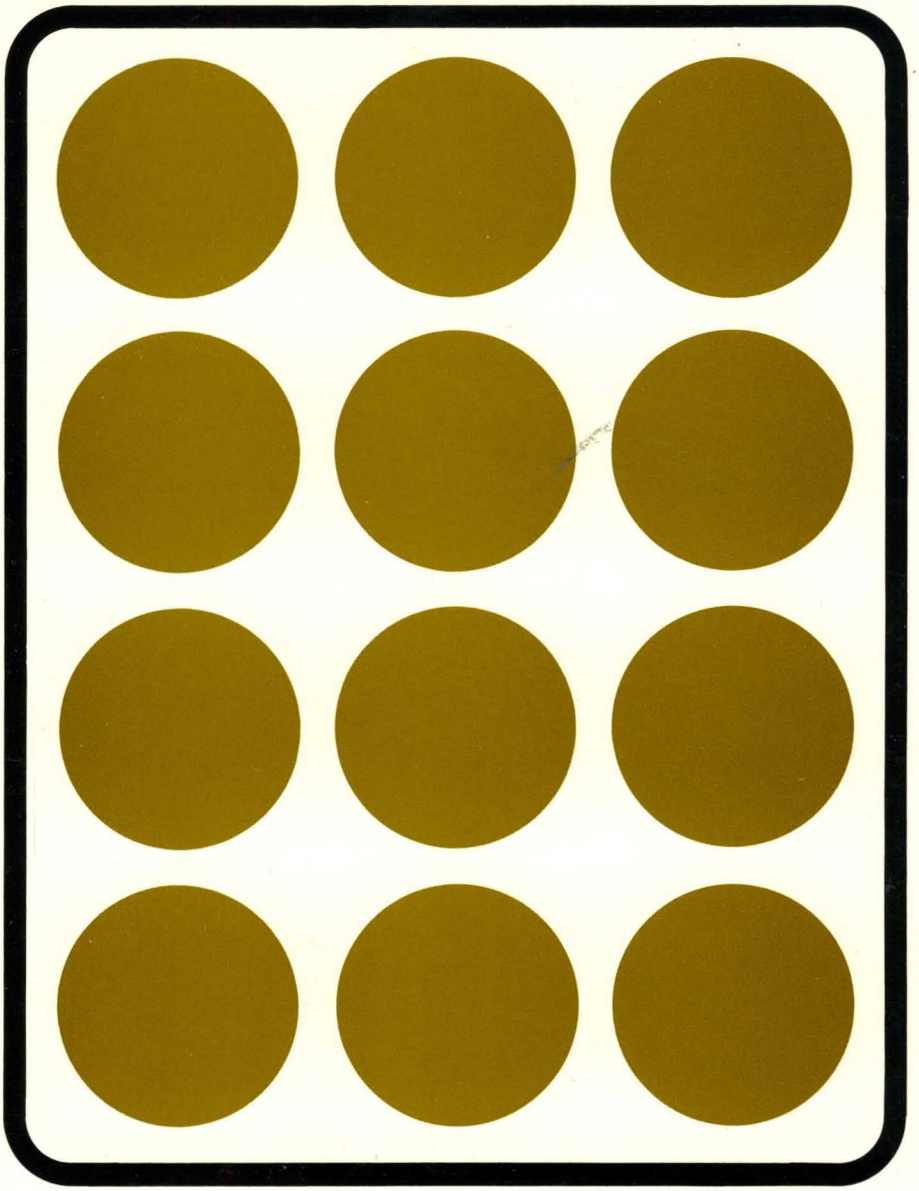
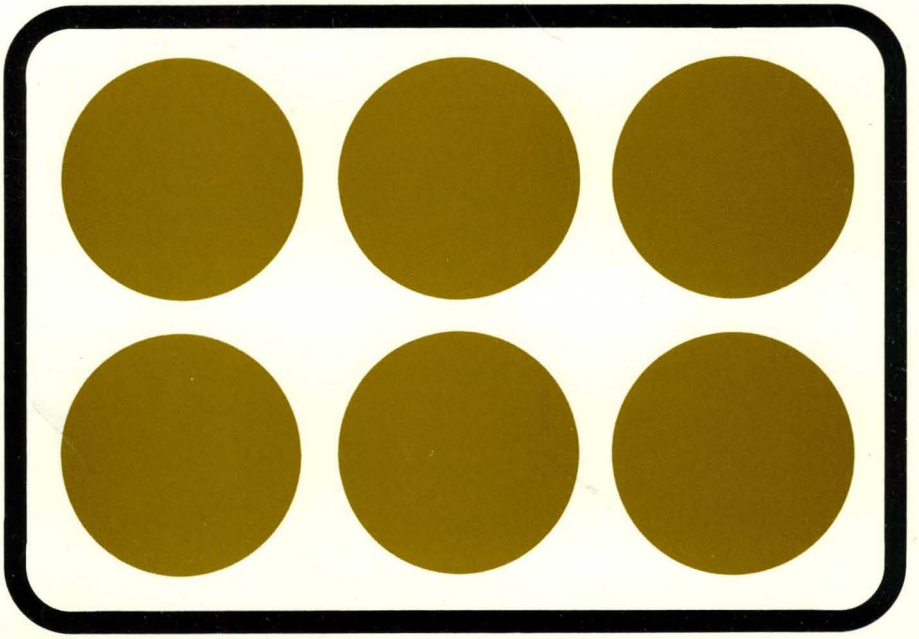


1995 DISK/TREND® REPORT



OPTICAL DISK DRIVES

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OPTICAL DISK DRIVES

August, 1995

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FOREWORD

The optical disk drive industry is poised on the threshold of a major transition to lower cost, higher performance drives. CD-ROM and related products are leading the charge, followed by 3.5" MO drives. 5.25" drives are also getting a make-over. New products such as the PD drive are shipping, the CD-E drive is within sight, and the next generation of high capacity, high performance CD-ROM drives anticipated in 1996 is expected to transform the optical storage market in many ways.

It isn't all good news: 12" drive shipments slowed, and the bottom end of the optical library business took a beating from high capacity rigid magnetic disk drives. With all the new and current products addressing the removable storage market in the over 500 megabyte range, there is sure to be a messy shoot-out in that arena. And the shakeout that we suggested in last year's report is taking place, with several significant product line restructurings completed or currently under way, a process impacting every product area except CD-ROM.

The number of new suppliers in the CD-ROM related drive business is still growing. The CD-ROM industry really does look a lot like the floppy drive business in its heyday, except that the rate of technological progress is faster than anything the floppy drive business ever experienced. The smaller producers will find it increasingly difficult to compete, and we expect the number of drive makers to begin shrinking in a year or two. However, we expect to see innovation and new producers in the CD-ROM format library business.

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 celebrating its tenth anniversary. The organization of this year's report is consistent with reports of previous years, but we have changed the product breakdowns in several product sections to reflect product changes. One new table has been added in the section on drives with more than 1 gigabyte to differentiate between write-once and rewritable drives. Disk diameter tables have been modified to reflect anticipated new product introductions. Here are a few reminders to help in interpreting the information presented.

* This report concentrates on optical disk drives and optical libraries used with general purpose and dedicated application computers, including games, rather than upon media, controllers, or other related topics. Not included are optical disk drives and libraries designed for consumer audio and video entertainment applications, optical tape drives, and optical card drives.

* Market share tables, usually included in DISK/TREND reports, are omitted for some product groups of this report, because the 1994 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 format 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.

SUMMARY: OPTICAL DISK DRIVES AND LIBRARIES

Industry size

Booming CD-ROM sales again provided a major boost to 1994 total optical disk drive sales revenues, which grew 68.3% to over $3.7 billion. CD-ROM drive sales soared 88.4% to almost $2.9 billion, but revenues for read/write drives also improved. Revenues for read/write drives under one gigabyte rose 26.5% to almost $743 million, led by improving sales of aggressively priced 3.5" drives and a growing CD-R market. Drives over one gigabyte increased revenues by 5% to $100.6 million.

While shipments of 3.5" magneto-optic drives improved in 1994, sales to large OEMs remained weak, and the prospects for growth in OEM 3.5" sales depend upon higher capacity and lower prices. Shipments of 5.25" drives grew slightly, while shipments of 12" drives declined.

Of 24.8 million optical drives shipped in 1994, over 24 million were CD-ROM drives. Shipments of read/write drives under 1 gigabyte expanded 58.4% to 724,200 units, due to growth in the Japanese 3.5" market and strong sales growth for CD-R drives, which compensated for meager growth in 5.25" drive shipments. 1994 shipments for drives over 1 gigabyte grew 21.1% to 8,600 units, with shipment growth for 5.25" drives masking a decline in 12" drive shipments.

1994 optical library shipments jumped 104.7% to 70,074 units, with most of the gain coming from rising shipments of small CD-ROM libraries. 75.4% of the 1994 total was accounted for by the CD-ROM optical libraries, and further increases are anticipated, exceeding 97% in 1998. Optical library revenues increased 17.9% to $304.8 million, led by libraries in the 70 or more cartridge category, which captured 43.2% of library revenues. Libraries with 1-39 cartridges captured 33.2% of 1994 library revenues, but actually lost share because of competition from high capacity magnetic disk drives. (The library revenues don't include revenues of associated drives, to avoid double counting.)

U.S. manufacturers again lost revenue share in 1994 with a drop to 6.5% of worldwide optical disk drive revenues, reflecting minimal participation by U.S. firms in the CD-ROM market. U.S. companies also lost six share points of total

1994 library revenues, capturing 46% of the worldwide total. The U.S. share of drive shipments is insignificant as a result of very large CD-ROM drive shipments from non-U.S. firms. U.S. manufacturers' 1994 share of library unit shipments fell to 12.5%, because of the large increase in CD-ROM library shipments by non-U.S. suppliers, and is expected to decline further for the same reason.

1994 sales of optical disk drives to U.S. destinations accounted for 45.9% of worldwide revenue, down from 1993. The U.S. market accounted for 61.3% of library revenues, also a decline from 1993. The U.S. optical drive market is expected to be 53.1% of a $7.9 billion drive market in 1998, while the proportion of the library market in the U.S. will be nearly constant, holding 59.4% of an anticipated $829 million total in 1998.

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. Since 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.

Because non-U.S. companies have major strengths in optical drive component technology, non-U.S. manufacturers have emerged as the major drive producers. U.S. firms have difficulty in overcoming the Japanese lead in media, lasers, optical components, heads and mechanisms and are relegated to the role of drive assemblers. 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 to 60 companies, but all of the newcomers are CD-ROM drive producers. There were also four departures, and more companies are expected to leave in 1995. The roster of optical library manufacturers shrank to 35 as a result of seven departures and six new vendors. All but one of the new entrants are CD-ROM library producers. In addition, some organizations moved from being considered U.S. companies to non-U.S. status as a result of being purchased or merged, which accounts for some of the gains recorded by non-U.S. producers.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994		Forecast							
	Revenues		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	18.7	41.9	16.6	27.3	10.0	17.8	10.2	20.2	12.5	22.1
PCM/Reseller	74.3	112.0	70.3	93.4	82.1	106.4	78.0	105.8	85.2	113.4
OEM/Integrator	45.5	71.0	44.4	64.7	42.4	61.9	43.3	66.3	43.1	61.7
TOTAL U.S. REVENUES	138.5	224.9	131.3	185.4	134.5	186.1	131.5	192.3	140.8	197.2
Non-U.S. Manufacturers										
Captive	216.5	873.1	247.8	856.1	212.6	727.0	272.5	924.3	307.1	1,081.5
PCM/Reseller	388.7	841.6	464.5	987.4	566.8	1,166.6	783.6	1,507.6	1,005.4	1,806.9
OEM/Integrator	959.1	1,769.3	1,399.5	2,792.3	1,902.8	3,487.3	2,390.9	4,419.1	2,721.5	4,780.9
TOTAL NON-U.S. REVENUES	1,564.3	3,484.0	2,111.8	4,635.8	2,682.2	5,380.9	3,447.0	6,851.0	4,034.0	7,669.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,702.8	3,708.9	2,243.1	4,821.2	2,816.7	5,567.0	3,578.5	7,043.3	4,174.8	7,866.5

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL LIBRARIES

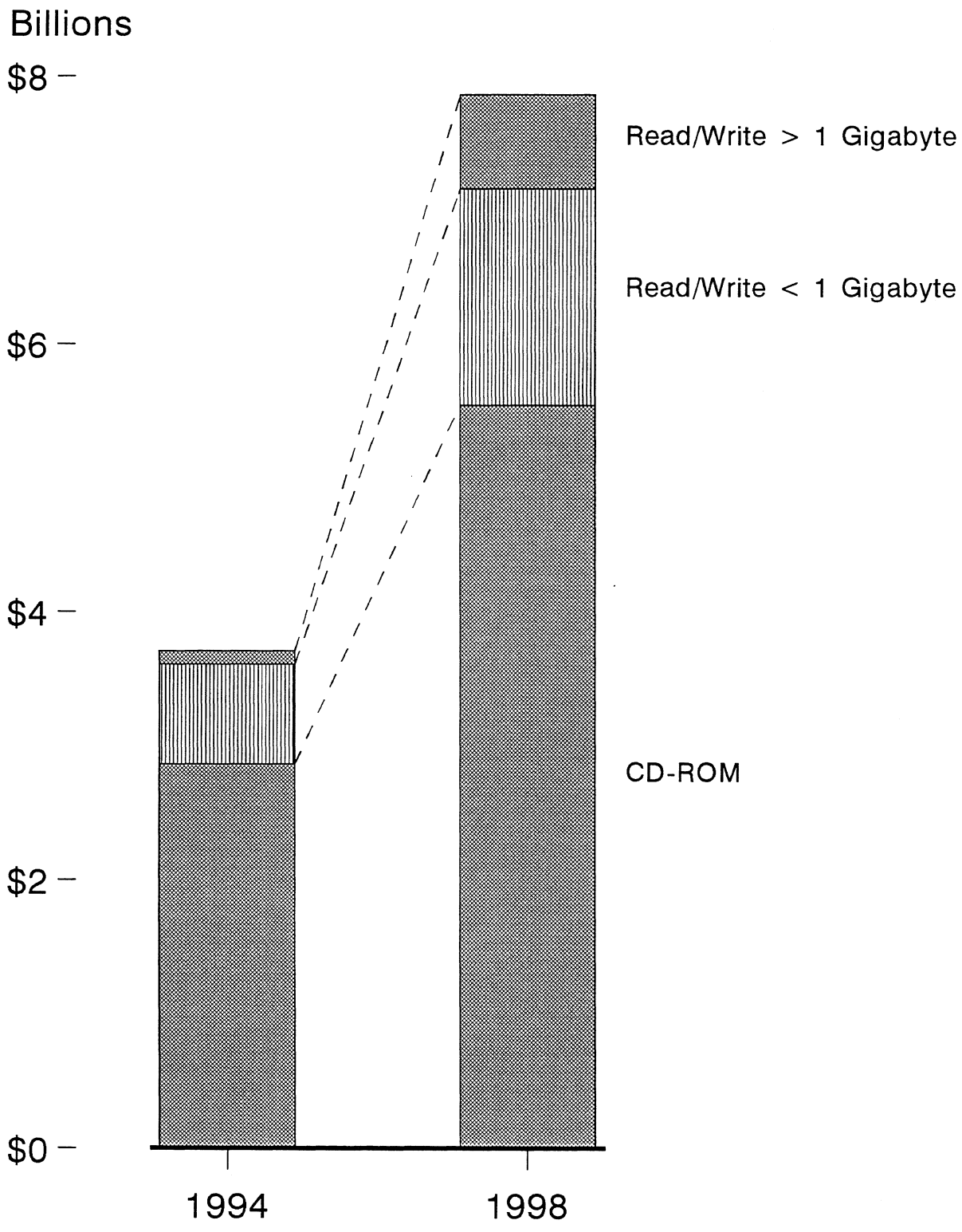
REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994		Forecast							
	Revenues		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	40.5	52.9	48.6	65.2	51.6	73.0	54.3	78.2	54.4	80.6
PCM/Reseller	9.0	17.3	29.6	40.6	36.2	49.4	39.1	53.3	41.0	55.9
OEM/Integrator	54.8	69.9	70.0	94.7	85.0	113.5	92.8	124.1	99.7	133.0
TOTAL U.S. REVENUES	104.3	140.1	148.2	200.5	172.8	235.9	186.2	255.6	195.1	269.5
Non-U.S. Manufacturers										
Captive	--	23.4	--	24.3	--	22.8	--	25.2	--	27.6
PCM/Reseller	36.9	65.5	48.2	87.6	70.4	121.9	84.8	147.9	95.7	168.4
OEM/Integrator	45.5	75.8	67.2	108.6	97.0	157.1	141.0	235.0	201.5	363.5
TOTAL NON-U.S. REVENUES	82.4	164.7	115.4	220.5	167.4	301.8	225.8	408.1	297.2	559.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	186.7	304.8	263.6	421.0	340.2	537.7	412.0	663.7	492.3	829.0

Figure 1

CHANGING PRODUCT MIX

Worldwide Optical Disk Drive Revenue

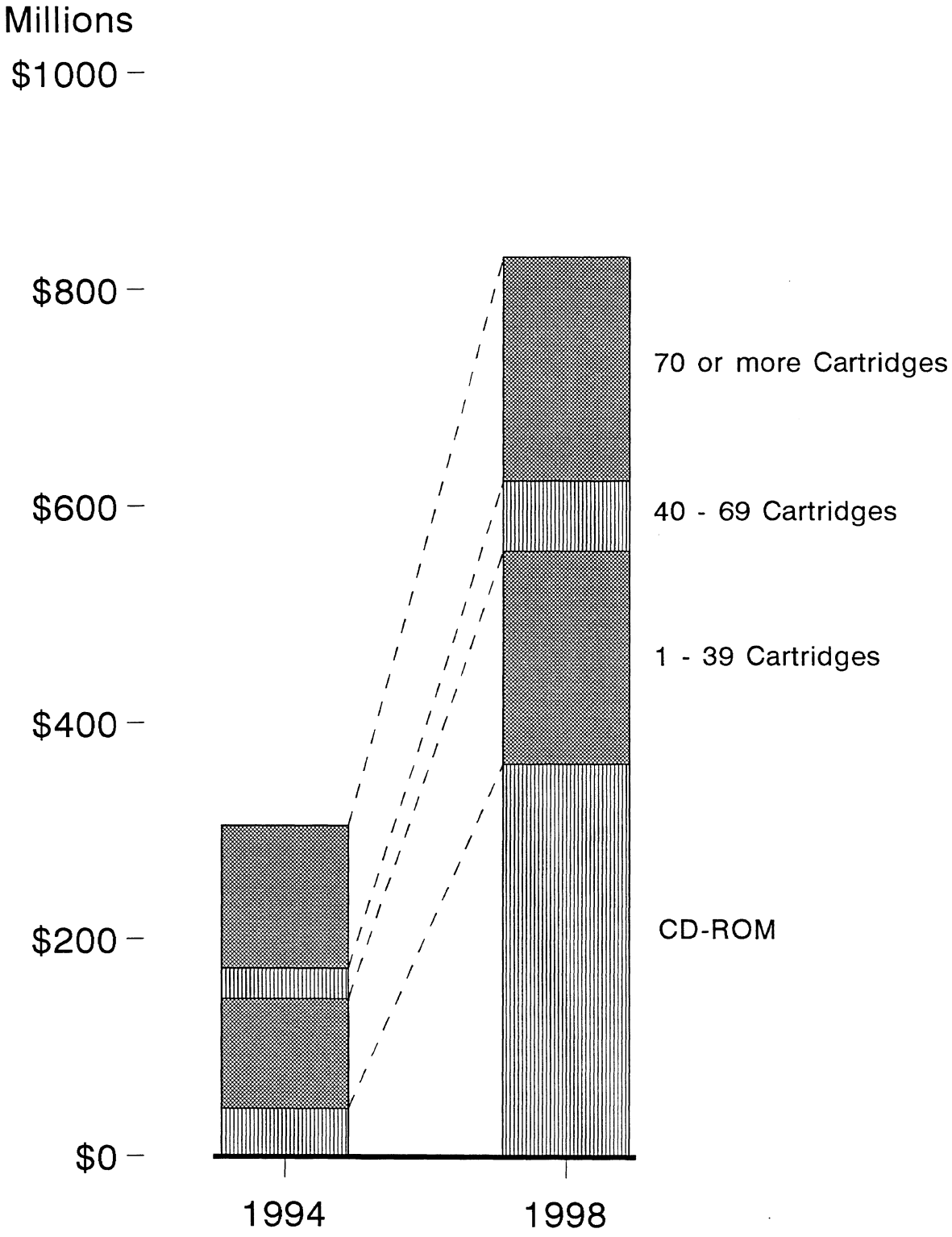


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Figure 2

CHANGING PRODUCT MIX

Worldwide Optical Library Revenue



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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.

1994 OEM/Integrator optical disk drive revenues surged 66% to over $1.8 billion, 49.6% of the worldwide sales revenue of $3.7 billion. PCM/Reseller revenues accounted for 25.7% , while the captive channel contributed 24.7%. Significant revenue gains over 1993 were made in all three channels. The 1998 pattern will be similar. The OEM/Integrator channel will contribute 61.6% of over $7.8 billion in total revenue, while the PCM/Reseller share is projected to shrink to 24.4%, and the captive share is forecasted to decline to 14% of 1998 revenues. The gain in OEM revenue share is largely accounted for by large increases in sales of CD-ROM drives to personal computer manufacturers.

1994 optical disk library revenues of $304.8 million were split 47.8% from OEM/Integrators, 27.2% from the PCM/Reseller channel, and 25.0% from the captive channel. 1998 expected revenues of $829 million will be shared among OEM/Integrators with 59.8%, PCM/Reseller sales with 27.1% and captive sales with 13.1%. 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 the value-added content and perform increasing amounts of system integration. As a result, the OEM share of revenues is forecasted to increase at a faster rate than PCM reseller revenues.

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. 10 U.S. companies, 47 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 and Taiwan. Both U.S. and Asian firms may have their drives made on a contract basis by other Asian producers, with an increasing number being made in China.

As of mid-1995, 39 companies produce CD-ROM drives. 37 are non-U.S. firms and 16 are Japanese organizations. 28 manufacturers are making read/write drives less than 1 gigabyte: 22 of these have rewritable or multifunction drives. 9 companies make optical disk drives with more than 1 gigabyte capacity. 4 of these are rewritable 5.25" drives, and 1 is a 12" rewritable drive.

10 U.S. firms, 17 Asian manufacturers and 8 European suppliers offer optical libraries. Of the 35 companies, 19 make CD-ROM libraries: 10 of these do not participate in any other product groups. Of the 24 read/write library producers, 14 firms make only 5.25" libraries, while 8 make larger diameter libraries. Only two companies make a 3.5" library. Eight 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; others will soon offer this capability.

