Although Maxtor pioneered the market for high performance 5.25" rigid disk drives, the company now concentrates on 3.5" drives for personal computers and 1.8" drives for notebook computers and specialized applications. 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" MO rewritable drive with 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 Maxoptix double capacity drive with a 19 millisecond seek time was introduced in June, 1993.

MEDIA VISION, INC.
47300 Bayside Parkway
Fremont, CA 94538

Media Vision is a manufacturer of multimedia products, video cards and sound board add-ons for personal computers. While the firm buys most of its CD-ROMs, a portable model is manufactured for the company on a contract basis by one of the Matsushita companies. The company is under severe financial strain and entered Chapter 11 status in mid-1994. As a result, Media Vision's future interest in proprietary drives is uncertain.

MOUNTAINGATE DATA SYSTEMS (Formerly Cherokee Data Systems)
Subsidiary of Lockheed Corporation
9393 Gateway
Reno, NV 89511

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 in 1986 invested $2,000,000 in Cherokee, intending 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 non-ruggedized version of the drive became available in late 1989. In 1992, Lockheed purchased the remaining interest in Cherokee and the company moved to new facilities in Reno. 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.

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, founded in 1987, 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. In 1994, Pinnacle introduced the Orray, an array of 5.25" optical drives with a controller that can operate them concurrently.

SIERRA TECHNOLOGIES CORPORATION
2938 Janitell Road
Colorado Springs, CO 80906

Founded in November, 1993 by former employees of defunct Literal Corporation, Sierra is doing end-of-life assembly of drives and media inherited from Literal and its licensee, Maximum Storage. A very limited supply of new drives is available to existing customers, but enough media is available to meet needs for the next few years.

In addition, the firm is remarketing high capacity drives from Matsushita Electric, and is slowly converting the old Literal customer base to the MEI phase change media based product line.

SIGMA DESIGNS IMAGING SYSTEMS (Formerly Docupoint Corporation)
46515 Landing Parkway
Fremont, CA 94538

Docupoint, a document imaging systems manufacturer, was also a manufacturer of modular 5.25" optical library systems. The firm was founded in 1988. In late 1993, Sigma Designs, which held a controlling interest in the firm, merged its terminal product line with the Docupoint line and reorganized the organization as a wholly owned subsidiary under its current name. Optical libraries accounted for a relatively small part of the firm's total revenues in 1993.

The company's current product is the DP520 library, which holds up to 10 drives and up to 288 5.25" cartridges. Introduction of the library was made at the 1992 AIIM conference, with production shipments beginning in early 1993. With its reorganization complete, SDIS is expected to engage in aggressive cost reduction and marketing efforts, as well as expanding its optical library product.

TAC SYSTEMS, INC.
1031 Putnam Drive
Huntsville, AL 35814

TAC Systems has been building subsystems incorporating multiple CD-ROM drives since 1991. In 1994, the firm introduced the JukeDrive, a rotary CD-ROM library with 24 disk capacity. The library is based upon a purchased mechanism.

TODD ENTERPRISES
31 Water Mill Lane
Great Neck, NY 11021

Todd Enterprises, established in 1971, is a producer of storage subsystems, including CD-ROM jukeboxes, single and multidrive CD-ROM subsystems. The firm has shown a 200 disk library at several trade shows and is in limited production of the library.

Asian Manufacturers

(All fiscal years end in March, 1993, unless otherwise noted. All companies are in Japan unless otherwise noted.)

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

1993 total net sales: $7,553,964,000 Net income: $105,649,000

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 were not shipped until 1990.

AIWA COMPANY, LTD.
Subsidiary of Sony Corporation
1-11-6 Higashi-Nakano
Nakano-ku, Tokyo 164

1993 total net sales: $1,586,874,000 Net income: $19,793,000

Aiwa was formed in 1951 and originally was a producer of telephone and audio equipment. Sony holds a 52.5% share in the company. The firm today manufactures audio and video products, helical scan tape drives, modems and CD-ROM drives. Aiwa began shipping a double speed drive in 1994 and plans higher performance drives.