The U.S. based count of library manufacturers has declined to 10: ADIC, Access, Sigma Designs and TAC Systems halted production, and IDE was merged into Plasmon, a European organization, to become Plasmon Data Systems. CD International and Dynatek Automation (Canadian) have begun marketing libraries. The Asian manufacturer roster of library producers increased with the market entry of Sanyo Electric and Aiwa (both CD-ROM library producers), plus PFU, a 3.5" library producer. New European library manufacturers include ASM, a German firm, and Plasmon Data Systems.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1994 Revenues $M	1994 Revenues %	1995 Forecast $M	1995 Forecast %	1996 Forecast $M	1996 Forecast %	1997 Forecast $M	1997 Forecast %	1998 Forecast $M	1998 Forecast %
U.S. Manufacturers										
Captive	41.9 -25.7%	1.1%	27.3 -34.8%	.5%	17.8 -34.8%	.3%	20.2 +13.5%	.2%	22.1 +9.4%	.2%
PCM/Reseller	112.0 +105.9%	3.0%	93.4 -16.6%	1.9%	106.4 +13.9%	1.9%	105.8 -.6%	1.5%	113.4 +7.2%	1.4%
OEM/Integrator	71.0 +37.9%	1.9%	64.7 -8.9%	1.3%	61.9 -4.3%	1.1%	66.3 +7.1%	.9%	61.7 -6.9%	.7%
Total U.S. Manufacturers	224.9 +38.6%	6.0%	185.4 -17.6%	3.7%	186.1 +.4%	3.3%	192.3 +3.3%	2.6%	197.2 +2.5%	2.3%
Non-U.S. Manufacturers										
Captive	873.1 +103.8%	23.5%	856.1 -1.9%	17.7%	727.0 -15.1%	13.0%	924.3 +27.1%	13.1%	1,081.5 +17.0%	13.7%
PCM/Reseller	841.6 +51.1%	22.6%	987.4 +17.3%	20.4%	1,166.6 +18.1%	20.9%	1,507.6 +29.2%	21.4%	1,806.9 +19.9%	22.9%
OEM/Integrator	1,769.3 +67.5%	47.9%	2,792.3 +57.8%	58.2%	3,487.3 +24.9%	62.8%	4,419.1 +26.7%	62.9%	4,780.9 +8.2%	61.1%
Total Non-U.S. Manufacturers	3,484.0 +70.6%	94.0%	4,635.8 +33.1%	96.3%	5,380.9 +16.1%	96.7%	6,851.0 +27.3%	97.4%	7,669.3 +11.9%	97.7%
Worldwide Recap										
Captive	915.0 +88.7%	24.7%	883.4 -3.5%	18.3%	744.8 -15.7%	13.4%	944.5 +26.8%	13.4%	1,103.6 +16.8%	14.0%
PCM/Reseller	953.6 +56.0%	25.7%	1,080.8 +13.3%	22.4%	1,273.0 +17.8%	22.9%	1,613.4 +26.7%	22.9%	1,920.3 +19.0%	24.4%
OEM/Integrator	1,840.3 +66.1%	49.6%	2,857.0 +55.2%	59.3%	3,549.2 +24.2%	63.7%	4,485.4 +26.4%	63.7%	4,842.6 +8.0%	61.6%
Total All Manufacturers	3,708.9 +68.3%	100.0%	4,821.2 +30.0%	100.0%	5,567.0 +15.5%	100.0%	7,043.3 +26.5%	100.0%	7,866.5 +11.7%	100.0%

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	1994 Revenues $M	1994 Revenues %	1995 Forecast $M	1995 Forecast %	1996 Forecast $M	1996 Forecast %	1997 Forecast $M	1997 Forecast %	1998 Forecast $M	1998 Forecast %
U.S. Manufacturers										
Captive	52.9	17.3%	65.2	15.4%	73.0	13.5%	78.2	11.7%	80.6	9.7%
	+69.0%		+23.3%		+12.0%		+7.1%		+3.1%	
PCM/Reseller	17.3	5.6%	40.6	9.6%	49.4	9.1%	53.3	8.0%	55.9	6.7%
	+38.4%		+134.7%		+21.7%		+7.9%		+4.9%	
OEM/Integrator	69.9	22.9%	94.7	22.4%	113.5	21.1%	124.1	18.6%	133.0	16.0%
	-4.4%		+35.5%		+19.9%		+9.3%		+7.2%	
Total U.S. Manufacturers	140.1	45.8%	200.5	47.4%	235.9	43.7%	255.6	38.3%	269.5	32.4%
	+19.8%		+43.1%		+17.7%		+8.4%		+5.4%	
Non-U.S. Manufacturers										
Captive	23.4	7.6%	24.3	5.7%	22.8	4.2%	25.2	3.7%	27.6	3.3%
	+63.6%		+3.8%		-6.2%		+10.5%		+9.5%	
PCM/Reseller	65.5	21.4%	87.6	20.8%	121.9	22.6%	147.9	22.2%	168.4	20.3%
	+48.2%		+33.7%		+39.2%		+21.3%		+13.9%	
OEM/Integrator	75.8	25.2%	108.6	26.1%	157.1	29.5%	235.0	35.8%	363.5	44.0%
	-8.8%		+43.3%		+44.7%		+49.6%		+54.7%	
Total Non-U.S. Manufacturers	164.7	54.2%	220.5	52.6%	301.8	56.3%	408.1	61.7%	559.5	67.6%
	+16.3%		+33.9%		+36.9%		+35.2%		+37.1%	
Worldwide Recap										
Captive	76.3	25.0%	89.5	21.3%	95.8	17.8%	103.4	15.6%	108.2	13.1%
	+67.3%		+17.3%		+7.0%		+7.9%		+4.6%	
PCM/Reseller	82.8	27.2%	128.2	30.5%	171.3	31.9%	201.2	30.3%	224.3	27.1%
	+46.0%		+54.8%		+33.6%		+17.5%		+11.5%	
OEM/Integrator	145.7	47.8%	203.3	48.2%	270.6	50.3%	359.1	54.1%	496.5	59.8%
	-6.7%		+39.5%		+33.1%		+32.7%		+38.3%	
Total All Manufacturers	304.8	100.0%	421.0	100.0%	537.7	100.0%	663.7	100.0%	829.0	100.0%
	+17.9%		+38.1%		+27.7%		+23.4%		+24.9%	

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

Product mix

Optical disk drive shipments grew to nearly 24.8 million units in 1994, with the CD-ROM product group contributing most of the growth. CD-ROM drive shipments of over 24 million units accounted for 97.1% of the 1994 worldwide shipment total, but the percentage of read-only CD-ROM drives is forecasted to decrease to 89.9% in 1998 as a result of increasing shipments of writable CD-ROM format drives in the other product groups. CD-ROM shipments include shipments associated with both computers and freestanding consumer equipment such as games and CD-I players, but not audio or video players. As a result of the strong growth in CD-ROM drive shipments, the share of read/write drives under 1 gigabyte declined from 3.9% to 2.9% of worldwide unit shipments in 1994. The share of read/write drives over 1 gigabyte was under .1%.

Within the less than 1 gigabyte read/write product group, 5.25" drive shipments grew only slightly because of competition from rigid magnetic drives, but their weak performance was counterbalanced by shipment growth of aggressively priced 3.5" drives. Shipments of MO drives in this group are increasingly impacted by competition from high capacity 5.25" and 3.5" magnetic disk drives and, potentially, PD drives and CD-E drives in the future. CD-R drive shipments again tripled from the previous year's levels, with growth heavily influenced by lowered prices and new software for improved usability.

Rewritable or multifunction drives captured 91.9% of the less than 1 gigabyte product group shipments in 1994, but increasing sales of CD-R drives reduced that share to 87.4% in 1995. As CD-E drives displace CD-R drives, the share of rewritable drives is expected to again increase, reaching 98% in 1998. CD-R drives are currently 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 more than 1 gigabyte product group, and beginning in 1995 are rapidly increasing their participation, exceeding 12"/14" unit shipments. DVD type CD-ROM and rewritable CD drives are expected to appear in this group beginning in 1996 and are expected to be the dominant type of drive in the more than 1 gigabyte group in 1997.

1994 revenues came predominantly from shipments in the CD-ROM product group, which contributed 77.4% of optical drive revenues. Read/write drives less

than 1 gigabyte contributed 20.0% of revenues, followed by read/write drives more than 1 gigabyte, with 2.6%. The revenue share for CD-ROM drives is expected to grow slightly in the near term, but will decline to 70.6% in 1998 as writable CD-ROM format drives and DVD drives begin to ship towards the end of the forecast period. Drives under 1 gigabyte will see their revenue share decline slightly in the short term but recover to 20.6% in 1998. The share for read/write drives over 1 gigabyte is expected to grow year to year starting in 1995, pushed by increasing 5.25" drive and writable DVD drive shipments.

CD-ROM drive shipments are forecasted to exceed 60 million units in 1998, as the result of increasing acceptance of the devices as integral parts of personal computer and game systems. The performance requirements of multimedia capable systems have shifted demand toward higher performance 12 centimeter drives, with 4X (quad speed) drives almost completely displacing lower performance models by the end of 1995. The 4X CD-ROM models are themselves due for displacement by 6X, 8X and DVD models over the next 2 to 3 years, and shipments of 4X drives will represent less than 10% of drive shipments in 1998.

Optical library shipments for 1994 were again led by CD-ROM format optical libraries, which gathered a 75.4% share of total library shipments, up from 57.9% in 1993. The next largest segment was the 1-39 disk cartridge library which captured a 18.2% share. Share for the 40-69 cartridge library group declined slightly to 2.6%, from 8.3% share in 1993. The share of libraries with 70 or more cartridges declined to 3.8%. The largest year-to-year growth rates were exhibited by CD-ROM format libraries (166.3%) and the 70 or more cartridge group (50.2%). Shipments of small, inexpensive CD-ROM autochangers holding fewer than 10 disks (some internally mounted in a 5.25" half high form factor) are expected to grow strongly and exceed one million units in 1998.

Of $304.8 million of 1994 optical library revenues, 43.2% were held by the 70 cartridge or more group, followed by the 1-39 cartridge group with 33.2% and the CD-ROM format library group with 14.3%. CD-ROM format libraries had a lower share as a result of their lower prices. The 40-69 cartridge group captured only a 9.3% share, but this is expected to increase in the short term as a result of new product introductions in this group. The share of CD-ROM format libraries is expected to increase annually, reaching 43.7% in 1998 as the result of strong shipments of small CD-ROM autochangers.

TABLE 5

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1994		Forecast							
ALL MANUFACTURERS	Revenues		1995		1996		1997		1998	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM	2,865.6	77.4%	3,882.9	80.6%	4,407.8	79.3%	5,520.7	78.5%	5,545.2	70.6%
	+88.4%		+35.5%		+13.5%		+25.2%		+.4%	
READ/WRITE	742.7	20.0%	810.7	16.8%	941.1	16.9%	1,180.9	16.8%	1,618.9	20.6%
LESS THAN 1 GIGABYTE	+26.5%		+9.2%		+16.1%		+25.5%		+37.1%	
READ/WRITE	100.6	2.6%	127.6	2.6%	218.1	3.8%	341.7	4.7%	702.4	8.8%
MORE THAN 1 GIGABYTE	+5.0%		+26.8%		+70.9%		+56.7%		+105.6%	
Total Worldwide Revenue	3,708.9	100.0%	4,821.2	100.0%	5,567.0	100.0%	7,043.3	100.0%	7,866.5	100.0%
	+68.3%		+30.0%		+15.5%		+26.5%		+11.7%	

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	1994		Forecast							
ALL MANUFACTURERS	Revenues		1995		1996		1997		1998	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM FORMAT OPTICAL LIBRARIES	43.5	14.3%	77.2	18.3%	135.0	25.1%	224.9	33.9%	362.4	43.7%
	+62.9%		+77.5%		+74.9%		+66.6%		+61.1%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	101.3	33.2%	141.0	33.5%	163.8	30.5%	181.6	27.4%	195.5	23.6%
	-2.9%		+39.2%		+16.2%		+10.9%		+7.7%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	28.2	9.3%	43.0	10.2%	56.9	10.6%	61.5	9.3%	64.5	7.8%
	-40.9%		+52.5%		+32.3%		+8.1%		+4.9%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	131.8	43.2%	159.8	38.0%	182.0	33.8%	195.7	29.4%	206.6	24.9%
	+65.2%		+21.2%		+13.9%		+7.5%		+5.6%	
Total Worldwide Revenue	304.8	100.0%	421.0	100.0%	537.7	100.0%	663.7	100.0%	829.0	100.0%
	+17.9%		+38.1%		+27.7%		+23.4%		+24.9%	

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	1994		Forecast							
IN THOUSANDS	Shipments		1995		1996		1997		1998	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM	24,048.2	97.1%	34,218.4	97.0%	44,619.0	96.5%	55,725.0	95.2%	60,923.0	89.9%
	+117.1%		+42.3%		+30.4%		+24.9%		+9.3%	
READ/WRITE	724.2	2.9%	1,081.4	3.0%	1,554.3	3.4%	2,580.2	4.4%	5,583.2	8.2%
LESS THAN 1 GIGABYTE	+58.4%		+49.3%		+43.7%		+66.0%		+116.4%	
READ/WRITE	8.6	--	20.8	--	98.1	.1%	279.1	.4%	1,339.5	1.9%
MORE THAN 1 GIGABYTE	+21.1%		+141.9%		+371.6%		+184.5%		+379.9%	
Total Worldwide Shipments	24,781.0	100.0%	35,320.6	100.0%	46,271.4	100.0%	58,584.3	100.0%	67,845.7	100.0%
	+114.8%		+42.5%		+31.0%		+26.6%		+15.8%	
% U.S. Manufacturers	1.0%		.7%		.6%		.5%		.5%	

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	1994 Shipments Units	1994 Shipments %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %
CD-ROM FORMAT OPTICAL LIBRARIES	52,753	75.4%	139,055	85.0%	316,597	91.8%	662,233	95.3%	1,260,293	97.2%
	+166.3%		+163.6%		+127.7%		+109.2%		+90.3%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	12,740	18.2%	18,636	11.4%	21,700	6.3%	24,890	3.6%	27,896	2.2%
	+30.5%		+46.3%		+16.4%		+14.7%		+12.1%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	1,832	2.6%	2,701	1.7%	3,194	.9%	3,627	.5%	4,010	.3%
	-35.4%		+47.5%		+18.2%		+13.6%		+10.6%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	2,749	3.8%	3,329	1.9%	3,931	1.0%	4,527	.6%	5,130	.3%
	+50.2%		+21.1%		+18.0%		+15.2%		+13.3%	
Total Worldwide Shipments	70,074	100.0%	163,722	100.0%	345,422	100.0%	695,277	100.0%	1,297,329	100.0%
	+104.7%		+133.6%		+111.0%		+101.3%		+86.6%	
% U.S. Manufacturers	12.5%		8.1%		4.8%		2.7%		1.6%	

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

Figure 3

WORLDWIDE SHIPMENT SUMMARY

Total Optical Disk Drives

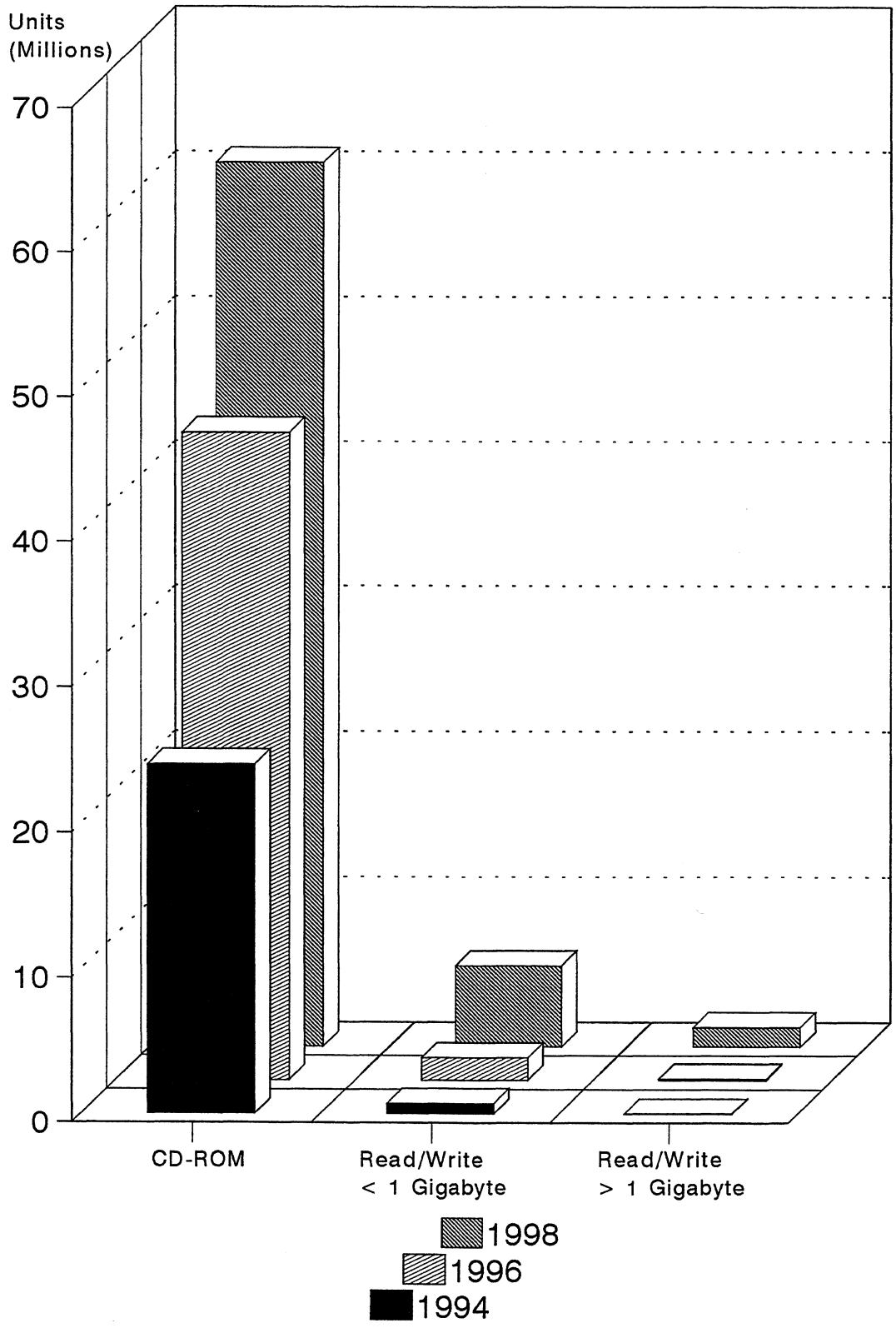
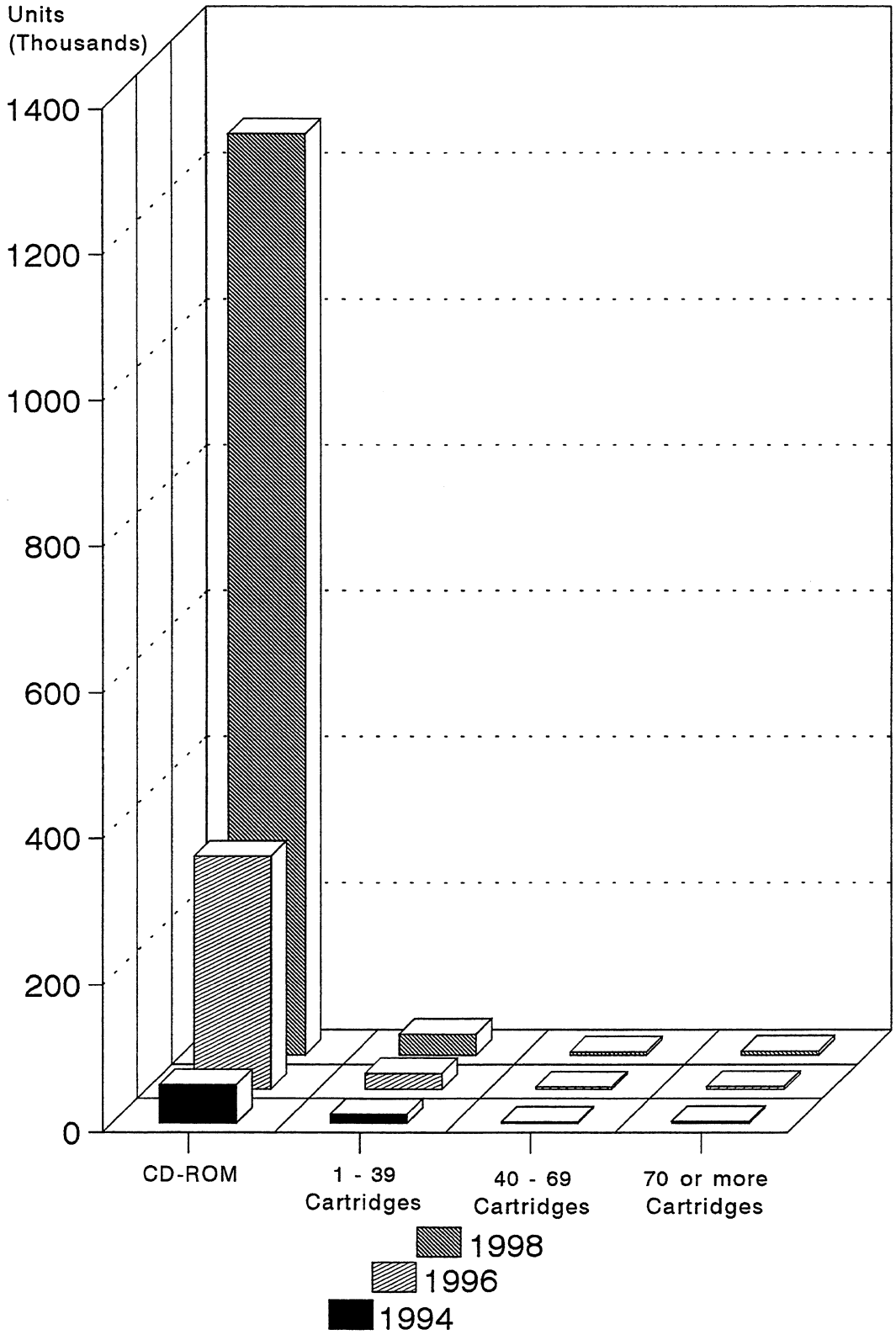


Figure 4

WORLDWIDE SHIPMENT SUMMARY

Total Optical Libraries



Noncaptive market

Once again, CD-ROM drive shipments to computer and game manufacturers exploded during the last year, driving the CD-ROM portion of the noncaptive optical disk drive total (OEM/Integrator and PCM/Reseller distribution channels) to 96.9% of the 21.9 million units shipped in 1994. Because of very strong growth by the CD-ROM market, the share of read/write drives less than 1 gigabyte shrank to 3.1% of optical disk drive total unit shipments, while the share for read/write drives more than 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 the CD-ROM market share will decline toward the end of the forecast period as shipments of higher capacity 3.5" and rewritable CD-ROM and DVD drives accelerate shipments in the read/write drive markets and recapture market share.