ALCO ELECTRONICS LTD.
1067 King's Road
Quarry Bay
Hong Kong

Alco Electronics, a member of the Alco Group, was established in 1968 as a manufacturer of audio products. Alco Digital Devices was created in 1993 to design and manufacture CD-ROM drives. Purchased mechanisms are used, with final assembly in Dongguan, China. A top loading single speed model was supplemented by a tray loading double speed unit in 1994.

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

1993 total net sales: $3,775,973,000 Net income: ($16,766,000)

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 1993. Alps has supplied components to other companies wishing to supply CD-ROMs and is able to supply design assistance, components, and to manufacture on a contract basis. In 1994, the firm began to market CD-ROM drives under its own name.

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.

AZTECH SYSTEMS LTD.
31 Ubi Road 1
Singapore 1440

Aztech was founded in 1986. The firm produces a variety of multimedia related products, including video and sound boards for personal computers and CD-ROM drives. Production of double speed drives with PC and IDE interfaces began in 1994.

BEHAVIOR TECH COMPUTER CORPORATION
12/F, No. 18, Section 1
Chang An East Road
Taipei
Taiwan

Established in February, 1982, BTC is a manufacturer of computer components such as keyboards, mice, trackballs, power supplies and various cards.

CD-ROM drives (using purchased mechanisms) were added to the product line in 1994.

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

1993 total net sales: $16,541,748,000 (FY ending 12/31/93) Net income: $190,108,000

Canon is a major supplier of business machines, copiers, and cameras, but about 42% of the firm's business is in computer peripherals. Another 14% 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 only for use in its own Canofile document management systems.

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

1993 total net sales: $460,486,000 Net income: ($28,964,000)

Chinon is best known for its cameras and lenses, but 70% 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 and the product line has since been expanded to include double speed drives. A 128 megabyte 3.5" drive was announced in 1992 and began shipping in early 1993. Chinon began shipping double speed CD-ROM drives in 1993. A quad speed drive is scheduled for shipment in late 1994.

CREATIVE TECHNOLOGY LTD.
67 Ayer Rajah Crescent #03-18
Singapore 0513

Creative Technology, founded in July, 1981, and its U.S. subsidiary, Creative Labs (established in 1988) are the largest suppliers of soundboards, multimedia add-on kits and related products for personal computers. The company has been a purchaser of CD-ROM drives, but is expected to begin producing its own drives using purchased mechanisms in the second half of 1994.

ELITEGROUP COMPUTER SYSTEMS CO., LTD.
No. 1, Lane 159, Lite Road
Pei Tou, Taipei
Taiwan

Motherboards and accessories for personal computers are Elitegroup's primary business. The firm showed a family of CD-ROM drives manufactured with Sony mechanisms at the 1994 COMPUTEX show in Taipei.

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

1993 total net sales: $31,166,079,000 Net income: ($293,500,000)

Fujitsu is Japan's largest producer of computer systems and also manufactures a wide variety of other electronic equipment. Computer products represented about 69% of Fujitsu's 1993 sales.

Fujitsu announced a write-once 12" drive for use in its document storage systems in 1984. The product was 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 MO rewritable drive with 8.9 gigabyte capacity was introduced in 1989. It was offered only in Japan and has since been discontinued.

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. The firm was among the earliest to introduce a 230 megabyte 3.5" drive, has succeeded in capturing a major share of the 3.5" market, and is expanding its production capacity for 3.5" drives in 1994.

FUNAI ELECTRIC
7-7-1 Nakagaito
Daito-shi, Osaka 574

1993 total net sales: $1,146,216,000 Net income: $1,189,000

Funai Electric, founded in 1961, manufactures audio and video equipment, telecommunications equipment, and audiovisual products. As a result of doing large scale contract manufacturing of CD-ROM drives for a major game company, the firm initiated a line of upgraded CD-ROM drives under its own name, with first shipments in 1993. A double speed IDE interface drive is scheduled for shipment in late 1994.

GOLDSTAR COMPANY, LTD.
20 Yoido-dong
Youngdungpo-gu
Seoul 150
Republic of Korea

1992 total net sales: $4,700,527,000 Net income: $32,901,000

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 double speed CD-ROM drives, and has announced a CD-I player, to be produced in Korea under a Philips license.

GROUP SENSE LTD.
213 Queens's Road East
Wanchai
Hong Kong

Group Sense is a producer of handheld electronic products such as games, translators and palmtop computers. Double speed CD-ROM drives manufactured with purchased mechanisms were added to the product line in 1994.

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

1993 total net sales: $67,844,490,000 Net income: $695,796,000

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 44% of 1993 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 began shipping a 5.25" one gigabyte per side magneto-optic drive in late 1993. Quantities shipped to date have been modest.

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.

HOPAX INDUSTRIES
No. 51, Section 2
Chung Ching South Road
Taipei
Taiwan

Hopax got started in the CD-ROM business as a manufacturer of optical pickups. The firm has leveraged this experience and now plans to manufacture double speed drives starting in 1994, with a quad speed drive planned for future production.

JUKO ELECTRONICS INDUSTRIAL CO. LTD.
Subsidiary of Juko Laboratories Holdings
8 Tai Chung Road
Tsuen Wan, New Territories
Hong Kong

The Juko organization began life in 1985 as a distributor of components, but rapidly developed into a manufacturer of motherboards and cards for personal computers. Juko Electronics is manufacturing CD-ROM drives at facilities in China using Sanyo mechanisms. The drives are double speed models with SCSI interface. IDE versions are planned for future development.

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

1993 total net sales: $6,926,964,000 Net income: $388,027,000

JVC, as it is commonly known, is a major producer of consumer audio equipment, including CD players. Videotape recorders accounted for 42% of JVC sales in 1993, but since 1985 it has experimented with several computer peripheral programs. Computer related products accounted for about 13% of 1993 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 except for some contract manufacturing. A CD-R 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 become a price leader for this type of CD product.

A subsidiary, Victor Data Systems, has begun to market a 200 disk CD-ROM library based upon a karaoke library. It was shown at the Japan business show in 1994 and will appear in the U.S. market in late 1994.

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

1993 total net sales: $11,803,694,000 Net income: $270,640,000

Kawasaki Steel entered the optical drive market through Kawatetsu Advantech, a subsidiary company. The firm began producing 5.25" write-once optical disk drives at its Nishinomiya plant in December of 1986 under license from ISI, which then became Literal Corporation. Kawasaki Steel marketed the drives under the Kawatetsu name to OEM customers in Asian markets through Kanto Denshi, a trading company, and acted as a source of supply to Literal. Because of Literal's closure and a lack of media due to the demise of the only media supplier, the firm stopped optical drive production in early 1994.

KUBOTA CORPORATION
1-2-47, Shikitsu-Higashi
Naniwa-ku
Osaka 556

Established in 1930, Kubota is best known for agricultural machinery and iron pipe. In recent years the company has aggressively diversified into electronics and has made investments in a number of firms, including Maxoptix, of which it currently holds a 34% share. Maxoptix and Kubota jointly manufacture the Maxoptix line of optical disk drives, and Kubota began shipping them in Japan under its own name in 1994.

KYUSHU MATSUSHITA ELECTRIC
Subsidiary of Matsushita Electric Industrial Co.
4-1-62 Minoshima, Hakata-ku
Fukuoka 812

KME is one of the Matsushita group's largest manufacturing companies, producing a range of electronic components (including magnetic and optical heads), cordless phones, and office equipment. MEI has 51.1% ownership. The company has begun manufacturing CD-ROM pickup and positioning assemblies with one of the fastest seek times available (180 milliseconds) and has begun manufacturing drives for other companies.

LASERBYTE CORPORATION
Subsidiary of Hyundai
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 MO drive in June, 1993, but actual production started with a 230 megabyte model in 1994. 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.