CD-ROM drives captured 73.3% of 1994 noncaptive revenues. The revenue share of read/write drives less than 1 gigabyte declined to 23.7%, while drives more than 1 gigabyte captured a 3.0% 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. 1998 noncaptive revenue of nearly $6.8 billion will again largely go to CD-ROM drives, which are expected to claim 71.6% of the total, followed by drives less than one gigabyte with 20.2% and drives more than 1 gigabyte, with 8.2%.

In 1994, the leading OEM/Integrator drive revenue producers were Matsushita Electric, Sony, NEC, Philips and Mitsumi, in that order. The top five companies accounted for 75.5% of total OEM/Integrator sales of nearly $1.8 billion. Matsushita Electric led with 33.6% of the OEM/Integrator total. The share held by the top five OEM channel manufacturers was down slightly from 1993, reflecting a strong market now being attacked by second and third tier drive suppliers. Fujitsu, Mitsumi, Matsushita Electric, NEC and Sony were the leading PCM/Reseller channel suppliers, together holding a 52.7% share of the $841.6 million sales in this channel. U.S. producers captured only 3.9% of total 1994 OEM/Integrator revenues, but improved their 1994 share of PCM/Reseller revenues to 11.7%.

The very strong growth of the CD-ROM drive market will drive an expansion of the noncaptive market share through 1997, completely overwhelming antici-

pated increases in captive sales by Hewlett-Packard, Hitachi, NEC and others, as well as the generally higher price levels for products sold on a captive basis.

1994 CD-ROM format library shipments generated 77.9% of the 67,802 noncaptive optical library units shipped, followed by the 1-39 cartridge library product group with 16.5% share. The CD-ROM format library and low-end segments of the read/write library market are expected to remain dominant through 1998, with the CD-ROM format library product group expanding to 97.5% share and the 1-39 cartridge libraries declining to 2.0%. Noncaptive shipments of the other library groups will also be declining as a result of the very strong projected growth of CD-ROM format library shipments.

Noncaptive library revenues exceeded $228 million in 1994 and are projected to rise to $720.8 million in 1998. Because of their higher prices, revenue shares for larger libraries exceeded their unit shipment shares. The 1-39 cartridge and more than 70 cartridge segments each captured over 38% of 1994 noncaptive revenue. However, the 1-39 disk product group lost ground relative to other groups as a result of strong competition from high capacity 5.25" magnetic disk drives. This product group, with higher prices than the CD-ROM library group, will recapture the share lead for 1995 and 1996, but will drop to second place thereafter, with 23.9% share in 1998. The 70 or more cartridge group will hold an 18.9% share in 1998. The CD-ROM segment share will rise to 50.4% in 1998, limited by lower average prices, although shipments are rapidly growing.

U.S. library manufacturers captured 48.0% of the OEM/Integrator channel revenues and 20.9% of the PCM/Reseller channel revenues in 1994. Hewlett-Packard, Sony and Philips LMS were the leading OEM/Integrator suppliers, accounting for 60.5% of $145.7 million channel revenues between them. The three top OEM/Integrator supplier's share grew slightly from 1993. In the PCM/Reseller channel, Pioneer, Hewlett-Packard, Plasmon Data Systems and Philips LMS were the leaders, together capturing 67.1% of nearly $83 million sales in the channel. Noncaptive library revenues will rise from a 75% share of the worldwide total in 1994 to a 86.9% share in 1998, with the strongest growth coming from sales of low-end libraries. The OEM/Integrator channel is expected to increase its share to 59.8% of total 1998 optical library revenues, while the PCM/Reseller channel will capture 27.1%.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1994		Forecast							
ALL MANUFACTURERS	Revenues		1995		1996		1997		1998	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM	2,046.4	73.3%	3,123.7	79.4%	3,816.7	79.2%	4,817.8	79.1%	4,835.5	71.6%
	+79.0%		+52.6%		+22.2%		+26.2%		+.4%	
READ/WRITE	662.0	23.7%	706.4	18.0%	822.7	17.1%	1,013.3	16.6%	1,363.3	20.2%
LESS THAN 1 GIGABYTE	+34.1%		+6.7%		+16.5%		+23.2%		+34.5%	
READ/WRITE	85.5	3.0%	107.7	2.6%	182.8	3.7%	267.7	4.3%	564.1	8.2%
MORE THAN 1 GIGABYTE	+3.9%		+26.0%		+69.7%		+46.4%		+110.7%	
Total Worldwide Revenues	2,793.9	100.0%	3,937.8	100.0%	4,822.2	100.0%	6,098.8	100.0%	6,762.9	100.0%
	+62.5%		+40.9%		+22.5%		+26.5%		+10.9%	

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	1994		Forecast							
ALL MANUFACTURERS	Revenues		1995		1996		1997		1998	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM FORMAT OPTICAL LIBRARIES	43.5	19.0%	77.2	23.3%	135.0	30.6%	224.9	40.2%	362.4	50.4%
	+62.9%		+77.5%		+74.9%		+66.6%		+61.1%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	80.6	35.4%	119.4	36.1%	143.2	32.5%	159.3	28.5%	172.5	23.9%
	-7.7%		+48.1%		+19.9%		+11.2%		+8.3%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	22.3	9.8%	31.4	9.5%	43.8	9.9%	47.4	8.4%	49.7	6.9%
	-51.0%		+40.8%		+39.5%		+8.2%		+4.9%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	82.1	35.8%	103.5	31.1%	119.9	27.0%	128.7	22.9%	136.2	18.8%
	+53.7%		+26.1%		+15.8%		+7.3%		+5.8%	
Total Worldwide Revenues	228.5	100.0%	331.5	100.0%	441.9	100.0%	560.3	100.0%	720.8	100.0%
	+7.3%		+45.1%		+33.3%		+26.8%		+28.6%	

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	1994		Forecast							
IN THOUSANDS	Shipments		1995		1996		1997		1998	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM	21,206.2	96.9%	31,139.8	96.9%	41,771.0	96.6%	52,655.0	95.4%	57,405.0	90.3%
	+128.1%		+46.8%		+34.1%		+26.1%		+9.0%	
READ/WRITE	686.9	3.1%	1,000.6	3.1%	1,434.4	3.3%	2,357.7	4.3%	5,074.0	8.0%
LESS THAN 1 GIGABYTE	+61.9%		+45.7%		+43.4%		+64.4%		+115.2%	
READ/WRITE	6.9	--	18.3	--	85.1	.1%	225.6	.3%	1,145.6	1.7%
MORE THAN 1 GIGABYTE	+6.2%		+165.2%		+365.0%		+165.1%		+407.8%	
Total Worldwide Shipments	21,900.0	100.0%	32,158.7	100.0%	43,290.5	100.0%	55,238.3	100.0%	63,624.6	100.0%
	+125.1%		+46.8%		+34.6%		+27.6%		+15.2%	
% U.S. Manufacturers	1.0%		.7%		.6%		.5%		.5%	

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

TABLE 12

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1994 Shipments Units	1994 Shipments %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %
CD-ROM FORMAT OPTICAL LIBRARIES	52,753	77.9%	139,055	86.5%	316,597	92.6%	662,233	95.8%	1,260,293	97.5%
	+166.3%		+163.6%		+127.7%		+109.2%		+90.3%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	11,212	16.5%	16,897	10.5%	19,727	5.8%	22,669	3.3%	25,493	2.0%
	+22.8%		+50.7%		+16.7%		+14.9%		+12.5%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	1,646	2.5%	2,319	1.4%	2,746	.8%	3,127	.5%	3,465	.3%
	-39.8%		+40.9%		+18.4%		+13.9%		+10.8%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	2,191	3.1%	2,705	1.6%	3,228	.8%	3,739	.4%	4,257	.2%
	+44.7%		+23.5%		+19.3%		+15.8%		+13.9%	
Total Worldwide Shipments	67,802	100.0%	160,976	100.0%	342,298	100.0%	691,768	100.0%	1,293,508	100.0%
	+104.3%		+137.4%		+112.6%		+102.1%		+87.0%	
% U.S. Manufacturers	10.4%		7.0%		4.1%		2.3%		1.4%	

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

Figure 5

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Disk Drives

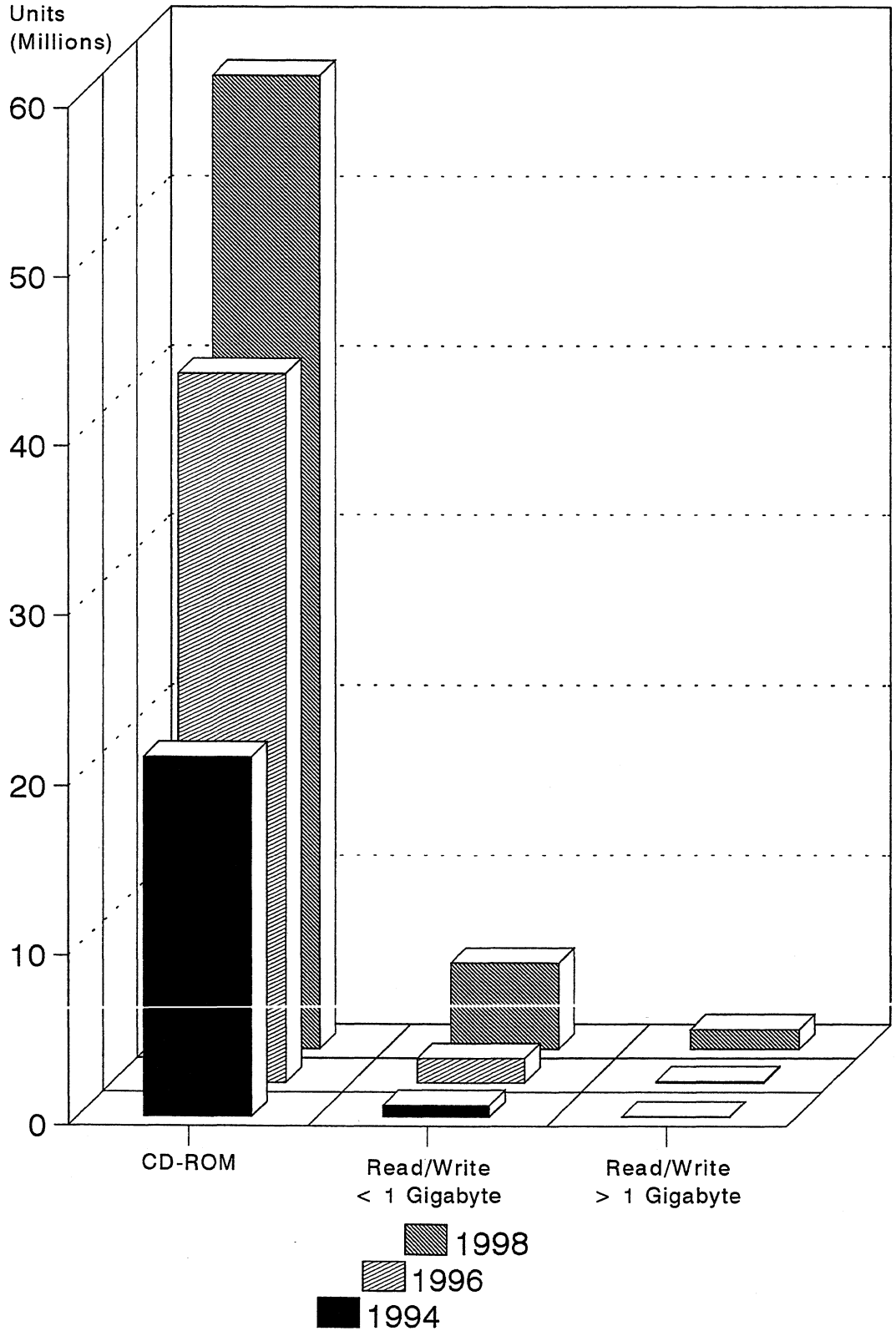


Figure 6

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Libraries

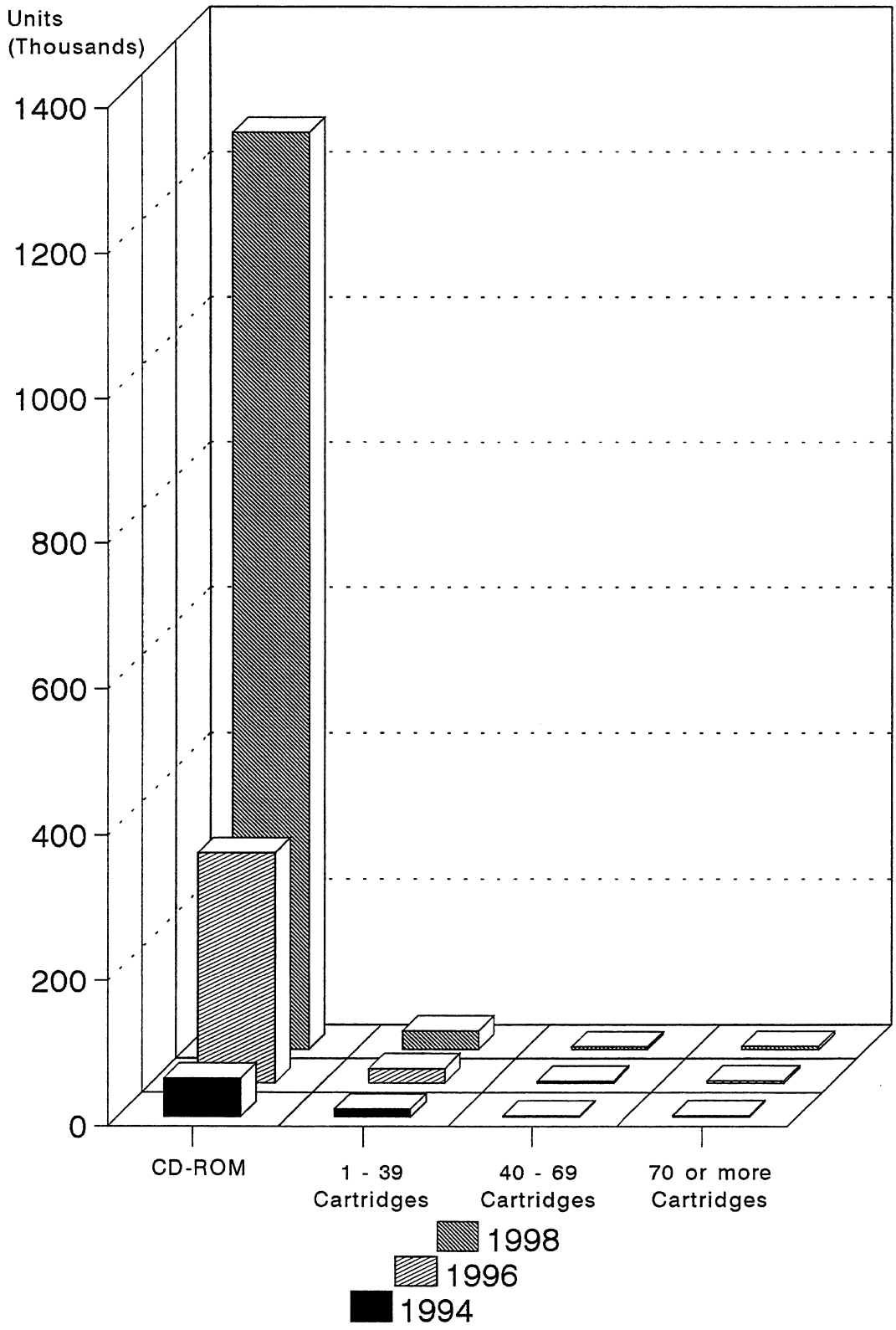


TABLE 13

1994 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK DRIVES
(Value of non-U.S. currencies estimated at average 1994 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Hewlett-Packard	12.3	1.3	32.8	3.4	23.7	1.3	68.8	1.9
IBM	26.7	2.9	34.2	3.6	24.3	1.3	85.2	2.3
Other U.S.	2.9	.3	45.0	4.7	23.0	1.2	70.9	1.9
U.S. Total	41.9	4.5	112.0	11.7	71.0	3.8	224.9	6.1
NON-U.S. MANUFACTURERS								
Fujitsu	.4	--	146.8	15.4	13.8	.7	161.0	4.3
Hitachi	14.3	1.6	36.2	3.8	27.8	1.5	78.3	2.1
Matsushita Electric Industrial	135.0	14.8	86.2	9.0	617.7	33.6	838.9	22.6
Mitsumi Electric	--	--	136.8	14.3	107.9	5.9	244.7	6.6
NEC	164.6	18.0	78.0	8.2	124.0	6.7	366.6	9.9
Philips	173.6	19.0	26.8	2.8	113.6	6.2	314.0	8.5
Sony	190.8	20.9	55.2	5.8	460.2	25.0	706.2	19.0
Toshiba	--	--	45.6	4.8	98.0	5.3	143.6	3.9
Other Non-U.S.	194.4	21.2	230.0	24.2	206.3	11.3	630.7	17.0
Non-U.S. Total	873.1	95.5	841.6	88.3	1,769.3	96.2	3,484.0	93.9
WORLDWIDE TOTAL	915.0	100.0	953.6	100.0	1,840.3	100.0	3,708.9	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

1994 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL LIBRARIES
(Value of non-U.S. currencies estimated at average 1994 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Eastman Kodak	12.3	16.1	.5	.6	13.9	9.5	26.7	8.8
Filenet	12.6	16.5	--	--	2.2	1.5	14.8	4.9
Hewlett-Packard	27.9	36.6	15.8	19.1	46.1	31.6	89.8	29.5
Other U.S.	--	.1	1.0	1.2	7.7	5.3	8.8	2.9
U.S. Total	52.9	69.3	17.3	20.9	69.9	48.0	140.1	46.0
NON-U.S. MANUFACTURERS								
ATG Cygnet	--	--	5.7	6.9	8.4	5.8	14.1	4.6
Hitachi	13.5	17.7	--	--	1.4	1.0	14.9	4.9
NK-EXA (NKK)	--	--	7.2	8.7	5.9	4.0	13.1	4.3
Philips	--	--	9.7	11.7	19.7	13.5	29.4	9.6
Pioneer Electronic	--	--	20.4	24.6	6.2	4.3	26.6	8.7
Plasmon Data Systems	--	--	9.7	11.7	.6	.4	10.3	3.4
Sony	--	--	.7	.8	22.4	15.4	23.1	7.6
Other Non-U.S.	9.9	13.0	12.1	14.6	11.2	7.7	33.2	10.9
Non-U.S. Total	23.4	30.7	65.5	79.1	75.8	52.0	164.7	54.0
WORLDWIDE TOTAL	76.3	100.0	82.8	100.0	145.7	100.0	304.8	100.0

Note: 1. Libraries 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 (10)	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, 5.25E	
IBM	C,O,P		3.5E, 5.25E	
Media Vision	P	12 cm		
MOST	O,P		3.5E	5.25E
Mountain Optech	O		3.5E, 5.25E	
Pinnacle Micro	O,P		12 cm.,5.25E	5.25E
Sierra Technologies	O,P		5.25	
Asian Manufacturers (47)				
Acer	C,O,P	12 cm		
Acer Peripherals	O,P	12 cm		
Aiwa	P	12 cm		
Alco Digital Devices	O,P	12 cm		
Asaca	O		5.25E	
Aztech Labs	O,P	12 cm		
Behavior Tech Computer	O,P	12 cm		
Birdy Electronics	O,P	12 cm		
Canon	C,O		5.25E	
Chinon	O,P	12 cm	3.5E	
Elitegroup Computer Systems	O,P	12 cm		
Fujitsu	C,O,P		3.5E, 5.25E	
Funai Electric	O	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		
IPC Peripherals	O	12 cm		
JVC	O		12 cm	
Kaimei (Jamicon)	P	12 cm		
LaserByte	O,P		3.5E	
LG Electronics	O,P	12 cm		
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,12cm	
Matsushita Electronic Comp.	O	12 cm		
Maxoptix	O,P		5.25E	
Mitsumi Electric	O,P	12 cm		
NEC	C,O,P	12 cm	3.5E, 5.25E, 12cm	12
Nikon	O			12E
Olympus	O,P		3.5E, 5.25E, 12cm	
Optics Storage	O,P	12 cm		
Pioneer Electronic	O,P	12 cm	5.25E, 12 cm	
Plextor (Shinano Kenshi)	O,P	12 cm		
Ricoh	C,O,P		3.5E, 12cm, 5.25E	
Samsung Electronics	O,P	12 cm		
Sanyo Electric	O,P	12 cm	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		
Umax Data Systems	O,P	12 cm		
Wearnes Technology	O,P	12 cm		
Yamaha	O,P		12 cm	
Yung Fu (Lxycon)	O,P	12 cm		
European Manufacturers (3)				
ATG Cygnet	O			12
Philips	O,P	12 cm	12 cm	
Philips LMS	O,P			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 (10)	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
Borett Automation Tech.	O	12 cm			5.25, 12
CD International	O,P	12 cm			
DISC	O	12 cm			5.25
Dynatek Automation (Canada)	O	12 cm			
Eastman Kodak	C,O,P	12 cm		5.25	14
FileNet	C,O,P				12
Hewlett-Packard	C,O,P		5.25	5.25	5.25
IBM	C,O		5.25		5.25
Kubik Enterprises	O	12 cm			5.25
Todd Enterprises	O,P	12 cm			
Asian Manufacturers (17)					
Aiwa	P	12 cm			
Aisin Seiki	O		5.25		
Asaca	O				5.25
Fujitsu	C,O		3.5, 5.25		5.25
Hitachi	C,O,P		5.25	5.25, 12	5.25
Matsushita Electric Ind.	C,O			5.25	
Microboards	O,P	12 cm			
Nakamichi	O,P	12 cm			
NEC	C	12 cm	5.25, 12	5.25	
Nikkyo	O		5.25	5.25	
NK-EXA (NKK)	O,P		5.25	5.25	5.25
Olympus	O,P		5.25		
PFU	O,P		3.5		
Pioneer	O,P	12 cm			
Ricoh	C,O		5.25	5.25	
Sanyo Electric	O	12 cm			
Sony	O,P		5.25, 12	12	12
European Manufacturers (8)					
Amber Technology	O,P	12 cm	5.25	5.25	
ASM	O,P	12 cm			
ATG Cygnet	O	12 cm	12		5.25, 12
DSM	O,P	12 cm	5.25, 12	12	5.25, 12
K+S	O,P	12 cm	5.25		5.25
NSM	O,P	12 cm			
Philips LMS	O,P		12		
Plasmon Data Systems	O,P		5.25	5.25	5.25

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

TECHNICAL REVIEW

The optical disk drive business has sometimes been characterized as exhibiting too slow an improvement rate to meet customer needs, but this probably won't be a strongly voiced complaint for the next few years as optical drives enter a period of rapid change.