LION OPTICS CORPORATION
Subsidiary of Lion Group
1751 McCarthy Boulevard
Milpitas, CA 95035

Lion Optics is a joint venture between the Lion Group, a Malaysia based organization and a group of U.S. managers and investors. The company was formed in 1993 and began operations in 1994, with a charter to manufacture CD-ROM drives and related products for the OEM marketplace. The firm does a considerable amount of contract manufacturing as well as producing its own brand of drives. Production of a 2X CD-ROM drive using the Philips mechanism began in mid-1994, with initial sales going to a number of system integrators in the United States. The company's production is done in Malaysia. The initial product has a Sony-type AT bus interface, but future products will be available with SCSI and ATAPI interfaces as well.

LONGSHINE ELECTRONICS CORPORATION
245, Section 3
Roosevelt Road
Taipei
Taiwan

1993 total net sales: $37,000,000

Longshine was started in 1981 as a manufacturer of communication and computer equipment. The firm and its subsidiaries now make personal computers, rigid disk drives, automotive electronics and security products and CD-ROM drives, which began production in 1994 using purchased mechanisms.

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

1993 total net sales: $3,619,279,000 Net income: $118,036,000

MACO, as the company is often known, produces a wide variety of electronic items, including audiovisual 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. The firm ships mostly mechanisms to other firms which integrate them into complete drives.

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

1993 total net sales: $65,566,378,000 Net income: $346,009,000

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 1992, and MKE has become one of the largest producers of CD-ROM drives and mechanisms.

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 captured a major share of the 5.25" write-once market with this drive and its 700 megabyte per side successor, introduced in late 1993. The company currently offers a line of 5.25" optical disk libraries as well as its drives.

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. The firm is also working on high capacity 3.5" phase change drives, but had not yet made a product announcement as of mid-1994.

MATSUSHITA-KOTOBUKI ELECTRONICS INDUSTRIES, LTD.
2-2-10 Kotobuki-machi
Takamatsu-shi 760

Matsushita Electric Industrial owns 57.6% of MKE, which was established in 1948. MKE is a major producer of VCRs and other consumer electronic items, some of which are sold by the Matsushita companies and some by other firms. Disk storage products include rigid disk drives made for Quantum, Floptical disk drives made for Insite Peripherals, and CD-ROM drives. CD-ROM drive production, which commenced in 1992, has become quite large, making MKE one of the leading CD-ROM manufacturers. Much of MKE's CD-ROM output is marketed through Matsushita companies.

MICROBOARDS
31-8 Takasecho
Funabashi-shi, Chiba 273

Microboards, which began in 1973 as a mail-order house, is a supplier of video boards and specialized CD-ROM based systems and subsystems. The firm has developed a 200 disk CD-ROM library based upon a karaoke library mechanism manufactured by Sony. Microboards provides the controller and required software. The library was shown at several trade shows in 1993, but production did not begin until 1994.

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

1993 total net sales: $29,372,081,000 Net income: $256,829,000

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 was sold as part of an optical storage library system that contained as many as two drives and 152 disks. Higher performance 5.25" MO type rewritable drives began to ship in the second quarter of 1990. All of Mitsubishi's library products were configured with 5.25" drives, but only libraries with rewritable drives were marketed after 1992 and these only in Japan.

A 128 megabyte 3.5" magneto-optic drive was announced by Mitsubishi in 1991, but was never put into production, though 5.25" MO drives were produced for a while. 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 was used in early IBM optical libraries.

Mitsubishi's optical products never really caught on, and the firm elected to withdraw from the optical disk drive business in 1993.

MITSUMI ELECTRIC CO., LTD.
8-8-2 Kokuryo-cho
Chofu-shi, Tokyo

1993 total net sales: $1,561,351,000 Net income: $10,423,000
(FY ending 1/30/93)

Mitsumi, founded in 1949, is primarily a manufacturer of electronic components, but 18% of 1993 revenues were derived from floppy disk drives and 7% 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, and after a rough start seems to have found the formula, showing excellent growth in CD-ROM drive shipments in 1993 and 1994.