Some of the key areas where improvements are occurring are:

* Higher power, higher frequency lasers, for higher areal densities.
* Improved ASICs to do specialized coding, compression, or other signal processing functions.
* Adoption of selected rigid disk drive components for improved performance and cost.
* Improved MTBF, now specified at up to 150,000 hours.
* 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.
* Smaller and lower power drives, for use with portable equipment.

Despite the improvements, optical drives still face formidable competition from other technologies. Multigigabyte rigid disk drives have decimated the bottom end of the 5.25" optical drive and library markets, and a new generation of removable magnetic drives with capacities of one gigabyte or more per cartridge will keep the heat on in applications where removability is required.

With rigid disk drive technology expected to improve areal density at an average 60% annual rate for the next several years, optical disk drive technology is under strong pressure to improve. Still, as the success of CD-ROM drives and the optical library storage subsystem have shown, the technology is attractive for some applications.

Optical disk technology and applications

Three types of optical disk drives used as computer peripheral devices are discussed in the following sections: CD-ROM disk drives, write-once disk drives, and rewritable disk drives.

* CD-ROM 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 are expected to appear by 1997, but disagreement between major suppliers on specifications and standards will delay acceptance.

  The high production volumes achieved by CD-ROM drives have made possible steep cost reductions, while the demands of computer manufacturers for faster drives have stimulated performance improvements. CD-ROM drives from the majority of drive manufacturers have quadrupled the RPM and the data transfer rate in order to improve video output. 6X data rate drives appeared in the last half of 1995, and the first 8X drive has been announced. Average seek times are dipping under 180 milliseconds for some models. While most applications don't require 6X or 8X performance, computer manufacturers eager to improve system specifications are expected to create early, if limited, demand for higher performance CD-ROM drives.

  The most significant technical requirement for CD-ROM drives is for increased capacity. The entertainment industry, in particular, wants drives and media capable of storing and playing back feature length movies. The computer industry wants capacity increases to eliminate the need for multiple disks and to provide more multimedia content for educational and entertainment products. Multiple gigabyte storage and 3 megabyte per second transfer rates are required for the next generation drives, which are often called DVD (Digital Video Disk) drives.

  Two contending groups of manufacturers are proposing feasible, but incompatible, specifications for DVD drives. The Multi Media CD (MMCD) format, proposed by Sony and Philips, is opposed by the Super Density (SD) format, sponsored by Toshiba and Matsushita. Each format has other supporters representing drive producers, media producers, disk replicators, and software and content providers. As might be expected, each format has comparative strengths and weaknesses, leading to pref-

erences by many in the entertainment industry for the SD format and by much of the computer industry for the MMCD format. Neither camp is willing to compromise at this juncture, so the result may be the introduction of two incompatible families of high capacity CD-ROM drives within the next two years. A standards contest similar to the VHS vs. Beta battle seems unavoidable.

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, and have stimulated sales of CD-R drives. DVD type disks will require a few additional process steps and more complex equipment to accommodate dual layer media, but replication costs are not likely to be increased unduly by the new formats. However, replicators that elect to support both SD and MMCD formats will incur costs in supporting two formats.

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. Higher rotation rates require higher power lasers. 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.

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 become available in late 1995 and early 1996. MOST is the first company to formally announce such a drive.

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. Other firms provide direct overwrite by modulation of the intensity of the laser beam during writing.

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. Phase change recording appears to be the technique of choice for rewritable drives in the DVD generation CD-ROM equivalent drives.

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

obtained with this technique because developers have not been able to demonstrate a large number of write/erase cycles 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.

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

  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. Libraries with direct network attachment capability are also appearing in the marketplace. Numerous 5.25" libraries have been introduced by firms such as NK-EXA, 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-1995, CD-ROM libraries with capacities ranging from 3 to 20,000 disks were available.

  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.

  The benefit of higher areal density is higher capacity and higher data transfer rate. The next generation of 5.25" drives will have capacity of 1.3 gigabytes per side (the Pinnacle Micro Apex drive will have 2.3 gigabytes per side), the next 3.5" generation will be 640/650 megabytes per side,

and DVD type CD-ROM drives will offer from 7.4 to 9 gigabytes per side, assuming double layer media is used.

* Multilayer disks: IBM and others have demonstrated the feasibility of multilayer recording disks. The disk is accessed from only one side, but by changing the plane of the laser focus, information can be accessed on any of several layers. Multilayer disks present relatively few problems when reading, hence are likely to appear first in high density CD-ROM systems. Multilayer recording presents more problems, resulting in lower writable capacity than readback capacity.

  Both the SD and MMCD versions of the DVD 12 centimeter CD-ROM propose two layer recording (with 9 gigabyte and 7.4 gigabyte capacity, respectively), and Hitachi has proposed a four layer SD version with 18 gigabyte capacity. The writable versions proposed so far have considerably lower capacity.

* 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 backward 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. Most users appear satisfied if a drive is read-compatible with the previous two generations of media.

* 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 other drive producers, and some other manufacturers have announced multiple heads in some models of their 12" 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 in manufacturing. 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 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 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 rewritable media can be expected to have a useful life of 10 years or more (some suppliers claim 30), but there is no field experience of actual lifetimes of this duration.

* Head positioning methods: The track density achieved on an optical drive is much higher than that obtainable on a magnetic disk drive because most optical drive designs use a pregrooved substrate as a device to provide tracking information to the head positioning servo. This method is known as the continuous composite servo (CCS) method. Some designs, such as those favored by ATG 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, but has not been widely accepted.

  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 expected as red lasers come into use, and TPI is expected to move above 20,000 TPI. The 5.25" 650 megabyte per side drives and media specify 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 read/write optical drives are small, integration of the electronics 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. Oak Technology's CD-ROM controller chip has been very successful. 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 41.3 millimeter high space. Fujitsu announced a one inch high 3.5" drive in 1992.

  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. A few drives with 19 millimeter or less height have been announced. Sony and others have shown 17.5 millimeter high CD-ROM drives and may be able to package rewritable 12 centimeter drives in this thinner format.

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

* Power: The power requirements of optical drives make them largely less suitable 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 incorporate internal CD-ROM also. Because the CD-ROM is usually used in conjunction with presentations that are given where AC power is available, the power requirement is not a serious disadvantage. TEAC's CD40 requires only two watts, adequate for use in most situations.

* Interface: The most common interface encountered on optical drives is SCSI, covering the range from low-end CD-ROM players to larger drives intended for use with multiuser or document storage systems. Interfaces compatible with the IDE standard used with most IBM personal computers are also common on CD-ROM hardware and 5.25" drives. Drives used in certain document filing systems and with sound cards have frequently used proprietary interfaces, but the SCSI family of interfaces will remain common in server based applications. Current SCSI drives usually have the SCSI controller embedded within the standard drive package, eliminating the need for a separate controller card for the drive.

  PC manufacturers began using CD-ROM drives with the ATAPI interface in 1994 because of its lower cost compared to SCSI and its ease of integra-

tion into personal computer systems. ATAPI has become the dominant form of interface for CD-ROM drives, displacing both SCSI and proprietary interfaces 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. Maxoptix, 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.

  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 can be 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.

* CD-ROM 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 progress relatively quickly, and after only minor changes, became ISO standard 9660 in 1988.

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. ECMA 168/ISO 13490, CD-R recording standards, allow for the addition of one file at a time to a disk during multisession recording.

Standards interest in the current generation of 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 CD-ROM media, but may require tighter quality and process control by replicators. Media for CD-R drives may need to be reformulated to record properly at higher spin rates. However, proposals for higher density CD-ROM media are reopening basic standards issues for CD-ROMs.

For the DVD ("digital video disk") generation of CD-ROM drives, it appears that initially, at least, there will be two major physical standards, SD and MMCD. As of mid-1995, there were no serious negotiations under way between the competing camps to arrive at a single compromise standard. The ad hoc Technical Working Group (TWG), consisting of Apple, Compaq, IBM, Hewlett-Packard and Microsoft have set forth a list of requirements that any future CD-ROM standard would have to meet. Both the SD and MMCD groups claim conformance with all stated requirements except one -- that there be a single standard.

Aside from the DVD related conflicts mentioned above, multimedia formats remain 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-1 encoding offers enough compression to enable 74 minutes of near VHS quality video to be stored on a current CD-ROM disk, but MPEG-2 will be required for VHS or better quality on a single disk and the capacity required is well beyond the current generation of CD-ROM disks.

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 discouraged acceptance.

A third multimedia format, CDTV, was used by Commodore. It is incompatible with the other two formats. 3DO, a multimedia player company that licenses its technology to hardware producers uses yet a fourth incompatible format. Other proprietary formats include Apple Computer's HFS and Eastman Kodak's Photo CD (which is similar to the CD-I format).

Read/write standards: The ANSI X3B11 technical subcommittee 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 ANSI 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 level in the optical storage area was too weak to override the formal standards activities. Currently, IBM is very active within ANSI 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 has influenced 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. Video and audio data require less error correction than other forms of data, as errors manifest themselves as a short transient in the data flow, with no lasting impact.

  A number of algorithms are currently 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

* Rigid disk drives: Rigid magnetic disk drives are the mainstay of today's auxiliary storage devices. Because they generally exhibit advantages in price/performance, packaging and power when compared to optical drives, 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. The Elite 9 has also shown itself a formidable competitor against small optical libraries. A new generation of gigabyte capacity removable rigid disk cartridge drives from SyQuest and Iomega, expected to be in production next year, will place increasing pressure upon optical disk drives. 18 gigabyte 5.25" rigid drives are expected to be in production within the same time frame.

  While optical drives have improved performance to the point where they can offer 30-40 millisecond average seek time on a 650 megabyte drive, magnetic drives typically offer sub-12 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. Even high performance optical drives, such as the new Pinnacle Micro Apex, do not match rigid magnetic drive performance.

  Most significantly, the highest areal densities of current magnetic drives, now in excess of 800 megabits per square inch, are approaching the areal density of optical drives at a fast rate and are expected to be at 10 gigabits per square inch or more by the end of the decade. Rigid drives with areal densities exceeding 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 disk drive, or to build large on-line data or multimedia libraries, may outweigh performance considerations. Such applications can include graphics design projects, video servers and video-on-demand, 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.

* 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 new high density floppy drives such as the Iomega Zip drive and the anticipated advanced floptical disk drive have extended floppy drive capacity to the 100 megabyte range. While inferior in capacity to optical drives, their much lower relative pricing for both drives and media make them a threat to 3.5" optical drives.

Alternative optical devices

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

  Optical Recording Corporation, Toppan Printing Company, Sony, Canon and Dai Nippon Printing have announced other optical card formats, but none have the momentum of the Drexler-led effort, and of these, Canon's has been the only alternate effort to proceed and remains Drexler's only significant competition. 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.

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

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

* Optical tape: Optical tape drives represent another potential solution for those needing a way to store large amounts of archival data. So far, only write-once technology has been shown to be feasible for these devices. While optical tape devices are inherently less capable of fast access to data than are disks, they do provide substantially greater capacity than magnetic tape in a single media unit, eliminating the need to handle as many media units per volume of data accessed. Only a few firms have been active in the optical tape field. The earliest were Docdata N.V., which has been developing a 6.2 gigabyte tape drive for use with IBM compatible tape controllers, and Laserstore, which worked on a 2.5 gigabyte product. LaserTape Systems, a start-up company, attempted to develop an optical tape drive using a 50 gigabyte tape cartridge similar in dimensions to the IBM 3480 tape cartridge. The firm ran out of money in 1992 and ceased operations. CREO Products, a Canadian firm, has been working with ICI on a write-once optical tape drive. CREO made its first shipment to the Canadian Government in 1990, but the total number of drives shipped is small.

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

* Electron trapping: An approach being developed by Optex Corporation, involves "electron trapping," by shifting the energy level of electrons in a material which holds them in a stable state for long periods in either the high or low energy state. A visible wavelength laser pulse moves an illuminated area to a high energy state. An infrared laser pulse causes the electrons to revert to the low energy state, emitting light as they do so. The presence or absence of light in response to a read (infrared) pulse

yields a bit of information. The process is infinitely reversible, but is subject to interference from unwanted ambient light. In its current form, the design requires multiple lasers operating at different wavelengths.

* Holographic storage: Holographic storage has been a theoretical possibility for several decades, but limitations of materials and economics have kept it from being a practical reality. Holographic storage requires a three-dimensional storage medium exhibiting photorefraction, plus appropriate electronic scanning devices for data writing and reading. Storage cell materials used have typically included lithium niobate, gallium arsenide and other photorefractive crystalline substances. Holographic storage is still in an embryonic state of development: It will be years before current storage techniques are threatened.

  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. Tamarack has received further funding from ARPA and other sources to develop a 128 gigabyte write-once system, followed by a read/write version.

  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. In 1995, NTT discussed a video holographic system using Eu doped yttrium silicate material. It, also, works only at cryogenic temperatures.

Magnetic tape drives

* High performance tape drives: Magnetic tape drives have shifted away from reel-to-reel format in favor of cartridge formats. The IBM 3480 set a standard for high-end tape drives and imitators have appeared. 3480 class products are competitive with the lower end of the optical disk product lines in terms of capacity and are superior in terms of data transfer rate, but are inferior in terms of average access time. DLT, a tape format originated by Digital Equipment Corporation, utilizing a serpentine recording format, has also made inroads in this segment of the tape drive market. 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, but the lower cost per stored megabyte typical of tape keeps tape in contention.

  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.

DEC's DLT tape product line was acquired by Quantum Corporation in 1994, along with DEC's disk drive products, and the firm has indicated an intention to continue with development of the successful product line. The current DLT tape cartridge drives offer capacities up to 20 gigabytes, with available autoloaders. DLT tape drives have become a growing competitor in the market for disk backup and archiving devices, and are positioned well to compete against other high capacity tape drive systems, as well as against optical disk drives utilized for archival storage applications.

* 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 PD drive and CD-R write-once technology and CD-E rewritable 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 Fujitsu 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

* Hewlett-Packard is considered a U.S. manufacturer.

* 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 1995 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 the 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, Hewlett-Packard 3000, Compaq SystemPro.

Personal computers: Attached to a general purpose microcomputer normally for a single user. Examples: IBM personal computers, Apple Macintosh, Compaq DeskPro, Toshiba Satellite series, Packard Bell and other 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, Sony PlayStation. Multimedia systems for home use, such as the Sega Genesis, 3DO players and most CD-I players are also included in this category.

Other applications: Any application not included above.

CD-ROM OPTICAL DISK DRIVES

1995 DISK/TREND REPORT

CD-ROM OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter (4.72") disk diameter

Acer	CD743E, CD525E
Acer Peripherals	CDE625A, CDA645A
Aiwa	ACD-300
Alco Digital Devices	CDR 931, CDR 938
Aztech Labs	CDA 268, CDA 468, CDA 668
Behavior Tech Computer	CDD-110, CDD-139
Birdy Electronics	CA 101
CD-ROM, Inc.	CRI 1100, CRI 1400
Chinon	CDS-565, CDS-525, CDS-545
Elitegroup Computer Systems	Vertos 100, Vertos 300
Funai Electric	E2540UA, PL1345
Group Sense	CDAT-300XB, CDIDE300i
Hitachi	CDR 6750, CDR 7730
Hopax Industries	520SI, 520/E, 964H
IPC Peripherals	MCD242
Kaimei (Jamicon)	Dual Speed
Lion Optics	XC 200, XC 400, XE 600
LG Electronics (GoldStar)	GCD-R320B, GCD-R540B
Longshine Electronics	LCS 7260, LCS 7460
Matsushita Electric Industrial	CR-563, LK-MC509S, LK-MC604S
Matsushita Electronic Components	EBP-201, EBP-401
Media Vision	Reno
Mitsumi Electric	CRMC-FX001DE, CRMC-FX400
NEC	PC-CD160S, CDR-401, CDR-602
Optics Storage	Dolphin 8000, Stingray 8222
Philips	CM206, CM207, CM405ABK, CDI350
Pioneer	DR-U124X, DR-S104X
Plextor (Shinano Kenshi)	PX 43CH, PX 65CS
Samsung Electronics	SCDR-530, SCR-630
Sanyo	CRD-244P, CDR 93, CDR H93
Sony	CDU-50E, CDU-76E, PRD-150
TEAC	CD-40, CD-44, CD-55
Toshiba	XM-1102B, XM-3601B, XM-5302B
TXC	TXCD-A4, TXCD-PCM1, CD-1400
Umax Data Systems	CD-IS201, CD-IS401
Wearnes Technology	CDD-220, CDD-320
Yung Fu (LXYCON)	CDE-300, CDM-420

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 more than 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 and equipment comes down and they become easier to use.

Market status

The growth of the CD-ROM drive market was as wild in 1994 as it was in 1993, and 1995 looks to be another strong year. Personal computer manufacturers have 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. However, multimedia kits, typically incorporating a sound board and a CD-ROM drive, and sold through retail and mail order channels, are being displaced, as personal computer manufacturers increasingly bundle drives into systems at the factory. Because of component and mechanism shortages, especially for 4X (quad speed) drives, the industry has fallen

considerably short of demand. However, component shortages are expected to ease in the fourth quarter of 1995 and in 1996.

Unit shipments rocketed upwards by 117% to slightly more than 24 million units, while worldwide revenues grew 88% to exceed $2.8 billion. Revenue growth was limited by sharply declining prices resulting from manufacturing economies, lower cost designs and competitive pressures. The rapidly growing market, which increasingly resembles the floppy drive business, continues to attract new entrants, many in Southeast Asia, and encourages the growth of contract manufacturing of CD-ROM drives in Southeast Asia, China and other locations. Most 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 offer it as a feature.

The Matsushita companies, Sony and Mitsumi were again the leading non-captive CD-ROM drive producers in 1994, followed by NEC and Toshiba. Sega is 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 Media Vision 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.

Marketing trends

CD-ROM drive shipments are expected to grow strongly for the next several years. Shipments of nearly 61 million units are anticipated in 1998, with associated revenues exceeding $5.54 billion. DVD (Digital Video Disk) drive shipments are expected to commence in 1996 and grow to nearly 11% of unit shipments in 1998. Drive, media and content producers are divided into two camps, one favoring the MMCD (multimedia CD) format proposed by Philips and Sony, and the other preferring the SD (super density) format sponsored by Toshiba and Matsushita Electric. Displacement of the current generation CD-ROM drives would probably proceed more quickly if the SD and MMCD factions were able to agree upon a single standard format before production begins.

The probable result of failure to arrive at a single DVD standard is a polarization of the entertainment industry to the SD camp, while the computer industry is judged more likely to adopt the MMCD format because of perceived lower technical and manufacturing risks. The entertainment content providers have immense libraries of material that could be quickly brought to market, but when viewing movies at home most people prefer see them on a television set, rather than a computer. Conversely, most computer based CD-ROM applications, even those requiring multiple disks, won't require the same high capacities needed for feature length digitized movies, and will tend to appear only after development is completed for titles capable of using multigigabyte capacities.

Average OEM prices are expected to decrease from $89 in 1994 to $79 in 1998, although 1995 prices are expected to average $94 as the result of the constrained supply of 4X drives. Prices for 2X drives dropped into the low $70 range in 1995, but the large number of high performance drives shipped are keeping average prices higher. 6X drives are entering the market as of mid-1995. Because the components required for the 6X drives are similar to those used in 4X drives, 6X prices could decline rapidly as volume builds. It is considered likely that computer manufacturers striving for competitive advantage will begin using the 6X drives in quantity in 1996. The prospects for 8X drives, which are expect-

ed to ship in low quantities beginning in late 1995, are more problematic, as they require more sophisticated and expensive components. The probable timing of an 8X generation coincides with the initial deployment of DVD drives, to the possible detriment of both. The rapid succession of higher performance product generations is expected to keep average OEM prices from falling below the high $70 range during the forecast period.

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 have arranged to manufacture their drives in China. In Taiwan, Acer, Acer Peripherals, Behavior Tech, Elitegroup, Hopax 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.

OEM shipments for 1998 are projected at about 80% of the total, up from 70.6% in 1994. Reseller shipments, 17.5% of the 1994 total, will decline to 14.1% in 1998. Captive shipments are expected to decline from 11.8% in 1994 to a 5.8% share in 1998. Both captive and reseller unit shipments are actually increasing, but will decline as a percentage of the total as OEM sales will grow faster.

Increasing numbers of freestanding game and multimedia players using CD-ROMs are expected to be sold in future years. Nintendo has declined to offer CD-ROM based games, but Sega, Philips and others had significant 1993 and 1994 shipments, and 1995 shipments are expected to exceed 2 million units, as Sony launches its new home system.

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-1 decoder chip to the drive controller. Personal computers equipped with MPEG-1 decoders can also play back CD-ROM video content. MPEG-2 will be used in both the SD and MMCD format DVD drives.

Video CD, also using MPEG-1, has attracted some industry interest, with players available from several sources. Image quality is (roughly) similar to VHS video playback. However, the format 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 the DVD high density formats able to hold two or more hours of video content are expected to be available in the next 1-2 years.

Applications

CD-ROM drives are used mostly with microcomputer based systems, including personal computers, multiple user microcomputers and network servers, 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 80.7% of CD-ROM drive unit shipments in 1994. Consumer computer and other applications, notably games such as Sega's and CD-I players, decreased to 9.8% because of the strong

growth in PC usage. CD-ROM drive use with network servers declined to 4.0% in 1994. Although unit shipments in this category increased, they were swamped by the very large increases in usage on personal computers. In 1998, single user personal computers will remain the largest application for CD-ROM drives, capturing 75.4% of the drive shipments. Consumer applications, led by entertainment and education uses, are expected to be the second largest application area, with 16.4% of the units sold. Network servers will use 2.9% 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 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, Novell and other firms use the 12 centimeter CD-ROM to distribute software and system documentation for

network servers and workstations. CD-ROM disks have become one of the most widely used media for distribution of software from independent publishers. Other types of company data distributed on CD-ROM include product information and product demonstrations, with some disks containing software and online 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 data bases 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 distribution. 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 oriented toward consumer applications, but business applications may eventually use 8

centimeter drives where portability is required, such as field maintenance. Some notebook computers 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 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

Until recently, the basic technology utilized in this product group was relatively stable, as it was derived from the consumer CD player, with significant product differentiation based primarily on performance and embedded features. However, within one to two 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, is now supported by most drives. Many sound boards for use in personal computers include CD-ROM drive interfaces on the card, but these interfaces often support only the CD-ROM drives of a particular supplier. The next generation of high capacity DVD drives are designed specifically for

multimedia applications and hopefully will be supported with better interface standardization.

Capacity: Pressure for increased capacity per disk is mounting. Legal data bases may span several disks, and game manufacturers are eager for the new video features increased capacity will make possible. 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-1995, no industry consensus on a high density format had been reached. Drives and media with capacities in the 3.7 to 9 gigabyte per side range should start to become available in 1996. The high capacity drives employ shorter wavelength red lasers (635-650 nanometers), higher track densities (19,000 to 21,000 TPI) and higher bit densities. In addition to the difficulties created by the current lack of agreement between the sponsors of the two different proposed standards, other obstacles in the march to higher capacity 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.

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 preferred in high-end drives used with file servers.

Jukebox designers may find caddies easier for high speed picker mechanisms to handle than unprotected disks, although lower performance, lower cost libraries seem to be able to handle unenclosed disks satisfactorily. Higher performance drives (8X 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. 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 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, MPEG-2 was developed to fully activate the CD-ROM based video market. 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.

The SD and MMCD formats referenced earlier are not yet official standards, but have enough support to be considered potential standards within the groups that support them. Each has undergone a series of evolutionary steps. SD began as a proposal for a two sided disk with 5 gigabytes per side. MMCD started as a single sided disk with 3.7 gigabytes per side. Both have now developed multilayer versions that should be available when production begins in 1996. SD offers a single sided, two layer 9 gigabyte disk (possibly expandable to 18 gigabytes on four layers in the future), while MMCD has a two layer, 7.4 gigabyte offering. The SD approach requires bonding together two single layer disks.

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 routinely manufacture drives with at least four times the original 150 KB/second data transfer rate, with the improvement in performance achieved by increasing the rotation rate. Most firms have announced 4X (quadruple rate) drives and some were shipping small quantities of 6X or 8X drives in 1995.

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), but drives with 256 kilobyte and 1 megabyte buffers are increasingly preferred for multimedia applications. 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 DVD drives when they enter the marketplace. Newer operating systems, such as Windows 95, can support CD-ROM drives without the addition of third party software.

Interface: 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 CD-I players, use a proprietary interface, as do some multimedia add-on kits.

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 began in the second half of 1994, and IDE/ATAPI became the most used interface in 1995, as a result of widespread adoption by personal computer manufacturers. Compaq, AST, Dell, and Gateway 2000 were 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.

Cost reduction: 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 use of more complex ASICs.

Packaging: The packaging of CD-ROM drives has changed rapidly. In 1986, most of the drives shipped were not compatible with the full height and half high form factors that have been adopted for 5.25" magnetic disk drive products. Today, CD-ROM drives are mostly half high models, but a few one inch high models have appeared and even thinner units capable of fitting under the keyboard of a notebook computer have been announced 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. CD-ROM autochangers with up to 4 disk capacities are becoming available for installation in a single half high 5.25" drive bay.

Authoring systems: Publishers of CD-ROMs require tools to help them prepare various types of content including text, data bases, audio and video for mastering and replication. Multimedia projects, in particular, are complex and require sophisticated tools to help nonexperts prepare multimedia titles. The advent of write-once CD drives (CD-R) encouraged products that include all software and hardware tools needed, and easy to use production tools for use with CD-R drives began appearing in 1994. 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 is increasing, with libraries ranging in storage capacity from three disks to several thousand 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 were 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 high spin rate drives. Media replicators and drive producers seem to be overcoming these problems. The arrival of multilayer DVD disks and higher spin rates seem likely to exacerbate 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 CD-E (CD-erasable) drives proposed by Philips are expected to begin shipping in 1996. See the section on read/write drives under a gigabyte for a full discussion.

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. However, the 2.5" drive is substantially more expensive than a CD-ROM drive and does not appear a serious contender.

3.5" magneto-optic drives offered 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.

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. The most significant competition to CD-ROM is likely to be writable versions such as CD-E drives, CD-R drives and their DVD equivalents, which might capture from 5% to 10% of the available drive slots in 1998.

Forecasting assumptions

1. CD-ROM drive production capability will substantially meet demand, although component shortages may recur in 1996.

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. DVD generation CD-ROM drives will begin shipments starting in 1996. There will be no resolution of the SD and MMCD formats into a single standard prior to the start of production.

5. CD format write-once or rewritable drives will have relatively little impact on CD-ROM sales. No other form of read-only optical memory will seriously challenge CD-ROM through 1998.

6. The CD-I format and proprietary formats 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 6X and higher operating rates. Replicator confusion about which DVD format to support and the complications of supporting both will delay the generation of DVD media replication capability.

8. There will be insignificant impact on CD-ROM shipments from the Sony 2.5" minidisk or other unannounced low-end optical drives through 1998.

TABLE 17

CD-ROM OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994		Forecast							
	Revenues		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	27.2	28.6	30.6	33.7	35.3	39.2	31.5	35.1	36.8	41.0
OEM/Integrator	3.2	4.5	3.6	4.9	4.8	5.9	4.2	5.9	4.2	5.7
TOTAL U.S. REVENUES	30.4	33.1	34.2	38.6	40.1	45.1	35.7	41.0	41.0	46.7
Non-U.S. Manufacturers										
Captive	212.5	819.2	244.8	759.2	195.3	591.1	235.9	702.9	228.4	709.7
PCM/Reseller	271.6	497.8	320.3	602.2	388.1	721.5	516.5	930.1	517.2	911.4
OEM/Integrator	849.5	1,515.5	1,250.7	2,482.9	1,690.9	3,050.1	2,082.2	3,846.7	2,223.8	3,877.4
TOTAL NON-U.S. REVENUES	1,333.6	2,832.5	1,815.8	3,844.3	2,274.3	4,362.7	2,834.6	5,479.7	2,969.4	5,498.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,364.0	2,865.6	1,850.0	3,882.9	2,314.4	4,407.8	2,870.3	5,520.7	3,010.4	5,545.2
OEM Average Price ($000)		.089		.094		.087		.086		.079

TABLE 18

CD-ROM OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994 Shipments		Forecast							
	1995		1996		1997		1998			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	112.2	116.2	139.4	148.3	162.0	180.0	136.0	151.0	160.0	178.0
OEM/Integrator	10.0	14.0	12.0	16.2	17.0	21.0	17.0	24.0	20.0	27.0
TOTAL U.S. SHIPMENTS	122.2	130.2	151.4	164.5	179.0	201.0	153.0	175.0	180.0	205.0
Non-U.S. Manufacturers										
Captive	1,054.0	2,842.0	1,113.0	3,078.6	1,000.0	2,848.0	1,050.0	3,070.0	1,127.0	3,518.0
PCM/Reseller	2,181.4	4,090.7	2,426.2	4,636.1	3,460.0	6,500.0	4,310.0	7,820.0	4,700.0	8,400.0
OEM/Integrator	9,536.6	16,985.3	13,209.8	26,339.2	19,245.0	35,070.0	24,520.0	44,660.0	27,900.0	48,800.0
TOTAL NON-U.S. SHIPMENTS	12,772.0	23,918.0	16,749.0	34,053.9	23,705.0	44,418.0	29,880.0	55,550.0	33,727.0	60,718.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	12,894.2	24,048.2	16,900.4	34,218.4	23,884.0	44,619.0	30,033.0	55,725.0	33,907.0	60,923.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	22.7	40.7	39.6	74.9	63.5	119.5	93.5	175.3	127.4	236.2

TABLE 19

CD-ROM OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DATA TRANSFER RATE

	1994		Forecast												
	Revenues		1995			1996				1997			1998		
	1X-2X	3X-4X	2X	3X-4X	6X-8X	2X	3X-4X	6X-8X	DVD	3X-4X	6X-8X	DVD	3X-4X	6X-8X	DVD
U.S. MANUFACTURERS															
PCM/Reseller	28.6	--	23.5	10.2	--	1.1	36.3	1.8	--	22.0	13.1	--	15.8	25.2	--
OEM/Integrator	4.5	--	3.4	1.5	--	--	5.0	.9	--	2.3	3.6	--	.4	5.3	--
TOTAL U.S. REVENUES	33.1	--	26.9	11.7	--	1.1	41.3	2.7	--	24.3	16.7	--	16.2	30.5	--
NON-U.S. MANUFACTURERS															
Captive	789.4	29.8	526.6	136.3	96.3	72.0	361.1	144.0	14.0	317.4	310.5	75.0	235.0	346.5	128.2
PCM/Reseller	426.4	71.4	106.3	344.5	151.4	7.7	437.1	238.0	38.7	222.5	506.0	201.6	62.4	414.0	435.0
OEM/Integrator	1,433.4	82.1	331.4	2,092.9	58.6	95.2	2,570.4	360.0	24.5	967.3	2,558.5	320.9	170.0	3,377.4	330.0
TOTAL NON-U.S. REVENUES	2,649.2	183.3	964.3	2,573.7	306.3	174.9	3,368.6	742.0	77.2	1,507.2	3,375.0	597.5	467.4	4,137.9	893.2
WORLDWIDE RECAP															
Captive	789.4	29.8	526.6	136.3	96.3	72.0	361.1	144.0	14.0	317.4	310.5	75.0	235.0	346.5	128.2
	+108.8%	--	-33.3%	+357.4%	--	-86.3%	+164.9%	+49.5%	--	-12.1%	+115.6%	+435.7%	-26.0%	+11.6%	+70.9%
PCM/Reseller	455.0	71.4	129.8	354.7	151.4	8.8	473.4	239.8	38.7	244.5	519.1	201.6	78.2	439.2	435.0
	+32.3%	+101.7%	-71.5%	+396.8%	--	-93.2%	+33.5%	+58.4%	--	-48.4%	+116.5%	+420.9%	-68.0%	-15.4%	+115.8%
OEM/Integrator	1,437.9	82.1	334.8	2,094.4	58.6	95.2	2,575.4	360.9	24.5	969.6	2,562.1	320.9	170.4	3,382.7	330.0
	+88.4%	--	-76.7%	--	--	-71.6%	+23.0%	+515.9%	--	-62.4%	+609.9%	--	-82.4%	+32.0%	+2.8%
Total Revenues	2,682.3	183.3	991.2	2,585.4	306.3	176.0	3,409.9	744.7	77.2	1,531.5	3,391.7	597.5	483.6	4,168.4	893.2
	+80.6%	+403.6%	-63.0%	--	--	-82.2%	+31.9%	+143.1%	--	-55.1%	+355.4%	+674.0%	-68.4%	+22.9%	+49.5%
ANNUAL SHARE, BY DIAMETER	93.7%	6.3%	25.6%	66.6%	7.8%	4.0%	77.5%	16.9%	1.6%	27.8%	61.4%	10.8%	8.7%	75.3%	16.0%

Notes: 1. 1X, 2X, 3X, 4X, 6X, 8X refer to data transfer rates relative to 150 kilobytes per second.
2. DVD refers to SD and MMCD drives based on digital videodisk technology.
3. Figures include 12 centimeter and 8 centimeter drives.

TABLE 20

CD-ROM OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DATA TRANSFER RATE

	1994 Shipments		Forecast												
			1995			1996				1997			1998		
	1-2X	3X-4X	2X	3X-4X	6X-8X	2X	3X-4X	6X-8X	DVD	3X-4X	6X-8X	DVD	3X-4X	6X-8X	DVD
U.S. MANUFACTURERS															
PCM/Reseller	116.2	--	118.3	30.0	--	10.0	165.0	5.0	--	110.0	41.0	--	88.0	90.0	--
OEM/Integrator	14.0	--	11.2	5.0	--	--	18.0	3.0	--	9.0	15.0	--	2.0	25.0	--
TOTAL U.S. SHIPMENTS	130.2	--	129.5	35.0	--	10.0	183.0	8.0	--	119.0	56.0	--	90.0	115.0	--
NON-U.S. MANUFACTURERS															
Captive	2,723.0	119.0	2,091.6	602.0	385.0	600.0	1,628.0	600.0	20.0	1,570.0	1,350.0	150.0	1,285.0	1,650.0	583.0
PCM/Reseller	3,614.2	476.5	1,111.1	2,767.8	757.2	110.0	4,600.0	1,700.0	90.0	2,500.0	4,600.0	720.0	800.0	4,600.0	3,000.0
OEM/Integrator	16,342.3	643.0	4,189.8	21,856.1	293.3	1,400.0	30,600.0	3,000.0	70.0	13,250.0	30,100.0	1,310.0	2,500.0	43,300.0	3,000.0
TOTAL NON-U.S. SHIPMENTS	22,679.5	1,238.5	7,392.5	25,225.9	1,435.5	2,110.0	36,828.0	5,300.0	180.0	17,320.0	36,050.0	2,180.0	4,585.0	49,550.0	6,583.0
WORLDWIDE RECAP															
Captive	2,723.0	119.0	2,091.6	602.0	385.0	600.0	1,628.0	600.0	20.0	1,570.0	1,350.0	150.0	1,285.0	1,650.0	583.0
	+53.2%	--	-23.2%	+405.9%	--	-71.3%	+170.4%	+55.8%	--	-3.6%	+125.0%	+650.0%	-18.2%	+22.2%	+288.7%
PCM/Reseller	3,730.4	476.5	1,229.4	2,797.8	757.2	120.0	4,765.0	1,705.0	90.0	2,610.0	4,641.0	720.0	888.0	4,690.0	3,000.0
	+62.7%	+303.8%	-67.0%	+487.2%	--	-90.2%	+70.3%	+125.2%	--	-45.2%	+172.2%	+700.0%	-66.0%	+1.1%	+316.7%
OEM/Integrator	16,356.3	643.0	4,201.0	21,861.1	293.3	1,400.0	30,618.0	3,003.0	70.0	13,259.0	30,115.0	1,310.0	2,502.0	43,325.0	3,000.0
	+137.6%	--	-74.3%	--	--	-66.7%	+40.1%	+923.9%	--	-56.7%	+902.8%	--	-81.1%	+43.9%	+129.0%
Total Shipments	22,809.7	1,238.5	7,522.0	25,260.9	1,435.5	2,120.0	37,011.0	5,308.0	180.0	17,439.0	36,106.0	2,180.0	4,675.0	49,665.0	6,583.0
	+108.3%	+915.2%	-67.0%	--	--	-71.8%	+46.5%	+269.8%	--	-52.9%	+580.2%	--	-73.2%	+37.6%	+202.0%
ANNUAL SHARE, BY DIAMETER	94.9%	5.1%	22.0%	73.9%	4.1%	4.8%	83.0%	11.9%	.3%	31.4%	64.8%	3.8%	7.7%	81.6%	10.7%

Notes: 1. 1X, 2X, 3X, 4X, 6X, 8X refer to data transfer rates relative to 150 kilobytes per second.
2. DVD refers to SD and MMCD drives based on digital videodisk technology.
3. Figures include 12 centimeter and 8 centimeter drives.

TABLE 21

CD-ROM OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	60.9	.1
MAINFRAME SYSTEMS				
General purpose	--	--	121.8	.2
NETWORKS/MINI/MULTIUSER				
Midrange systems and network servers	957.1	4.0	1,766.8	2.9
PERSONAL COMPUTERS				
Business and professional, single user	19,411.7	80.7	45,935.9	75.4
WORKSTATIONS				
Engineering and office, single user	1,079.8	4.5	2,376.0	3.9
CONSUMER, GAME AND HOBBY COMPUTERS	2,366.3	9.8	9,930.4	16.3
OTHER APPLICATIONS	233.3	1.0	731.2	1.2
Total	24,048.2	100.0	60,923.0	100.0

TABLE 22

CD-ROM OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	1X-2X	3X-4X	Total		1X-2X	3X-4X	Total	
Matsushita Electric	3920.0	--	3920.0	33.1	7639.0	--	7639.0	36.0
Sony	2800.0	--	2800.0	23.6	4610.0	--	4610.0	21.7
Mitsumi Electric	900.0	190.0	1090.0	9.2	1800.0	370.0	2170.0	10.2
NEC	810.0	203.0	1013.0	8.6	1335.0	377.0	1712.0	8.1
Toshiba	810.0	137.0	947.0	8.0	1134.0	222.0	1356.0	6.4
Other U.S.	122.2	--	122.2	1.0	130.2	--	130.2	.6
Other Non-U.S.	1832.5	115.5	1948.0	16.5	3782.5	150.5	3589.0	17.0
TOTAL	11194.7	645.5	11840.2	100.0	20086.7	1119.5	21206.2	100.0

Note: 1. See section DT-11 for CD-R drives.
2. Includes 12 centimeter and 8 centimeter drives.

READ/WRITE OPTICAL DISK DRIVES LESS THAN 1 GIGABYTE

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Coverage

Examples of disk drives in this group include:

2.5" disk diameter

Sony	MDH-10 (E), MDM-111(E)

3.5" disk diameter

Chinon	MOA 300DX (E)
Fujitsu	M2511A (E), M2514B (E)
IBM	MTA 3230 (E)
LaserByte	LB4230 (E)
Matsushita Electric Industrial	LF-3100 (E), LF-3294 (E)
MOST	RMD 5200-S (E), RMD 5300-S (E)
Mountain Optech	SE-250 R/W (E)
NEC	PC-OD301 (E)
Olympus	230MO Plus (E), MOS320E (E)
Ricoh	RO-3012E (E), RO-3020 (E)
Seiko Epson	OMD 6020 (E)
Sony	SMO-F331 (E), HS-D650
TEAC	OD-3000 (E), OD-5000

12 centimeter disk diameter

Eastman Kodak	PCD Writer 200, PCD Writer 600
JVC	XR-W2001, XR-S201
Matsushita Electric Industrial	LF-1000AB, LF-1004AB (E)
NEC	ODX1 (E)
Philips	CDD522, CDD2000
Pinnacle Micro	RCD1000
Ricoh	RS-9200CD, RO-1060C
Sony	CDW-900E, CDU-920S, CDU-921S
Yamaha	CDR-100, CDE-100

5.25" disk diameter

Asaca	AMD-1341NS (E)
Canon	MO-5001S (E), OM-500D (E)
Fujitsu	F6445A11 (E), IFD1300A (E)
Hewlett-Packard	C1716T (E)
Hitachi	OD 101-1, OD-112-1 (E)
Honeywell	AN/MU-928, DDU (E)
IBM	0632-CHC (E), 0632-CHA (E)
Matsushita Electric Industrial	LF-7394 (E), LF-5300
Maxoptix	T4-1300, T3-1300
Mountain Optech	CS-1000 M/F (E), RM-2000 M/F

5.25" disk diameter (continued)

NEC	N7915 (E), N1137-57 (E), ODD-155 (E)
Olympus	MOS525E (E), MOS520E (E)
Pinnacle Micro	Sierra
Pioneer	DE-SH7101 (E)
Ricoh	RO-5060E (E), RO-5031E (E)
Sharp	JY 800 (E), JY-750 (E)
Sierra Technologies	525GB+
Sony	SMO-F531 (E), RMO-S570

(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), CD-Erasable (CD-E) and the PD drive also fit 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

1994 was a mixed year for drives in this product group. Unit shipments saw a 62.5% increase to 742,700 units, but almost all of the growth was in 3.5" drives shipped in the Japanese domestic market and in CD-R drives. 5.25" drive shipments increased slightly, with a decline in write-once drive shipments canceling out much of a small gain in rewritable drive shipments, which reached 182,700 units. The primary reasons for this lackluster performance were poor cost/performance trade-offs compared to high capacity magnetic disk drives such as SyQuest's family of removable cartridge drives and the 9 gigabyte 5.25"

Seagate Elite 9 that depressed sales of small optical libraries and single optical drive subsystems. 12 centimeter CD-R drives did well, growing almost 219%, to 51,000 units shipped worldwide in 1994, as a result of the growing base of CD-ROM drives, continuing price decreases and the availability of better authoring tools.

1994 shipments of 3.5" drives rose to 481,700 units, primarily due to aggressive price reductions by manufacturers (notably Fujitsu), 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 typically strong demand for this product in that country that assisted in boosting 1994 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.

Hewlett-Packard, Sony, Matsushita Electric, and Olympus were the leading noncaptive producers of 5.25" drives in 1994, while Fujitsu produced more 3.5" drives than all other 3.5" drive producers. Philips was the leading manufacturer of write-once drives by virtue of its CD-R shipments.

Rewritable drive shipments far outnumbered write-once drive shipments, with rewritable drives capturing 91.9% of unit shipments. 27.6% of the rewritable drives shipped in this product group were 5.25" drives, and 3.5" drive shipments increased to 72.4% of 1994 rewritable drive shipments.

1994 worldwide revenues rose 26.5% to $742.7 million, with the largest part of the increase coming from rising 3.5" MO drive shipments and CD-R shipments. U.S. firms accounted for 24.6% of 1994 revenues, about the same as in 1993, with Hewlett-Packard turning in a particularly strong performance. The U.S. market accounted for 39.8% of worldwide revenues in 1994 as a result of strong 3.5" drive sales in non-U.S. markets.

Marketing trends

Rewritable 5.25" drives with capacities of over a gigabyte per side are expected to be available next year, and this will result in declining shipments of 5.25" drives in this product group from 1995 onward. Competition from 5.25"

magnetic disk drives, expected to be available with 15-20 gigabyte capacity and very low OEM pricing in the next year will also contribute to the decline. The inability of the optical drive industry to match the 60% per year areal density growth rate of the magnetic drive industry will continue to 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 through 1997 as prices decline and usability improves. CD-E drives will displace CD-R drives after that time. Although CD-E drives are expected to begin to ship in 1996, their disks can't be read by older CD-ROM drives, and CD-R drives will continue to be needed to prepare disks for these older drives. By 1997, newer, high performance CD-ROM drives compatible with CD-E disks should be in significant production, at which time displacement effects should begin.

The PD drive is expected to begin shipping in 1995 and is expected to account for over 17% of 1995 worldwide shipments. Initial shipments will be used in Matsushita's "Woody" model personal computer, but some PCM/Reseller and OEM/Integrator sales are also anticipated.

By the end of 1995, 3.5" drives with capacity of 640 megabytes or higher may be in production. These drives, if properly priced, may be attractive to OEMs and integrators. However, the 3.5" MO drive will be challenged by SyQuest's and Iomega's new families of 3.5" removable cartridge gigabyte plus drives which will be available with higher capacity, lower prices and superior performance in the coming year. The PD drive, and later the CD-R drive, will also compete in the same capacity segment of the market.

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" optical disk 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 willing to accept 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 optical drive satisfies that requirement as well.

1,081,000 units are expected to ship in 1995 for the entire product group, growing to 5,583,200 units in 1998, largely due to strong increases in shipments of CD-E drives. Rewritable drives are expected to account for 98% of shipments in 1998, of which almost 80% will be CD-E drives. 16.6% will be 3.5" drives and 1.9% will be 5.25" units. 2.5" drives, if cost reduced, may be able to capture a 1.7% share.

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.

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.

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. CD-R drives are expected to be eventually replaced by CD-E drives which offer more flexibility in use of media and can provide the same storage utility functions currently provided by floppy disk drives, albeit at a higher price.

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:

Save/restore operations

* Archival storage of files.

Hierarchical storage systems

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

Document storage and processing

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

* Office automation systems, especially those 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 "T" 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 prepress 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 1994 again was personal computers, which captured 72% of the units shipped, an increase reflecting growth of 3.5" drive shipments and CD-R shipments. The share held by workstations declined to 13.4%, while the multiuser systems share declined to 10.0%. The decline is due to the changing mix, as 3.5" drives are almost never used on network servers.

During the forecast period, about 15 to 20% 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, Plasmon Data Systems, Nikkyo, NK-EXA and others. Only a small percentage of 3.5" drives will be installed in optical libraries.