(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" MO 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 beginning in 1992. A 384 megabyte drive (also capable of operating at 230, 256 and 128 megabytes) is expected to go into production in the third quarter of 1994. 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

1993 total net sales: $234,712,000 (FY ending 2/28/93) Net income: $7,775,000

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 1% of 1993 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" MO drive to reach the marketplace. Nakamichi markets the MOST drives in Japan.

In 1994, Nakamichi began marketing a seven disk tabletop CD-ROM library derived from an audio library design. The firm plans an aggressive pricing and marketing effort.

NEC CORPORATION
5-33-1, Shiba
Minato-ku, Tokyo 108

1993 total net sales: $31,643,671,000 Net income: ($406,554,000)

NEC has defined its product area as communications and computers, with computer products accounting for about 49% of 1993 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, 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" MO 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 more powerful game systems.

In 1992, NEC introduced CD-ROM drives that operate with a doubled rotation and data transfer rate in order to accommodate multimedia video requirements and followed that up with 3X and 4X models in 1993 and 1994 respectively. The firm also produces a similar 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 and has become one of the market's major suppliers.

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

1993 total net sales: $2,089,405,000 Net income: $79,396,000

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. Nikon's drive was initially sold only in Japan, but after a round of redesign and cost reduction was also marketed in the U.S., where it is one of the drives supported by ATG Cygnet in its 12" libraries.

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-optic 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

1993 total net sales: $16,744,117,000 Net income: $40,135,000

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 was 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

1993 total net sales: $2,411,874,000　　Net income: $34,279,000

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.

Olympus began marketing under its own brand name in 1992 when it introduced a 3.5" 128 megabyte drive. This was followed by a 230 megabyte version in early 1994. At that time the firm also announced 5.25" full height and half height MO drives. The company is currently expanding its marketing channels in the United States for the drives, and in early 1994 adopted the brand name "Deltis" for its externally packaged drive subsystems and related products.

OPTICS STORAGE PTE. LTD.
85 Defu Lane 10, #04-00
Singapore 1953

In June, 1993, Optics Storage was created to develop and manufacture products with CD-ROM technology. The company was started by rigid drive industry veterans with experience at IBM and Conner Peripherals.

The firm's initial products are based upon double speed Philips mechanisms and are equipped with PC AT interfaces.

PIONEER ELECTRONIC CORPORATION
4-1, Meguro 1-chome
Meguro-ku, Tokyo 153

1993 total net sales: $5,312,703,000   Net income: $97,171,000

Pioneer, founded in 1947, is a major manufacturer of consumer electronic equipment. 97% of Pioneer's 1993 revenues came from sales of audio, video and automotive electronic equipment. The firm is especially strong in the laser-disc 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, which began production in late 1993. At the 1994 AIIM show, Pioneer displayed a 500 disk CD-ROM library based upon a karaoke system also produced by Pioneer.

In 1990, Pioneer introduced a multifunction drive using dye or MO 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.

PLEXTOR (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 achieved a moderate degree of success selling through reseller channels in the United States. In 1994, the firm changed its identity and now operates under the Plextor name.

RICOH CO., LTD.
15-1, Minami-Aoyama 1-chome
Minato-ku, Tokyo 107

1993 total net sales: $9,206,441,000 Net income: $45,180,000

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 24% of 1993 revenues. Ricoh was Pioneer's partner in the development of an 8" write-once optical drive which Ricoh used in a document storage system, and the firm showed a prototype OEM 8" write-once drive at the 1986 NCC show. However, Ricoh 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 performance 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.

Ricoh began manufacturing CD-R recorders in 1993, and is among the more aggressive marketers for this type of drive.

SAMSUNG ELECTRONICS
7 Soonwha-Dong
Seoul
Korea

1992 total net sales: $7,574,024,000 Net income: $89,891,000

Founded in 1969, Samsung Electronics is Korea's largest manufacturer of electronic products, which range from semiconductor components to telecommunications equipment and computers. About one fifth of the firm's revenues are derived from information systems and related products. Disk drive products include rigid, flexible and optical disk drives. In 1992, a 5.25" MO drive was announced, but the firm decided not to place it into production. A double speed CD-ROM drive was announced in late 1993 and is currently in production.