3.5" drives are expected to increase in capacity to the 640 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.

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 disk drive industry. The key areas of change are reviewed below.

Capacity: The capacity of shipped 5.25" rewritable drives is expected to reach the 1.3 gigabyte per side level by late 1995 or early 1996, although volume shipments are not expected until the second quarter of 1996. 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 by the end of 1995. Capacity increases for 12 centimeter CD-R and CD-E drives will advance to the multigigabyte range as DVD drives enter the market, but initially, at least, will have lower capacity than the DVD CD-ROM models.

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 late 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 per side 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-optic 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 1995, 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-optic 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. The introduction of the PD drive, which uses rewritable phase change media, has restimulated customer interest in phase change technology.

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.

Recording format: The recording format and related error correction schemes used in CD-ROM compatible CD-R and CD-E is optimized for sequential writing in a CLV mode. To make writing to CD-E disks more

efficient, a recording scheme is required that permits writing in sector-like blocks with ECC sector related rather than spread across several blocks. Such schemes, known as packet writing, are currently being discussed in an OSTA (Optical Storage Technology Association) technical committee, and are expected to be proposed as a standard.

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.

Average access times: 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, 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, Pinnacle Micro 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.

Data transfer rate: 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 megabytes 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.

Standards for 5.25" 650 megabyte per side media have already been approved by ECMA (ECMA standard 184) and ISO as ISO 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 stand-

ards committees. A proposal for triple capacity media has been approved as ECMA 195 and ISO 13842. The standards for 230 megabyte 3.5" media are ECMA 201 and ISO 13963. 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 prevailing pattern in the past.

The X3B11.1 technical subcommittee prepared a standard for a logical interchange format, now designated as ECMA 167 and ISO 13346. 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.

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.

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

* CD-R and CD-E drives have an error correction scheme that makes writing inefficient when not done sequentially. Packet writing software, currently being discussed in an OSTA committee, is needed to permit effective random mode writing.

* 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" drives is anticipated from a range of products, including new gigabyte range rigid cartridge drives expected from Iomega and SyQuest within the next year. The OEM prices, expected to be in the $300 to $350 range, will be substantially

under current prices for 3.5" MO drives. And fixed magnetic drives with gigabyte capacities are being advertised at retail prices in the $200 to $300 range as of mid-1995.

High capacity 5.25" magnetic drives from Seagate, Micropolis and others have impacted 5.25" optical drive sales in those stand-alone applications where a removable disk is not mandatory, and the inexpensive high capacity 3.5" drives are having a restraining effect on 3.5" MO sales as well.

Forecasting assumptions

1. 5.25" optical disk 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 1996.
2. Rewritable and write-once media will be available in adequate production quantities throughout the forecast period.
3. 12 centimeter CD-E (rewritable) drives will be available from multiple sources beginning in 1996. Drive prices will decline sharply after introduction.
4. At least one current major supplier will cease production of optical disk drives in 1995.
5. CD-E drives will impact shipments of CD-R and PD drives, starting in 1996.
6. 600+ megabyte 3.5" drives will be introduced by major producers with shipments beginning in late 1995.

TABLE 23

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	15.7	38.9	10.9	21.6	4.8	12.6	5.2	12.7	5.3	12.5
PCM/Reseller	47.1	83.4	37.9	57.4	39.0	57.8	36.7	57.6	37.4	57.0
OEM/Integrator	39.5	60.9	30.3	45.8	22.2	33.2	20.8	30.9	13.4	19.6
TOTAL U.S. REVENUES	102.3	183.2	79.1	124.8	66.0	103.6	62.7	101.2	56.1	89.1
Non-U.S. Manufacturers										
Captive	4.0	41.8	3.0	82.7	17.3	105.8	26.6	154.9	54.7	243.1
PCM/Reseller	112.2	332.1	135.5	368.5	161.4	413.6	232.9	514.9	351.8	707.8
OEM/Integrator	77.1	185.6	107.7	234.7	149.9	318.1	222.6	409.9	305.6	578.9
TOTAL NON-U.S. REVENUES	193.3	559.5	246.2	685.9	328.6	837.5	482.1	1,079.7	712.1	1,529.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	295.6	742.7	325.3	810.7	394.6	941.1	544.8	1,180.9	768.2	1,618.9
OEM Average Price ($000)		1.117		.766		.586		.421		.242

TABLE 24

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.6	17.9	3.5	7.0	1.7	4.5	2.0	4.9	2.2	5.2
PCM/Reseller	30.0	59.5	21.2	32.0	23.0	34.0	23.0	36.0	25.0	38.0
OEM/Integrator	29.2	49.5	22.4	34.0	18.0	27.0	18.0	27.0	13.0	19.2
TOTAL U.S. SHIPMENTS	65.8	126.9	47.1	73.0	42.7	65.5	43.0	67.9	40.2	62.4
Non-U.S. Manufacturers										
Captive	2.0	19.4	1.5	73.8	21.3	115.4	39.1	217.6	112.0	504.0
PCM/Reseller	118.9	406.8	198.4	602.7	282.0	801.3	557.7	1,275.9	1,339.4	2,570.6
OEM/Integrator	57.4	171.1	132.3	331.9	251.0	572.1	555.8	1,018.8	1,356.2	2,446.2
TOTAL NON-U.S. SHIPMENTS	178.3	597.3	332.2	1,008.4	554.3	1,488.8	1,152.6	2,512.3	2,807.6	5,520.8
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	244.1	724.2	379.3	1,081.4	597.0	1,554.3	1,195.6	2,580.2	2,847.8	5,583.2
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	.9	2.1	1.3	3.2	1.9	4.7	3.0	7.3	5.9	12.9

TABLE 25

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

WRITE-ONCE DRIVES: BREAKDOWN BY DISK DIAMETER

	1994 Revenues		Forecast 1995		1996		1997		1998	
	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.
U.S. MANUFACTURERS										
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS										
Captive	3.6	--	2.5	--	1.7	--	1.4	--	1.4	--
PCM/Reseller	6.0	22.3	5.9	44.2	5.6	47.5	5.1	35.5	4.7	22.1
OEM/Integrator	3.0	67.0	2.8	80.5	2.7	85.0	2.6	73.9	2.3	33.0
TOTAL NON-U.S. REVENUES	12.6	89.3	11.2	124.7	10.0	132.5	9.1	109.4	8.4	55.1
WORLDWIDE RECAP										
Captive	3.6	--	2.5	--	1.7	--	1.4	--	1.4	--
	+12.5%	--	-30.6%	--	-32.0%	--	-17.6%	--	--	--
PCM/Reseller	6.0	22.3	5.9	44.2	5.6	47.5	5.1	35.5	4.7	22.1
	-55.6%	+43.9%	-1.7%	+98.2%	-5.1%	+7.5%	-8.9%	-25.3%	-7.8%	-37.7%
OEM/Integrator	3.0	67.0	2.8	80.5	2.7	85.0	2.6	73.9	2.3	33.0
	-80.3%	+121.1%	-6.7%	+20.1%	-3.6%	+5.6%	-3.7%	-13.1%	-11.5%	-55.3%
Total Revenues	12.6	89.3	11.2	124.7	10.0	132.5	9.1	109.4	8.4	55.1
	-60.5%	+84.5%	-11.1%	+39.6%	-10.7%	+6.3%	-9.0%	-17.4%	-7.7%	-49.6%
ANNUAL SHARE, BY DIAMETER	12.4%	87.6%	8.2%	91.8%	7.0%	93.0%	7.7%	92.3%	13.2%	86.8%

TABLE 26

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

WRITE-ONCE DRIVES: BREAKDOWN BY DISK DIAMETER

	1994 Shipments		Forecast							
			1995		1996		1997		1998	
	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.	5.25"	12 cm.
U.S. MANUFACTURERS										
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS										
Captive	1.2	--	.9	--	.6	--	.5	--	.5	--
PCM/Reseller	4.2	10.2	3.9	37.2	3.3	51.0	2.9	53.0	2.6	46.0
OEM/Integrator	2.3	40.8	2.2	92.0	2.1	125.0	1.8	132.0	1.2	59.0
TOTAL NON-U.S. SHIPMENTS	7.7	51.0	7.0	129.2	6.0	176.0	5.2	185.0	4.3	105.0
WORLDWIDE RECAP										
Captive	1.2	--	.9	--	.6	--	.5	--	.5	--
	--	--	-25.0%	--	-33.3%	--	-16.7%	--	--	--
PCM/Reseller	4.2	10.2	3.9	37.2	3.3	51.0	2.9	53.0	2.6	46.0
	-50.6%	+67.2%	-7.1%	+264.7%	-15.4%	+37.1%	-12.1%	+3.9%	-10.3%	-13.2%
OEM/Integrator	2.3	40.8	2.2	92.0	2.1	125.0	1.8	132.0	1.2	59.0
	-79.3%	+329.5%	-4.3%	+125.5%	-4.5%	+35.9%	-14.3%	+5.6%	-33.3%	-55.3%
Total Shipments	7.7	51.0	7.0	129.2	6.0	176.0	5.2	185.0	4.3	105.0
	-63.0%	+218.8%	-9.1%	+153.3%	-14.3%	+36.2%	-13.3%	+5.1%	-17.3%	-43.2%
ANNUAL SHARE, BY DIAMETER	13.1%	86.9%	5.1%	94.9%	3.3%	96.7%	2.7%	97.3%	3.9%	96.1%

TABLE 27

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

REWRITABLE DRIVES: BREAKDOWN BY DISK DIAMETER

	1994 Revenues			Forecast															
				1995				1996				1997				1998			
	5.25"	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"
U.S. MANUFACTURERS																			
Captive	21.8	17.1	--	21.6	--	--	--	12.6	--	--	--	12.7	--	--	--	12.5	--	--	--
PCM/Reseller	61.2	22.2	--	57.4	--	--	--	57.8	--	--	--	57.6	--	--	--	57.0	--	--	--
OEM/Integrator	49.8	11.1	--	45.8	--	--	--	33.2	--	--	--	30.9	--	--	--	19.6	--	--	--
TOTAL U.S. REVENUES	132.8	50.4	--	124.8	--	--	--	103.6	--	--	--	101.2	--	--	--	89.1	--	--	--
NON-U.S. MANUFACTURERS																			
Captive	31.4	6.8	--	33.2	44.0	3.0	--	18.3	82.6	3.2	--	15.6	134.7	3.2	--	13.0	225.3	3.4	--
PCM/Reseller	81.6	222.2	--	69.9	33.8	213.4	1.3	53.3	90.4	209.1	7.7	31.9	209.3	214.2	18.9	17.8	415.3	225.8	22.1
OEM/Integrator	67.5	47.4	.7	64.8	14.0	66.9	5.7	57.5	94.1	70.4	8.4	42.9	206.7	74.2	9.6	22.0	433.0	78.5	10.1
TOTAL NON-U.S. REVENUES	180.5	276.4	.7	167.9	91.8	283.3	7.0	129.1	267.1	282.7	16.1	90.4	550.7	291.6	28.5	52.8	1,073.6	307.7	32.2
WORLDWIDE RECAP																			
Captive	53.2	23.9	--	54.8	44.0	3.0	--	30.9	82.6	3.2	--	28.3	134.7	3.2	--	25.5	225.3	3.4	--
	-21.8%	+22.6%	--	+3.0%	--	-87.4%	--	-43.6%	+87.7%	+6.7%	--	-8.4%	+63.1%	--	--	-9.9%	+67.3%	+6.3%	--
PCM/Reseller	142.8	244.4	--	127.3	33.8	213.4	1.3	111.1	90.4	209.1	7.7	89.5	209.3	214.2	18.9	74.8	415.3	225.8	22.1
	+107.3%	+96.8%	--	-10.9%	--	-12.7%	--	-12.7%	+167.5%	-2.0%	+492.3%	-19.4%	+131.5%	+2.4%	+145.5%	-16.4%	+98.4%	+5.4%	+16.9%
OEM/Integrator	117.3	58.5	.7	110.6	14.0	66.9	5.7	90.7	94.1	70.4	8.4	73.8	206.7	74.2	9.6	41.6	433.0	78.5	10.1
	-30.0%	+.2%	--	-5.7%	--	+14.4%	+714.3%	-18.0%	+572.1%	+5.2%	+47.4%	-18.6%	+119.7%	+5.4%	+14.3%	-43.6%	+109.5%	+5.8%	+5.2%
Total Revenues	313.3	326.8	.7	292.7	91.8	283.3	7.0	232.7	267.1	282.7	16.1	191.6	550.7	291.6	28.5	141.9	1,073.6	307.7	32.2
	+2.9%	+61.7%	--	-6.6%	--	-13.3%	+900.0%	-20.5%	+191.0%	-.2%	+130.0%	-17.7%	+106.2%	+3.1%	+77.0%	-25.9%	+95.0%	+5.5%	+13.0%
ANNUAL SHARE, BY DIAMETER	49.0%	51.0%	--	43.5%	13.6%	42.0%	.9%	29.2%	33.4%	35.4%	2.0%	18.0%	51.9%	27.4%	2.7%	9.1%	69.1%	19.8%	2.0%

Note: 12 centimeter drives include PD drives and CD-E drives.

TABLE 28

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

REWRITABLE DRIVES: BREAKDOWN BY DISK DIAMETER

	1994 Shipments			Forecast															
				1995				1996				1997				1998			
	5.25"	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"	5.25"	12 cm.	3.5"	2.5"
U.S. MANUFACTURERS																			
Captive	6.5	11.4	--	7.0	--	--	--	4.5	--	--	--	4.9	--	--	--	5.2	--	--	--
PCM/Reseller	31.0	28.5	--	32.0	--	--	--	34.0	--	--	--	36.0	--	--	--	38.0	--	--	--
OEM/Integrator	32.4	17.1	--	34.0	--	--	--	27.0	--	--	--	27.0	--	--	--	19.2	--	--	--
TOTAL U.S. SHIPMENTS	69.9	57.0	--	73.0	--	--	--	65.5	--	--	--	67.9	--	--	--	62.4	--	--	--
NON-U.S. MANUFACTURERS																			
Captive	13.7	4.5	--	14.9	55.0	3.0	--	7.3	104.0	3.5	--	6.1	207.0	4.0	--	5.0	494.0	4.5	--
PCM/Reseller	54.7	337.7	--	50.7	75.0	434.0	1.9	41.0	181.0	510.0	15.0	29.0	551.0	595.0	45.0	18.0	1,775.0	664.0	65.0
OEM/Integrator	44.4	82.5	1.1	44.8	35.0	145.4	12.5	46.0	199.0	176.0	24.0	38.0	609.0	206.0	32.0	20.0	2,092.0	238.0	36.0
TOTAL NON-U.S. SHIPMENTS	112.8	424.7	1.1	110.4	165.0	582.4	14.4	94.3	484.0	689.5	39.0	73.1	1,367.0	805.0	77.0	43.0	4,361.0	906.5	101.0
WORLDWIDE RECAP																			
Captive	20.2	15.9	--	21.9	55.0	3.0	--	11.8	104.0	3.5	--	11.0	207.0	4.0	--	10.2	494.0	4.5	--
	+1.5%	+39.5%	--	+8.4%	--	-81.1%	--	-46.1%	+89.1%	+16.7%	--	-6.8%	+99.0%	+14.3%	--	-7.3%	+138.6%	+12.5%	--
PCM/Reseller	85.7	366.2	--	82.7	75.0	434.0	1.9	75.0	181.0	510.0	15.0	65.0	551.0	595.0	45.0	56.0	1,775.0	664.0	65.0
	+120.3%	+134.9%	--	-3.5%	--	+18.5%	--	-9.3%	+141.3%	+17.5%	+689.5%	-13.3%	+204.4%	+16.7%	+200.0%	-13.8%	+222.1%	+11.6%	+44.4%
OEM/Integrator	76.8	99.6	1.1	78.8	35.0	145.4	12.5	73.0	199.0	176.0	24.0	65.0	609.0	206.0	32.0	39.2	2,092.0	238.0	36.0
	-28.6%	+15.0%	--	+2.6%	--	+46.0%	--	-7.4%	+468.6%	+21.0%	+92.0%	-11.0%	+206.0%	+17.0%	+33.3%	-39.7%	+243.5%	+15.5%	+12.5%
Total Shipments	182.7	481.7	1.1	183.4	165.0	582.4	14.4	159.8	484.0	689.5	39.0	141.0	1,367.0	805.0	77.0	105.4	4,361.0	906.5	101.0
	+9.8%	+89.7%	--	+.4%	--	+20.9%	--	-12.9%	+193.3%	+18.4%	+170.8%	-11.8%	+182.4%	+16.8%	+97.4%	-25.2%	+219.0%	+12.6%	+31.2%
ANNUAL SHARE, BY DIAMETER	27.6%	72.4%	--	19.4%	17.5%	61.7%	1.4%	11.6%	35.4%	50.2%	2.8%	5.9%	57.3%	33.7%	3.1%	1.9%	79.8%	16.6%	1.7%

Note: 12 centimeter drives include PD drives and CD-E drives.

TABLE 29

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1994		Forecast							
	--Shipments--		-----1995----		-----1996----		-----1997----		-----1998----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	17.9		7.0		4.5		4.9		5.2	
Rewritable	17.9	100.0%	7.0	100.0%	4.5	100.0%	4.9	100.0%	5.2	100.0%
Noncaptive Total	109.0		66.0		61.0		63.0		57.2	
Rewritable	109.0	100.0%	66.0	100.0%	61.0	100.0%	63.0	100.0%	57.2	100.0%
Total U.S.	126.9		73.0		65.5		67.9		62.4	
Rewritable	126.9	100.0%	73.0	100.0%	65.5	100.0%	67.9	100.0%	62.4	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	19.4		73.8		115.4		217.6		504.0	
Write-once	1.2	6.2%	.9	1.2%	.6	.5%	.5	.2%	.5	.1%
Rewritable	18.2	93.8%	72.9	98.8%	114.8	99.5%	217.1	99.8%	503.5	99.9%
Noncaptive Total	577.9		934.6		1,373.4		2,294.7		5,016.8	
Write-once	57.5	10.0%	135.3	14.5%	181.4	13.2%	189.7	8.3%	108.8	2.2%
Rewritable	520.4	90.1%	799.3	85.5%	1,192.0	86.8%	2,105.0	91.7%	4,908.0	97.8%
Total Non-U.S.	597.3		1,008.4		1,488.8		2,512.3		5,520.8	
Write-once	58.7	9.8%	136.2	13.5%	182.0	12.2%	190.2	7.6%	109.3	2.0%
Rewritable	538.6	90.2%	872.2	86.5%	1,306.8	87.8%	2,322.1	92.4%	5,411.5	98.0%
WORLDWIDE RECAP										
Total Worldwide Shipments	724.2		1,081.4		1,554.3		2,580.2		5,583.2	
	+58.4%		+49.3%		+43.7%		+66.0%		+116.4%	
Write-once	58.7	8.1%	136.2	12.6%	182.0	11.7%	190.2	7.4%	109.3	2.0%
	+59.5%		+132.0%		+33.6%		+4.5%		-42.4%	
Rewritable	665.5	91.9%	945.2	87.4%	1,372.3	88.3%	2,390.0	92.6%	5,473.9	98.0%
	+58.3%		+42.0%		+45.2%		+74.2%		+129.0%	

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	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	18.5	2.6	33.5	.6
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	71.7	9.9	1,250.6	22.4
PERSONAL COMPUTERS Business and professional, single user	520.5	71.9	2,149.5	38.5
WORKSTATIONS Engineering and office, single user	99.0	13.7	2,021.2	36.2
CONSUMER, GAME AND HOBBY COMPUTERS	1.5	.2	16.7	.3
OTHER APPLICATIONS	13.0	1.7	111.7	2.0
Total	724.2	100.0	5,583.2	100.0

TABLE 31

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	12 cm.	3.5"	2.5"	Total		5.25"	12 cm.	3.5"	2.5"	Total	
Fujitsu	--	--	66.0	--	66.0	28.0	--	--	251.0	--	251.0	36.5
Sony	9.0	1.5	4.0	.2	14.7	6.2	29.0	2.8	60.0	1.1	92.9	13.5
Matsushita Electric	19.0	--	4.0	--	23.0	9.8	28.0	--	59.0	--	87.0	12.7
IBM	9.8	--	16.0	--	25.8	11.0	14.0	--	45.6	--	59.6	8.7
Olympus Optical	11.0	--	15.0	--	26.0	11.0	18.0	--	38.0	--	56.0	8.2
Hewlett-Packard	20.8	--	--	--	20.8	8.8	31.4	--	--	--	31.4	4.6
Ricoh	2.0	1.5	1.0	--	4.5	1.9	13.2	3.0	11.0	--	27.2	4.0
Other U.S.	12.6	--	--	--	12.6	5.4	18.0	--	--	--	18.0	2.6
Other Non-U.S.	6.1	34.8	1.2	--	42.1	17.9	17.4	45.2	1.2	--	63.8	9.2
TOTAL	90.3	37.8	107.2	.2	235.5	100.0	169.0	51.0	465.8	1.1	686.9	100.0

READ/WRITE OPTICAL DISK DRIVES MORE THAN 1 GIGABYTE

1995 DISK/TREND REPORT

READ/WRITE OPTICAL DISK DRIVES MORE THAN 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

Eastman Kodak	System 2000

12" disk diameter

ATG Cygnet	GD6001, GD9001/S
Hitachi	OD 301A-1, OD 321-1
NEC	N6513-23, N6513-20
Nikon	MO-DD121-1AJ (E)
Philips LMS	LD 4100, LD 6100
Sony	WDD 600, WDD 930-01, WDD-530

5.25" disk diameter

Hitachi	OD 152 (E)
Pinnacle Micro	Orray (E), Apex (E)
Pioneer	DE-SH2200

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 1995. The Pinnacle Micro Orray 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 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. 12 centimeter rewritable drives are expected to enter this group in 1996.

Market status

Drive shipments in this group increased to 8,600 units in 1994, a 21% increase. A decrease of nearly 20% in 12" drive shipments was offset by an increase in 5.25" drive shipments, which accounted for a third of the year's worldwide shipments. 1994 revenues rose slightly to $100.6 million. U.S. manufacturers accounted for 8.5% of worldwide sales revenues. 42.9% of worldwide revenue was generated in the U.S. market, a substantial decline from 66.9% in 1993, caused by fewer shipments of expensive 12" drives to U.S. customers. 73.4% of 1994 revenues were generated by sales to OEMs and integrators, about the same as in 1993.

Over 96% of 1994 unit shipments were produced by non-U.S. firms, about the same as in 1993. 41.9% of 1994 unit shipments went to the U.S. market, a decrease, while 58.1% were sold in other parts of the world. 1994's leading noncaptive producers were Hitachi and Philips LMS.

Although there are relatively few producers of drives in this product group, with the arrival of high capacity 5.25" and 12 centimeter (4.72") 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 while 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" and 12 centimeter drives will expand the market for this product group into general industry.