SANYO ELECTRIC CO., LTD.
2-18 Keihan-Hondori
Moriguchi, Osaka 570

1993 total net sales: $14,025,631,000 (FY ending 11/30/93) Net income: ($14,054,000)

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, component 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. In 1994, Sanyo showed a prototype 3DO type player and is exploring the possibility of a major commitment to that market. The firm also displayed double speed drives and a prototype quad speed drive.

SEGA ENTERPRISES
1-2-12 Haneda
Ohta-ku, Tokyo 144

1993 total net sales: $3,749,856,000 Net income: $277,090,000

Sega is one of the world's major producers of electronic games and arcade equipment. About two thirds of its sales are derived from consumer equipment. The company sells more CD-ROM drive based game equipment sets than any other producer. The CD-ROM drives included with the games are made on a contract basis for Sega by several firms.

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 controls Japan's Seiko companies, known for watches and electronics. Epson is best known for its printers, but also manufactures a portable computer, displays, and floppy and rigid disk drives. In 1988, Epson agreed to supply Maxtor with a 160 megabyte 3.5" MO disk drive and media then under development. While plans to deliver such a drive to Maxtor were terminated, Seiko Epson 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

1993 total net sales: $35,972,234,000 Net income: $326,667,000

Founded in 1935, Sharp originally made 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. In mid-1987, the firm announced a 5.25" 190 megabyte MO drive. An improved 325 megabyte version began production in 1990 and was upgraded to a 41.3 millimeter high version in 1992. In early 1994, Sharp began shipments of a 650 megabyte per side half high 5.25" MO drive. Sharp also has announced an 8 centimeter 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

1993 total net sales: $35,972,234,000 Net income: $326,667,000

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, although this leadership position is being severely assaulted by other competitors. The company is vertically integrated and supplies its own media, and is currently the largest producer of magneto-optic media.

Sony fields 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" MO models. The rewritable drive product line is being aggressively developed, although Sony skipped the 230 megabyte generation to concentrate upon development of higher capacity models. To support its 12" 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. In 1994, Sony introduced a 20 disk 5.25" library which it manufactures in the United States.

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 write-once CD format recorder as part of a CD-ROM mastering system at the 1990 Microsoft Conference, but has lagged behind other manufacturers in providing a low cost CD-R drive.

In mid-1990, Sony introduced the Data Discman, a portable CD-ROM system using the first 8 centimeter 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 from 1989 through 1993, Sony has been the largest supplier of rewritable optical disk drives. 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 had a specified average seek time of 40 milliseconds and rotated at 3,000 RPM, among the faster optical drives. Sony surprised the industry when it failed to announce a 230 megabyte 3.5" drive in early 1994, but it now appears that the firm has made a strategic decision to leapfrog the competition and go directly to higher capacity 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 late 1994 seems likely. Sony is also looking for opportunities to apply the MD-DATA technology to other form factors.

TEAC CORPORATION
3-7-3 Naka-cho
Mushashino, Tokyo 180

1993 total net sales: $1,159,108,000 Net income: $8,703,000

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 line of CD-ROM drives, including quad speed drives introduced in 1994.

TOSHIBA CORPORATION
1-1-1, Shibaura
Minato-ku, Tokyo 105

1993 total net sales: $41,689,180,000 Net income: $185,144,000

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 51% of 1993 revenues 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 it 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" MO drive at the 1991 Tokyo Business show, but sold it only in Japan and has since withdrawn it.

CD-ROM shipments also began in 1986 and fared better. 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. An 8 centimeter CD-ROM drive was announced in 1992, but has since been withdrawn.

TXC CORPORATION
No. 16, Section 2
Chung Yang South Road
Peitou, Taipei
Taiwan

TXC is manufacturing CD-ROM drives using the Philips mechanism. Production started in 1994. The firm is assembling drives for sale under its own name and is also doing some contract assembly for other organizations.

WEARNES TECHNOLOGY PTE. LTD.
Subsidiary of Wearne Brothers, Limited
801, Lorong 7, #07-00
Toa Payoh, Singapore 1231

Wearne Brothers is a large corporate group with sales approaching $60 billion annually. Wearnes Technology is itself a multinational corporation with development and manufacturing operations in Asia, Europe and in the U.S. Wearnes manufactures computers, tape drives, displays, many kinds of components and, beginning in 1993, CD-ROM drives. The company uses Philips mechanisms as the base for its products.

Wearnes Technology owns a 25% share of Behavior Tech Computer Corp., a Taiwan company that has also begun to produce CD-ROM drives.

YAMAHA CORPORATION
10-1 Nakazawa-machi
Hamamatsu, Shizuoka

1993 total net sales: $4,355,495,000 Net income: $16,459,000

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 and is rapidly increasing its output of heads for disk drives.

Among more recent activities is the development of a CD-R 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. Yamaha's was the first commercial write-once CD format drive, and the firm followed up with a greatly cost reduced quad speed recorder that went into production in 1994. The CD-R systems are 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. A CD-ROM version was added in 1994.

ATG CYGNET
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. In 1993, ATG Gigadisc purchased Cygnet Systems, after a soured customer relationship forced Cygnet into Chapter 11 and the two firms were reorganized as ATG Cygnet.

ATG Cygnet products now include 12" write-once drives up to 5 gigabytes per side capacity, plus a library storage unit containing a drive and six 12" disks, and Cygnet's line of larger 12" library units. As one of the early entrants into the optical library arena, Cygnet enjoyed a substantial share of the available business, a position now enjoyed by ATG Cygnet. In 1993, the firm became the exclusive remarketer of the Access optical library, but is expected to phase the Access libraries out of the product line during late 1994.

The firm 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 Microsystems' 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. VERTRIEBSGESELLSCHAFT MBH
Gerberstrasse 5
90411 Nurnberg
Germany

K & S was founded in 1985 as a consulting firm for data processing and automation. The company 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. An 80 cartridge version was introduced in 1993, as was a 30 cartridge single drive CD-R library. Sony, Ricoh, Sharp, Pioneer and Maxoptix drives are being used, but the libraries are adaptable for use with most 5.25" drives.

LOGICAL ENGINEERING LC
Suite 27, Blacklands Way
Abingdon Business Park
Abingdon, Oxford OX14 1DY
United Kingdom

Logical Engineering manufactures a 300 disk CD-ROM library that accommodates a variety of CD-ROM and CD-R drives. Shipments began in 1993. The company was founded in 1991 as a manufacturer of film archive systems for newspapers, but CD-ROMs were determined to be a better archiving medium and the company switched its technological emphasis.

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 using audio drives 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, but has started a more visible marketing effort in the U.S., capturing some OEM business as well.

N. V. PHILIPS (See also Philips LMS)
5600 MD Eindhoven
The Netherlands

1993 total net sales: $31,651,870,000 Net income: $1,057,304,000

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. Manufacturing of CD-ROM drives, CD-R drives and MO drives (and mechanisms) is the responsibility of Philips Key Modules, in turn a subsidiary of Philips Consumer Electronics.

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 became the sole owner of LMSI, now renamed as Philips LMS.

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 Philips Key Modules, which also provides drive mechanisms to other Philips business units.

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. In late 1993, Philips and IBM announced a joint development venture leading to the introduction of a one inch high 3.5" MO drive by IBM that makes use of a mechanism manufactured by Philips Key Module Group. At that time, it was also indicated that there would be future joint developments.

PHILIPS LMS (Previously 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 Control Data 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. The firm was renamed Philips LMS in 1994.

The company makes optical disk drives and also produces magnetic tape drives. Philips LMS optical disk drives currently include CD-ROM drives based upon Key Modules Group mechanisms, a 12" write once drive, and 12" automated libraries. A 5.25" write-once drive was introduced at the Fall COMDEX conference in 1987 and went into production in late 1988, but has since been discontinued. In 1990, Philips LMS 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 a Philips LMS manufacturing operation sharing Philips media manufacturing facilities at Blackburn in the UK. Philips and Dupont Optical (PDO) also is a qualified media supplier.