Marketing trends

Shipments of 12" and 14" drives will improve gradually throughout the forecast period as a result of higher capacity drives becoming available. The first shipments of 5.25" drives in this group began in 1994 and are expected to eclipse shipments of 12" drives in 1995. 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 are also anticipated. 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.

The largest change in this group will be the result of multigigabyte rewritable DVD type drives that may begin appearing in the market as early as 1996. These drives will be quite inexpensive compared to other drives in the group, causing the average OEM price to fall sharply during the forecast period. Of the over 1.3 million drives in this product group expected to ship in 1998, nearly 89% will be 12 centimeter drives, and most will be attached to high end personal computers.

During the forecast period, total revenues are expected to grow from $100.6 million in 1994 to $702.4 million in 1998. The U.S. market is expected to generate 56.4% of 1998 worldwide revenues for this product group, with U.S. firms' share of worldwide revenues reaching only 8.7%. 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 began declining in 1995 due to the effect of 5.25" drives on the product 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. A major acceleration in the rate of price decline is expected in 1996 as 12 centimeter drive shipments in this group ramp up.

Applications

Networks and multiuser systems, high end personal computers and workstations were major application platforms for drives in this group in 1994, accounting for 86.2% of unit shipments, but libraries attached to mainframes used enough drives to account for 13.8% of group shipments. With the arrival of 12 centimeter drives in this group, the pattern will alter drastically, with personal computer attachments expected to capture 74.4% of the 1998 shipments.

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 required 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 may become less dominant, although many of the 12 centimeter drives may be used for archiving personal files.

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 1994, over 90% of the 12", 14" and 5.25" drives shipped in this group were attached to optical libraries, but library attachment is expected to gradually decline as 5.25" drives (which are less likely to be used with libraries) form a greater part of this product group. Only a very small percentage of 12 centimeter drives are likely to appear in libraries.

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 help sustain the optical disk drive market.

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 disk storage systems, 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.

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.

Manufacturers of 12" drives are planning to offer increasingly higher capacities in order to keep their product lines viable, with capacity expected to ultimately extend above 20 gigabytes per cartridge.

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, and already have much shorter average access times.

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 to be introduced in 1995 and 1996 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, although the MOST drive introduced early in 1995 only spins at 1,800 RPM.

Standards: Because various manufacturer's 12" product designs are already established and incompatible, standardization for 12" drives has been limited. ECMA 190 and ISO 13403 apply to the 12" CCS format, while ECMA 189 and ISO 13614 apply to the 12" sampled servo format. ISO standard 10885 for 14" media (which affects only the Eastman Kodak drive) has also been completed. In any event, the continuous servo

versus sampled servo conflict yet remains, and there is no standard for 12" rewritable media.

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.

12 centimeter drives will be highly standardized within the two formats (SD and MMCD) that will be in use. There is a possibility of an eventual convergence to one format, but probably not for several years.

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 weak 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. By virtue of Hewlett-Packard's strong position in the library industry, its library interface definition is becoming a de facto standard.

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 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. The family of 12" drives that started its introduction cycle in late 1994 offers 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 7.4 gigabytes per side and is also expected to further upgrade capacity. Several 12" drivve models now have dual heads, making the entire capacity of the cartridge available without the need to flip the disk.

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. On the other hand, 5.25" and 12 centimeter drives in this group will most often be rewritable drives.

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.

The 12" form factor was the most frequently encountered drive size in this product group during 1994, but in 1995 and thereafter 5.25" and 12 centimeter 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 large capacity 12" and 5.25" 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 disk 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 nonsemiconductor lasers and still achieve reasonable performance.

Because nonsemiconductor lasers can operate at higher frequencies and powers, very high performance may be possible by using them in optical storage systems. 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, while 12 centimeter media will use only plastic substrates.

Forecasting assumptions

1. 5.25" optical disk drives will be major participants in this product group after 1994, and 12 centimeter drives will be major participants beginning in 1996.
2. There will continue to be an adequate supply of media for drives in this product group.
3. There will be no generally accepted single standard for 12" drives and media through 1998.
4. Rewritable 12" drives and media will have only marginal impact.
5. 12 centimeter drives in this product group will be primarily rewritable DVD types and will be attached most often to personal computers.

TABLE 32

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994		Forecast							
	Revenues		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	3.0	3.0	5.7	5.7	5.2	5.2	5.0	7.5	7.2	9.6
PCM/Reseller	--	--	1.8	2.3	7.8	9.4	9.8	13.1	11.0	15.4
OEM/Integrator	2.8	5.6	10.5	14.0	15.4	22.8	18.3	29.5	25.5	36.4
TOTAL U.S. REVENUES	5.8	8.6	18.0	22.0	28.4	37.4	33.1	50.1	43.7	61.4
Non-U.S. Manufacturers										
Captive	--	12.1	--	14.2	--	30.1	10.0	66.5	24.0	128.7
PCM/Reseller	4.9	11.7	8.7	16.7	17.3	31.5	34.2	62.6	136.4	187.7
OEM/Integrator	32.5	68.2	41.1	74.7	62.0	119.1	86.1	162.5	192.1	324.6
TOTAL NON-U.S. REVENUES	37.4	92.0	49.8	105.6	79.3	180.7	130.3	291.6	352.5	641.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	43.2	100.6	67.8	127.6	107.7	218.1	163.4	341.7	396.2	702.4
OEM Average Price ($000)		11.9		6.0		2.4		1.3		.5

TABLE 33

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994 Shipments		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.1	.1	.2	.2	.2	.2	.2	.3	.3	.4
PCM/Reseller	--	--	2.0	2.6	10.0	12.0	15.0	20.0	20.0	28.0
OEM/Integrator	.1	.2	6.7	7.8	15.2	22.3	24.2	35.4	40.3	53.5
TOTAL U.S. SHIPMENTS	.2	.3	8.9	10.6	25.4	34.5	39.4	55.7	60.6	81.9
Non-U.S. Manufacturers										
Captive	--	1.6	--	2.3	--	12.8	10.0	53.2	40.0	193.5
PCM/Reseller	.3	.7	.5	1.1	5.2	14.1	33.6	65.1	304.7	407.2
OEM/Integrator	3.1	6.0	3.6	6.8	17.9	36.7	59.6	105.1	426.0	656.9
TOTAL NON-U.S. SHIPMENTS	3.4	8.3	4.1	10.2	23.1	63.6	103.2	223.4	770.7	1,257.6
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3.6	8.6	13.0	20.8	48.5	98.1	142.6	279.1	831.3	1,339.5
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	41.4	89.3	54.4	110.1	102.9	208.2	245.5	487.3	1,076.8	1,826.8

TABLE 34

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues		1995		1996			Forecast 1997			1998		
	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12 cm.	12"-14"	5.25"	12 cm.	12"-14"	5.25"	12 cm.
U.S. MANUFACTURERS													
Captive	3.0	--	5.7	--	5.2	--	--	7.5	--	--	9.6	--	--
PCM/Reseller	--	--	--	2.3	--	9.4	--	--	13.1	--	--	15.4	--
OEM/Integrator	5.6	--	8.1	5.9	7.8	15.0	--	10.2	19.3	--	12.5	23.9	--
TOTAL U.S. REVENUES	8.6	--	13.8	8.2	13.0	24.4	--	17.7	32.4	--	22.1	39.3	--
NON-U.S. MANUFACTURERS													
Captive	6.2	5.9	6.2	8.0	6.6	9.5	14.0	6.3	10.2	50.0	4.1	10.6	114.0
PCM/Reseller	11.7	--	16.3	.4	16.0	7.2	8.3	18.2	8.4	36.0	20.9	10.8	156.0
OEM/Integrator	65.2	3.0	71.0	3.7	75.0	40.2	3.9	79.9	52.0	30.6	88.9	61.7	174.0
TOTAL NON-U.S. REVENUES	83.1	8.9	93.5	12.1	97.6	56.9	26.2	104.4	70.6	116.6	113.9	83.1	444.0
WORLDWIDE RECAP													
Captive	9.2	5.9	11.9	8.0	11.8	9.5	14.0	13.8	10.2	50.0	13.7	10.6	114.0
	-31.9%	--	+29.3%	+35.6%	-.8%	+18.8%	--	+16.9%	+7.4%	+257.1%	-.7%	+3.9%	+128.0%
PCM/Reseller	11.7	--	16.3	2.7	16.0	16.6	8.3	18.2	21.5	36.0	20.9	26.2	156.0
	+17.0%	--	+39.3%	--	-1.8%	+514.8%	--	+13.8%	+29.5%	+333.7%	+14.8%	+21.9%	+333.3%
OEM/Integrator	70.8	3.0	79.1	9.6	82.8	55.2	3.9	90.1	71.3	30.6	101.4	85.6	174.0
	-2.1%	--	+11.7%	+220.0%	+4.7%	+475.0%	--	+8.8%	+29.2%	+684.6%	+12.5%	+20.1%	+468.6%
Total Revenues	91.7	8.9	107.3	20.3	110.6	81.3	26.2	122.1	103.0	116.6	136.0	122.4	444.0
	-4.3%	--	+17.0%	+128.1%	+3.1%	+300.5%	--	+10.4%	+26.7%	+345.0%	+11.4%	+18.8%	+280.8%
ANNUAL SHARE, BY DIAMETER	91.3%	8.7%	84.2%	15.8%	50.8%	37.3%	11.9%	35.8%	30.1%	34.1%	19.4%	17.4%	63.2%

Note: 12 centimeter disk drives are DVD types.

TABLE 35

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments		Forecast										
			1995		1996			1997			1998		
	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12 cm.	12"-14"	5.25"	12 cm.	12"-14"	5.25"	12 cm.
U.S. MANUFACTURERS													
Captive	.1	--	.2	--	.2	--	--	.3	--	--	.4	--	--
PCM/Reseller	--	--	--	2.6	--	12.0	--	--	20.0	--	--	28.0	--
OEM/Integrator	.2	--	.3	7.5	.3	22.0	--	.4	35.0	--	.5	53.0	--
TOTAL U.S. SHIPMENTS	.3	--	.5	10.1	.5	34.0	--	.7	55.0	--	.9	81.0	--
NON-U.S. MANUFACTURERS													
Captive	.3	1.3	.3	2.0	.3	2.5	10.0	.3	2.9	50.0	.2	3.3	190.0
PCM/Reseller	.7	--	.9	.2	1.0	3.1	10.0	1.1	4.0	60.0	1.2	6.0	400.0
OEM/Integrator	4.4	1.6	4.6	2.2	4.9	26.8	5.0	5.1	40.0	60.0	5.5	51.4	600.0
TOTAL NON-U.S. SHIPMENTS	5.4	2.9	5.8	4.4	6.2	32.4	25.0	6.5	46.9	170.0	6.9	60.7	1,190.0
WORLDWIDE RECAP													
Captive	.4	1.3	.5	2.0	.5	2.5	10.0	.6	2.9	50.0	.6	3.3	190.0
	-33.3%	--	+25.0%	+53.8%	--	+25.0%	--	+20.0%	+16.0%	+400.0%	--	+13.8%	+280.0%
PCM/Reseller	.7	--	.9	2.8	1.0	15.1	10.0	1.1	24.0	60.0	1.2	34.0	400.0
	-12.5%	--	+28.6%	--	+11.1%	+439.3%	--	+10.0%	+58.9%	+500.0%	+9.1%	+41.7%	+566.7%
OEM/Integrator	4.6	1.6	4.9	9.7	5.2	48.8	5.0	5.5	75.0	60.0	6.0	104.4	600.0
	-19.3%	--	+6.5%	+506.2%	+6.1%	+403.1%	--	+5.8%	+53.7%	--	+9.1%	+39.2%	+900.0%
Total Shipments	5.7	2.9	6.3	14.5	6.7	66.4	25.0	7.2	101.9	170.0	7.8	141.7	1,190.0
	-19.7%	--	+10.5%	+400.0%	+6.3%	+357.9%	--	+7.5%	+53.5%	+580.0%	+8.3%	+39.1%	+600.0%
ANNUAL SHARE, BY DIAMETER	66.4%	33.6%	30.3%	69.7%	6.8%	67.8%	25.4%	2.6%	36.6%	60.8%	.6%	10.6%	88.8%

Note: 12 centimeter disk drives are DVD types.

TABLE 36

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1994		Forecast							
	--Shipments--		-----1995----		-----1996----		-----1997----		-----1998----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	.1		.2		.2		.3		.4	
Write-once	.1	100.0%	.2	100.0%	.2	100.0%	.3	100.0%	.4	100.0%
Noncaptive Total	.2		10.4		34.3		55.4		81.5	
Write-once	.2	100.0%	.3	2.9%	.3	.9%	.4	.7%	.5	.6%
Rewritable	--	--	10.1	97.1%	34.0	99.1%	55.0	99.3%	81.0	99.4%
Total U.S.	.3		10.6		34.5		55.7		81.9	
Write-once	.3	100.0%	.5	4.7%	.5	1.4%	.7	1.3%	.9	1.1%
Rewritable	--	--	10.1	95.3%	34.0	98.6%	55.0	98.7%	81.0	98.9%
NON-U.S. MANUFACTURERS										
Captive Total	1.6		2.3		2.8		3.2		3.5	
Write-once	.3	18.8%	.3	13.0%	.3	10.7%	.3	9.4%	.2	5.7%
Rewritable	1.3	81.2%	2.0	87.0%	2.5	89.3%	2.9	90.6%	3.3	94.3%
Noncaptive Total	6.7		7.9		35.8		50.2		64.1	
Write-once	5.0	74.6%	5.3	67.1%	5.4	15.1%	5.5	11.0%	5.8	9.0%
Rewritable	1.7	25.4%	2.6	32.9%	30.4	84.9%	44.7	89.0%	58.3	91.0%
Total Non-U.S.	8.3		10.2		38.6		53.4		67.6	
Write-once	5.3	63.9%	5.6	54.9%	5.7	14.8%	5.8	10.9%	6.0	8.9%
Rewritable	3.0	36.1%	4.6	45.1%	32.9	85.2%	47.6	89.1%	61.6	91.1%
WORLDWIDE RECAP										
Total Worldwide Shipments	8.6		20.8		73.1		109.1		149.5	
	+21.1%		+141.9%		+251.4%		+49.2%		+37.0%	
Write-once	5.6	65.1%	6.1	29.3%	6.2	8.5%	6.5	6.0%	6.9	4.6%
	-19.9%		+8.9%		+1.6%		+4.8%		+6.2%	
Rewritable	3.0	34.9%	14.7	70.7%	66.9	91.5%	102.6	94.0%	142.6	95.4%
	--		+390.0%		+355.1%		+53.4%		+39.0%	

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

TABLE 37

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	1.3	.1
MAINFRAME SYSTEMS				
General purpose	1.2	13.8	9.4	.7
NETWORKS/MINI/MULTIUSER				
Midrange systems and network servers	4.7	54.8	136.6	10.2
PERSONAL COMPUTERS				
Business and professional, single user	1.2	13.8	996.6	74.4
WORKSTATIONS				
Engineering and office, single user	1.5	17.6	182.2	13.6
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	13.4	1.0
Total	8.6	100.0	1,339.5	100.0

TABLE 38

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	12"	5.25"	Total		12"	5.25"	Total	
Hitachi	.6	1.0	1.6	45.7	1.4	1.6	3.0	43.5
Philips	.8	--	.8	22.9	1.8	--	1.8	26.1
Sony	.7	--	.7	20.0	.9	--	.9	13.0
ATG Cygnet	.3	--	.3	8.6	.9	--	.9	13.0
Other U.S.	.1	--	.1	2.8	.2	--	.2	2.9
Other Non-U.S.	--	--	--	--	.1	--	.1	1.5
TOTAL	2.5	1.0	3.5	100.0	5.3	1.6	6.9	100.0

CD-ROM OPTICAL LIBRARIES

1995 DISK/TREND REPORT

CD-ROM FORMAT OPTICAL LIBRARIES

Coverage

Examples of optical disk libraries in this group include:

12 centimeter (4.72") disk diameter

Aiwa	ACD-630
Amber Technology	Rotostar CD
ASM	CDR 40, CDR 1400
ATG Cygnet	Cygnature
Borett Automation Technologies	VLC
CD International	CDJ2800, CDJ2801
DISC	D300, D600, D1260
DSM	CDR-40, CDR-71, CDR-53
Dynatek Automation	InfiniDISC
Eastman Kodak	CD-ADL 150
K&S	CDJ-30, CDJ-M
Kubik Enterprises	CDR240M, CD Tower
Microboards	DataWrite 500
Nakamichi	MBR-7, MBR 7.4
NEC	CDR-C301
NSM	CDR-100, Mercury-40
Pioneer	DRM624, DRM 1804X
Sanyo	CDR-C3G
Todd Enterprises	TAJ-2000
Victor Data Systems (JVC)	DM-5000

CD-ROM format 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. Most CD-ROM optical disk libraries were originally derivatives of designs incorporating audio drives, although a few high performance models were initially designed for 5.25" optical media and drives. CD-ROM libraries specifically designed for computer applications are increasingly available.

Market status

The number of CD-ROM format library manufacturers has nearly quadrupled in the past two years from 5 to 19, but only Pioneer and Nakamichi shipped more than 10,000 units each in 1994. A few other firms shipped hundreds of units. CD-ROM format libraries range from the 16,000+ disk version of Borett Automa-

tion to the half high form factor integrated drive and three disk capacity of Sanyo, which is derived from the design of a multidisk CD audio player.

ATG Cygnet, ASM, DISC, Todd Enterprises, Microboards, Pioneer and Dynatek Automation 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 each 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 companies are using karaoke system libraries to which have been added appropriate controller logic and software support.

52,753 units were shipped in 1994, up 166% from 1993, primarily as a result of Nakamichi's entry into the market with a low cost 7 disk autochanger. Non-U.S. suppliers had nearly 100% of the market, although more U.S. suppliers may appear in the future. 64.5% of the units were shipped to the U.S. market.

1994 revenues increased 41.7%, spurred by Nakamichi's introduction of its 7 disk changer and continued growth for Pioneer. The average OEM price in the product group dropped sharply under the stimulus of the added low end shipments.

87.3% of the units shipped in 1994 held fewer than 10 disks, 10.9% had from 10 to 100 disks, and 1.8% of the units shipped had over 100 disks. 47.5% of the revenues for the group came from the under 10 disk segment, and the anticipated growth of small autochangers for internal mounting in computers is expected to result in a revenue share increase for the segment to 72.6% in 1998.

Marketing trends

Total revenues are expected to jump sharply to $362.4 million in 1998. The strongest impetus to growth in the forecast is from large (over 1.2 million units) anticipated sales of inexpensive internally mounted autochangers for personal computers and small servers. The market will favor libraries with fewer than 10 disks or more than 100 disks. In 1998, 72.6% of revenues are expected to come from libraries with fewer than 10 disks, while 21.9% is anticipated from libraries with over 100 disks. Only 5.5% is forecasted for libraries with 10 to 100 disks,

and most of that is expected from products at the upper end of the capacity range. DVD drives will help to keep this segment active towards the end of the forecast period.

As noted above, 1998 unit shipments are expected to exceed 1.2 million units, with 80% of this resulting from shipments of internally mounted autochangers by several Asian producers. About 56% of the market is expected to be in the U.S. At the same time, the emphasis on distribution channels will shift from PCM/Reseller to OEM/Integrator, as internally mounted changers displace external add-on units.

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 and Gateway, include CD-ROM capability with their file servers, increasing the opportunity for upgrades to a library subsystem.

Applications

The major applications for CD-ROM format optical libraries continue to be in file servers on networks and for high-end personal computers and workstations. High-end CD-ROM format 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 CD-ROM 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 format 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.

The coming generation of DVD drives is expected to create new applications for CD-ROM autochangers in selected video-on-demand applications, but the higher capacity of the drives may actually decrease the size of the required library in applications currently requiring multiple disks. The availability of CD-E disks in 1996 and thereafter is also expected to be a positive stimulus for CD-ROM libraries, particularly the internally mounted types, which will then enable users to backup multigigabyte rigid disk drives automatically.

Technical trends

CD-ROM format disk library technology is derived from other well established product designs. The typical CD-ROM format 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 ATG Cygnet, DISC 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. Library designs derived from audio or karaoke systems usually don't do well as server attached libraries because their performance is slow, they are not engineered for high levels of MSBF, and the ratio of drives to media units is too low, resulting in undesirably long waiting times after data is requested.

Another 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. 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. Some current CD-ROM disk load/eject mechanism designs require modification so that the drive can be used in a library.

Some features normally found in read/write optical libraries are starting to migrate into the CD-ROM library arena. Faster exchange times, hard drive buffering, filtered air, and hot swap capability for drives all are anticipated features in future products.