SOCIETE D'APPLICATIONS GENERALES D'ELECTRICITE ET DE MECANIQUE (SAGEM)
6, Avenue d'Iena
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.

1994 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 AutoIm-port useful with other file translation tasks, it may be purchased independently from DISK/TREND or White Crane Systems, Inc.

IMPORTANT NOTE: Effective July, 1994, White Crane will ship version 3.13 or higher of AutoImport. Instructions in this section are written to work with this version. If you have an older version of AutoImport, refer to instructions in previous DISK/TREND reports. You must have AutoImport 3.13 or higher to use DISK/TREND ON DISK with these instructions.

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 1994 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1994 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.

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 1.44 megabyte 3.5" diskettes, but is also available on 1.2 megabyte 5.25" diskettes 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.

   <u>Installing AutoImport V3.xx</u>: 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: COPY A:*.* 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)
   V (Removable drive 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
   File VT2.WK1 is Removable Drive Report Table 2

   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 commands 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	1993 Rigid Report	1993 Flexible Report	1994 Optical Report	1994 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	--		--	
38	--		MASKA	
39	MASKD		MASKA	
40	MASKI		--	
41	--		--	
42	MASKA		MASKA	
43	MASKA		MASKA	
44	--		--	
45	--		--	
46	MASKD		MASKE	
47	MASKI		MASKA	

Cross reference (continued)

Table Number	1993 Rigid Report	1993 Flexible Report	1994 Optical Report	1994 Array Report
48	--		MASKA	
49	MASKA		--	
50	MASKA		--	
51	--		MASKE	
52	--		MASKA	
53	MASKD		MASKA	
54	MASKI		--	
55	--		--	
56	MASKA		MASKE	
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 the 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 by typing AI, then the ENTER key. When the opening screen appears, select the "File" menu bar item using the mouse or just type /F. (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears (File Selection menu), use the arrow keys or the mouse to select the Mask name option, then select the name of the mask you want from the displayed list. 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.

4. Select Input file name option on the File Selection Menu.

   Enter the name of the file, <u>including the extension</u>, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.94R FT12.94F OT14.94O AT19.94A

5. Select the Output file option on the File Selection menu.

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (A, R, V, 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.

   Examples: RT4 FT12 OT14 AT20

6. The default spreadsheet type to which 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 selecting Format from the File Selection menu and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Select "CONVERT" button using the mouse (or arrow keys and ENTER). If you are asked "Do you want to load input file *.* named in mask", answer "NO". 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 or use the mouse to select "Quit" on the menu bar to return to the AutoImport main menu 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 "File" using the mouse or type /F.

2. Name the input 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: OT10.94O

   To name the file, select Input file from the File selection menu. Type the desired 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 select "Lines" from the menu bar, then select "Header" from the pop-up window that opens. 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, selecting "Lines" and "Headings" again, and 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. Select "Column" from the menu bar, then "Auto Define". 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. Select "Column", then "Width & move". Select the column you wish to adjust with mouse (or arrows & ENTER), and then use arrow keys to move right column margin clear of the column of values. You can also shift the entire column by depressing the CONTROL key and using the appropriate arrow key (or drag with the mouse).

5. Save the mask in a mask file. Select "File", then "Mask", then the Save Mask button, or type /FMS (File:Mask:Save). Fill in the name of the mask file when asked.

   Example: MYMASK.MSK, or just MYMASK

6. Save the output file. Type /FO (File:Output). 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 /QY (quit).

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)
   V (Removable drive 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: OS194 Optical disk drive specification table.
LS194 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:

- o There are other "pop-up" programs resident in the memory of your computer. These should be removed.
- o 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.
- o 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 ??93 in the criterion field for the First Ship Date column will cause all products first shipped in 1993 to be extracted.