There is some competition for CD-ROM format 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. However, multiple copies of an application may be needed to serve all users adequately. 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 format 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 format library market. U.S. firms will concentrate upon lower volume, higher capacity and higher performance designs.
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 39

CD-ROM FORMAT OPTICAL LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	.2	.2	1.1	1.2	3.7	4.1	4.6	5.1	5.1	5.7
OEM/Integrator	4.1	4.6	7.5	8.7	12.0	13.3	15.1	16.9	17.7	20.0
TOTAL U.S. REVENUES	4.3	4.8	8.6	9.9	15.7	17.4	19.7	22.0	22.8	25.7
Non-U.S. Manufacturers										
PCM/Reseller	18.1	27.1	23.4	39.6	35.6	56.7	45.6	75.7	52.9	90.6
OEM/Integrator	8.6	11.6	21.4	27.7	46.4	60.9	86.1	127.2	141.4	246.1
TOTAL NON-U.S. REVENUES	26.7	38.7	44.8	67.3	82.0	117.6	131.7	202.9	194.3	336.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	31.0	43.5	53.4	77.2	97.7	135.0	151.4	224.9	217.1	362.4
OEM Average Price ($000)		1.020		.456		.332		.269		.240

TABLE 40

CD-ROM FORMAT OPTICAL LIBRARIES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	20	22	132	144	857	910	1,131	1,229	1,317	1,464
OEM/Integrator	340	379	538	599	752	832	976	1,089	1,221	1,379
TOTAL U.S. SHIPMENTS	360	401	670	743	1,609	1,742	2,107	2,318	2,538	2,843
Non-U.S. Manufacturers										
PCM/Reseller	23,578	36,848	34,842	59,124	57,120	92,400	73,770	124,520	87,170	151,860
OEM/Integrator	10,098	15,504	68,775	79,188	172,500	222,455	353,310	535,395	614,090	1,105,590
TOTAL NON-U.S. SHIPMENTS	33,676	52,352	103,617	138,312	229,620	314,855	427,080	659,915	701,260	1,257,450
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	34,036	52,753	104,287	139,055	231,229	316,597	429,187	662,233	703,798	1,260,293
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	68	102	172	241	403	557	833	1,220	1,536	2,480

TABLE 41

CD-ROM FORMAT OPTICAL LIBRARIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY LIBRARY SIZE

	1994 Revenues			Forecast											
	1995			1996			1997			1998					
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
PCM/Reseller	--	--	.2	--	.5	.7	--	3.1	1.0	--	4.0	1.1	--	4.6	1.1
OEM/Integrator	--	--	4.6	--	--	8.7	--	--	13.3	--	--	16.9	--	--	20.0
TOTAL U.S. REVENUES	--	--	4.8	--	.5	9.4	--	3.1	14.3	--	4.0	18.0	--	4.6	21.1
NON-U.S. MANUFACTURERS															
PCM/Reseller	16.5	8.7	1.9	19.1	7.6	12.9	26.0	7.2	23.5	35.0	7.7	33.0	42.8	8.1	39.7
OEM/Integrator	4.1	4.6	2.9	16.1	4.1	7.5	43.8	4.9	12.2	106.2	6.2	14.8	220.0	7.4	18.7
TOTAL NON-U.S. REVENUES	20.6	13.3	4.8	35.2	11.7	20.4	69.8	12.1	35.7	141.2	13.9	47.8	262.8	15.5	58.4
WORLDWIDE RECAP															
PCM/Reseller	16.5	8.7	2.1	19.1	8.1	13.6	26.0	10.3	24.5	35.0	11.7	34.1	42.8	12.7	40.8
	+73.7%	--	--	+15.8%	-6.9%	+547.6%	+36.1%	+27.2%	+80.1%	+34.6%	+13.6%	+39.2%	+22.3%	+8.5%	+19.6%
OEM/Integrator	4.1	4.6	7.5	16.1	4.1	16.2	43.8	4.9	25.5	106.2	6.2	31.7	220.0	7.4	38.7
	-31.7%	--	-33.0%	+292.7%	-10.9%	+116.0%	+172.0%	+19.5%	+57.4%	+142.5%	+26.5%	+24.3%	+107.2%	+19.4%	+22.1%
Total Revenues	20.6	13.3	9.6	35.2	12.2	29.8	69.8	15.2	50.0	141.2	17.9	65.8	262.8	20.1	79.5
	+32.9%	--	-14.3%	+70.9%	-8.3%	+210.4%	+98.3%	+24.6%	+67.8%	+102.3%	+17.8%	+31.6%	+86.1%	+12.3%	+20.8%
ANNUAL SHARE, BY DIAMETER	47.5%	30.6%	21.9%	45.7%	15.8%	38.5%	51.8%	11.3%	36.9%	62.9%	8.0%	29.1%	72.6%	5.5%	21.9%

Note: Headings define number of disks stored per library.

TABLE 42

CD-ROM FORMAT OPTICAL LIBRARIES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY LIBRARY SIZE

	1994 Shipments			Forecast											
				1995			1996			1997			1998		
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
PCM/Reseller	--	--	22	--	104	40	--	851	59	--	1,144	85	--	1,353	111
OEM/Integrator	--	--	379	--	--	599	--	--	832	--	--	1,089	--	--	1,379
TOTAL U.S. SHIPMENTS	--	--	401	--	104	639	--	851	891	--	1,144	1,174	--	1,353	1,490
NON-U.S. MANUFACTURERS															
PCM/Reseller	32,570	4,054	224	54,620	3,004	1,500	86,500	3,130	2,770	116,760	3,640	4,120	142,510	4,060	5,290
OEM/Integrator	13,420	1,714	370	76,590	1,258	1,340	219,000	1,415	2,040	531,000	1,830	2,565	1,100,000	2,250	3,340
TOTAL NON-U.S. SHIPMENTS	45,990	5,768	594	131,210	4,262	2,840	305,500	4,545	4,810	647,760	5,470	6,685	1,242,510	6,310	8,630
WORLDWIDE RECAP															
PCM/Reseller	32,570	4,054	246	54,620	3,108	1,540	86,500	3,981	2,829	116,760	4,784	4,205	142,510	5,413	5,401
	+208.9%	+536.4%	--	+67.7%	-23.3%	+526.0%	+58.4%	+28.1%	+83.7%	+35.0%	+20.2%	+48.6%	+22.1%	+13.1%	+28.4%
OEM/Integrator	13,420	1,714	749	76,590	1,258	1,939	219,000	1,415	2,872	531,000	1,830	3,654	1,100,000	2,250	4,719
	+78.9%	--	-33.6%	+470.7%	-26.6%	+158.9%	+185.9%	+12.5%	+48.1%	+142.5%	+29.3%	+27.2%	+107.2%	+23.0%	+29.1%
Total Shipments	45,990	5,768	995	131,210	4,366	3,479	305,500	5,396	5,701	647,760	6,614	7,859	1,242,510	7,663	10,120
	+154.9%	+805.5%	-11.8%	+185.3%	-24.3%	+249.6%	+132.8%	+23.6%	+63.9%	+112.0%	+22.6%	+37.9%	+91.8%	+15.9%	+28.8%
ANNUAL SHARE, BY DIAMETER	87.3%	10.9%	1.8%	94.5%	3.1%	2.4%	96.6%	1.7%	1.7%	97.9%	1.0%	1.1%	98.7%	.6%	.7%

Note: Headings define number of disks stored per library.

READ/WRITE OPTICAL LIBRARIES, 1-39 CARTRIDGES

1995 DISK/TREND REPORT

READ/WRITE OPTICAL LIBRARIES
1 - 39 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

3.5" disk diameter

Fujitsu	M2531A
PFU	MC700A

5.25" disk diameter

Aisin Seiki	JC2000
Amber Technology	Rotostar 121
DSM	4000
Fujitsu	M2522/AX
Hewlett-Packard	C1100A/B, C1713T, 40st, 20xt
Hitachi	OL101-11, OL112-21
IBM	3995-043, 3995-063
K&S	Megastore 1000
NEC	N1137-06, N1137-58
Nikkyo	NOL-102, NOL-161, NOL-322
NK-EXA	N-520
Olympus	OLS 10NSS, OLS S10
Plasmon Data Systems	MicroMulti, MiniMulti
Ricoh	RJ5210E
Sony	OSL 2000

12" disk diameter

ATG Cygnet	GF 6910, ASM-224W
DSM	28
Philips LMS	LF 4500, LF 6600
NEC	N7923
Sony	WDA-E330

5.25" optical libraries remain predominant in this product group. The first 3.5" optical libraries in the group were announced by IBM and IDE (now Plasmon Data Systems, but only a new model from Fujitsu (PFU uses the Fujitsu mechanism) is available as of mid-1995. The libraries in this group include both tabletop and deskside types, as well as conventional rack mounted units. They are used with workstations, high end personal computers and in local area networks.

Also included is the Philips LMS library, which incorporates a dual head optical drive, enabling 16% of its 72 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.

Market status

1994 unit shipments increased 30.5% to 12,740 units in 1994, although much of the increase was artificial as suppliers dumped low-end 5.25" library models being impacted by competition from high capacity rigid disk drives. As a result of this competition, revenues for 5.25" libraries declined markedly and overall group revenue dropped 2.9% to $101.3 million. 37.8% of 1994 revenues and 46.4% of 1994 shipments were generated by U.S. manufacturers, notably Hewlett-Packard. Philips LMS was the dominant 12" library supplier. 52.3% of unit shipments were made to U.S. destinations, a significant decrease from 1993, with the difference attributed to the increasing use of document imaging in non-U.S. markets.

Hewlett-Packard has a commanding lead in unit shipments within this product group, followed by Plasmon Data Systems and Philips LMS.

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.

Marketing trends

1998 worldwide unit shipments are forecasted to grow to 27,896, and total revenues will increase to $195.5 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 41.9% of 1998 unit shipments, while 49.5% will be through PCM/Resellers. 5.25" shipments, which were 84.2%

of the 1994 total shipments, are expected to improve slightly over the forecast period and hold 87.4% share in 1998. 12" autochangers in this product group held 15.8% share in 1994, and this share is expected to decline slightly to 11.1% in 1998. 3.5" libraries are projected to capture a 1.5% share in 1998. Manufacturers with facilities in Japan and Europe will continue to suffer the consequences of the weak U.S. dollar, and are not expected to make significant inroads on U.S. manufacturers.

Total sales revenues for 1998 are forecasted to reach $195.5 million, with 37.8% originating from U.S. manufacturers. About 56.1% of the worldwide library revenues from this product group are expected to be generated in the U.S. market in 1998.

As a result of competition from high capacity rigid disk drives, such as the Seagate nine gigabyte Elite 9, future libraries in this group will move to the upper end of the cartridge capacity spectrum. Libraries with fewer than 10 cartridges are gone, and the anticipated arrival of 18 gigabyte rigid disk drives in early 1996 will only accelerate this trend. Another consequence is the reversal of a declining average price trend in this product group. OEM prices will tend to increase slightly with time as product complexity grows. A second consequence is that the sales channel will become increasingly OEM dominated, as the PCM/Reseller channel handles most of the now discontinued low end libraries.

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 or networked 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 the 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 throughout the forecast period.

Technical trends

For the time being, most libraries in this product group will continue to use 5.25" or 12" drives and media. Although unannounced as of mid-1995, the eventual introduction of libraries using the 12 centimeter PD drive are a possibility. 3.5" libraries will use the 600+ megabyte drives expected to be in production starting in late 1995, but 3.5" libraries, offering so much less capacity than 5.25" libraries, and limited further by single sided recording, will be viewed as 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. The major competition to this product group comes from high capacity rigid magnetic disk drives such as the nine gigabyte Seagate Elite 9, which offer the capacity of a small optical library at a lower price and with better performance.

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 rewritable dual head 12" drives and media become readily available at lower prices, 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. The strong yen will continue to favor U.S. manufacturers.
2. The 5.25" format will remain the most commonly used, but it will receive competition from 12" libraries.
3. Rewritable or multifunction drives will be used in most of the 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 the upper end of this product group at the expense of the 40 to 69 cartridge product group.
7. Competition from very high capacity magnetic drives will continue to negatively impact shipments of libraries at the low end of this group.

TABLE 43

OPTICAL LIBRARIES, 1-39 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast							
	1995		1996		1997		1998			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	7.9	11.2	9.0	13.0	10.1	16.4	11.6	18.0	12.0	18.4
PCM/Reseller	--	5.7	16.1	23.0	17.6	25.1	18.6	26.6	19.3	27.7
OEM/Integrator	15.0	21.4	15.5	22.0	17.8	25.1	18.6	26.4	19.8	27.8
TOTAL U.S. REVENUES	22.9	38.3	40.6	58.0	45.5	66.6	48.8	71.0	51.1	73.9
Non-U.S. Manufacturers										
Captive	--	9.5	--	8.6	--	4.2	--	4.3	--	4.6
PCM/Reseller	12.3	25.7	16.4	32.5	22.1	42.4	25.1	47.0	27.2	50.4
OEM/Integrator	14.6	27.8	21.7	41.9	23.3	50.6	27.4	59.3	31.4	66.6
TOTAL NON-U.S. REVENUES	26.9	63.0	38.1	83.0	45.4	97.2	52.5	110.6	58.6	121.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	49.8	101.3	78.7	141.0	90.9	163.8	101.3	181.6	109.7	195.5
OEM Average Price ($000)		7.644		7.640		7.978		8.059		8.081

TABLE 44

OPTICAL LIBRARIES, 1-39 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	831	1,182	950	1,370	1,032	1,672	1,220	1,898	1,330	2,039
PCM/Reseller	--	820	2,300	3,280	2,700	3,860	3,100	4,440	3,500	5,030
OEM/Integrator	2,734	3,906	3,100	4,400	3,560	5,010	3,880	5,505	4,305	6,053
TOTAL U.S. SHIPMENTS	3,565	5,908	6,350	9,050	7,292	10,542	8,200	11,843	9,135	13,122
Non-U.S. Manufacturers										
Captive	--	346	--	369	--	301	--	323	--	364
PCM/Reseller	1,947	3,956	2,695	5,253	3,327	6,379	4,031	7,595	4,671	8,782
OEM/Integrator	1,148	2,530	1,902	3,964	1,932	4,478	2,246	5,129	2,490	5,628
TOTAL NON-U.S. SHIPMENTS	3,095	6,832	4,597	9,586	5,259	11,158	6,277	13,047	7,161	14,774
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6,660	12,740	10,947	18,636	12,551	21,700	14,477	24,890	16,296	27,896
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	22	37	33	56	46	77	60	102	77	130

TABLE 45

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues		Forecast											
			1995			1996			1997			1998		
	12-14"	5.25"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"
U.S. MANUFACTURERS														
Captive	--	11.2	--	13.0	--	--	16.4	--	--	18.0	--	--	18.4	--
PCM/Reseller	--	5.7	--	23.0	--	--	25.1	--	--	26.6	--	--	27.7	--
OEM/Integrator	--	21.4	--	22.0	--	--	25.1	--	--	26.4	--	--	27.8	--
TOTAL U.S. REVENUES	--	38.3	--	58.0	--	--	66.6	--	--	71.0	--	--	73.9	--
NON-U.S. MANUFACTURERS														
Captive	1.4	8.1	1.5	7.1	--	1.6	2.6	--	1.6	2.7	--	1.7	2.9	--
PCM/Reseller	12.4	13.3	15.5	16.4	.6	18.2	23.4	.8	19.0	27.1	.9	18.9	30.4	1.1
OEM/Integrator	23.2	4.6	33.3	8.4	.2	41.1	9.3	.2	48.5	10.5	.3	55.1	11.2	.3
TOTAL NON-U.S. REVENUES	37.0	26.0	50.3	31.9	.8	60.9	35.3	1.0	69.1	40.3	1.2	75.7	44.5	1.4
WORLDWIDE RECAP														
Captive	1.4	19.3	1.5	20.1	--	1.6	19.0	--	1.6	20.7	--	1.7	21.3	--
	-68.9%	+54.4%	+7.1%	+4.1%	--	+6.7%	-5.5%	--	--	+8.9%	--	+6.3%	+2.9%	--
PCM/Reseller	12.4	19.0	15.5	39.4	.6	18.2	48.5	.8	19.0	53.7	.9	18.9	58.1	1.1
	+74.6%	-19.1%	+25.0%	+107.4%	--	+17.4%	+23.1%	+33.3%	+4.4%	+10.7%	+12.5%	-.5%	+8.2%	+22.2%
OEM/Integrator	23.2	26.0	33.3	30.4	.2	41.1	34.4	.2	48.5	36.9	.3	55.1	39.0	.3
	+28.2%	-32.6%	+43.5%	+16.9%	--	+23.4%	+13.2%	--	+18.0%	+7.3%	+50.0%	+13.6%	+5.7%	--
Total Revenues	37.0	64.3	50.3	89.9	.8	60.9	101.9	1.0	69.1	111.3	1.2	75.7	118.4	1.4
	+24.6%	-13.8%	+35.9%	+39.8%	--	+21.1%	+13.3%	+25.0%	+13.5%	+9.2%	+20.0%	+9.6%	+6.4%	+16.7%
ANNUAL SHARE, BY DIAMETER	36.6%	63.4%	35.8%	63.8%	.4%	37.3%	62.2%	.5%	38.2%	61.3%	.5%	38.8%	60.6%	.6%

TABLE 46

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments		Forecast											
			1995			1996			1997			1998		
	12-14"	5.25"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"
U.S. MANUFACTURERS														
Captive	--	1,182	--	1,370	--	--	1,672	--	--	1,898	--	--	2,039	--
PCM/Reseller	--	820	--	3,280	--	--	3,860	--	--	4,440	--	--	5,030	--
OEM/Integrator	--	3,906	--	4,400	--	--	5,010	--	--	5,505	--	--	6,053	--
TOTAL U.S. SHIPMENTS	--	5,908	--	9,050	--	--	10,542	--	--	11,843	--	--	13,122	--
NON-U.S. MANUFACTURERS														
Captive	36	310	39	330	--	41	260	--	43	280	--	44	320	--
PCM/Reseller	636	3,320	719	4,354	180	776	5,370	233	828	6,483	284	857	7,588	337
OEM/Integrator	1,342	1,188	1,743	2,161	60	1,935	2,464	79	2,090	2,937	102	2,187	3,318	123
TOTAL NON-U.S. SHIPMENTS	2,014	4,818	2,501	6,845	240	2,752	8,094	312	2,961	9,700	386	3,088	11,226	460
WORLDWIDE RECAP														
Captive	36	1,492	39	1,700	--	41	1,932	--	43	2,178	--	44	2,359	--
	-60.0%	+175.3%	+8.3%	+13.9%	--	+5.1%	+13.6%	--	+4.9%	+12.7%	--	+2.3%	+8.3%	--
PCM/Reseller	636	4,140	719	7,634	180	776	9,230	233	828	10,923	284	857	12,618	337
	+30.1%	+2.1%	+13.1%	+84.4%	--	+7.9%	+20.9%	+29.4%	+6.7%	+18.3%	+21.9%	+3.5%	+15.5%	+18.7%
OEM/Integrator	1,342	5,094	1,743	6,561	60	1,935	7,474	79	2,090	8,442	102	2,187	9,371	123
	+35.7%	+42.3%	+29.9%	+28.8%	--	+11.0%	+13.9%	+31.7%	+8.0%	+13.0%	+29.1%	+4.6%	+11.0%	+20.6%
Total Shipments	2,014	10,726	2,501	15,895	240	2,752	18,636	312	2,961	21,543	386	3,088	24,348	460
	+28.4%	+31.2%	+24.2%	+48.2%	--	+10.0%	+17.2%	+30.0%	+7.6%	+15.6%	+23.7%	+4.3%	+13.0%	+19.2%
ANNUAL SHARE, BY DIAMETER	15.8%	84.2%	13.4%	85.4%	1.2%	12.7%	86.0%	1.3%	11.9%	86.7%	1.4%	11.1%	87.4%	1.5%

TABLE 47

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1994 --Shipments--		Forecast							
			1995		1996		1997		1998	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	1,182.0		1,370.0		1,672.0		1,898.0		2,039.0	
Rewritable	1,182.0	100.0%	1,370.0	100.0%	1,672.0	100.0%	1,898.0	100.0%	2,039.0	100.0%
Noncaptive Total	4,726.0		7,680.0		8,870.0		9,945.0		11,083.0	
Rewritable	4,726.0	100.0%	7,680.0	100.0%	8,870.0	100.0%	9,945.0	100.0%	11,083.0	100.0%
Total U.S.	5,908.0		9,050.0		10,542.0		11,843.0		13,122.0	
Rewritable	5,908.0	100.0%	9,050.0	100.0%	10,542.0	100.0%	11,843.0	100.0%	13,122.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	346.0		369.0		301.0		323.0		364.0	
Write-once	36.0	10.4%	39.0	10.6%	41.0	13.6%	43.0	13.3%	44.0	12.1%
Rewritable	310.0	89.6%	330.0	89.4%	260.0	86.4%	280.0	86.7%	320.0	87.9%
Noncaptive Total	6,486.0		9,217.0		10,857.0		12,724.0		14,410.0	
Write-once	2,475.0	38.2%	2,949.0	32.0%	3,196.0	29.4%	3,389.0	26.6%	3,501.0	24.3%
Rewritable	4,011.0	61.8%	6,268.0	68.0%	7,661.0	70.6%	9,335.0	73.4%	10,909.0	75.7%
Total Non-U.S.	6,832.0		9,586.0		11,158.0		13,047.0		14,774.0	
Write-once	2,511.0	36.8%	2,988.0	31.2%	3,237.0	29.0%	3,432.0	26.3%	3,545.0	24.0%
Rewritable	4,321.0	63.2%	6,598.0	68.8%	7,921.0	71.0%	9,615.0	73.7%	11,229.0	76.0%
WORLDWIDE RECAP										
Total Worldwide Shipments	12,740.0		18,636.0		21,700.0		24,890.0		27,896.0	
	+30.5%		+46.3%		+16.4%		+14.7%		+12.1%	
Write-once	2,511.0	19.7%	2,988.0	16.0%	3,237.0	14.9%	3,432.0	13.8%	3,545.0	12.7%
	+32.2%		+19.0%		+8.3%		+6.0%		+3.3%	
Rewritable	10,229.0	80.3%	15,648.0	84.0%	18,463.0	85.1%	21,458.0	86.2%	24,351.0	87.3%
	+30.2%		+53.0%		+18.0%		+16.2%		+13.5%	

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

READ/WRITE OPTICAL LIBRARIES, 40-69 CARTRIDGES

1995 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, Rotostar 262
Eastman Kodak	560E
Hewlett-Packard	80st
Hitachi	OL101-12, OL112-12, OL114-12
Matsushita Electric Industrial	LF-J7000A, LF-J7350A
NEC	N7925-83, N7925-84, N5817-31/32
Nikkyo	NOL-642, NOL-604
NK-EXA	N-556U
Plasmon Data Systems	Multi I
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, frequently attached to network platforms. The 12" models are frequently used in multiuser and networked systems because of their ability to keep large amounts of data accessible in minimal time. 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

In 1994, worldwide optical library shipments in this product group declined 35% compared to 1993 because of customer preferences for either larger or smaller libraries and the weak dollar, which put most of the suppliers in this category at a disadvantage. Revenues declined 41% to $28.2 million, reflecting both lower shipments and declining prices as manufacturers attempted to stimulate sales. Shipments of 5.25" units greatly exceeded shipments of 12" units,

capturing 91.6% of worldwide shipments, up slightly from 1992. A further shift to 5.25" libraries in this product group also contributed to the revenue decline.

Only 14.5% of 1994 revenues were generated by 12" libraries as a result of higher average prices compared to 5.25" libraries, down about 5% from 1993. With the increase of 5.25" drive capacities in 1993 and 1994, some sales of drives in this product group were diverted to the 1-39 cartridge group. However, next generation high capacity 5.25" drives are expected to help this group capture future share from larger libraries.

In 1994, Plasmon Data Systems (which purchased IDE) was the leading supplier in the product group, closely followed by NK-EXA. Hewlett-Packard, which began shipping a 64 disk library in 1995, will be a formidable future competitor.

Marketing trends

Unit shipments for this product group are projected to start a recovery in late 1995 and grow to over 4,000 units in 1998. The 1998 balance between 12" and 5.25" drive usage will tilt even more toward 5.25" as high capacity 5.25" drive shipments ramp up. 12" library shipments will benefit moderately from the availability of new drives in the 10-20 gigabyte range, permitting users to keep more data on line in a moderately sized library.

The number of manufacturers of 12" libraries in this group remained constant last year, but the number of 5.25" participants is expected to increase somewhat. There may be some 3.5" and 12 centimeter PD drive libraries in this product group within a few years, but the timing is too uncertain to forecast.

Only 7.1% of 1994 total library shipments in this group involved write-once drives, and in 1998 only 3.4% 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 applica-

tions, 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 directly attached to networks are expected to increasingly appear in the product group.

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 magnetic disk based video servers.

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 and the ATG Cygnet Cygnature, which appear in the DISK/TREND product group for libraries with over 70 disks, may be precursors of similar capabilities in this product group.

While the 5.25" drive is the dominant type used in this product group, it is possible that some firms might introduce models using the 12 centimeter PD drive, although none had been announced as of mid-1995.

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. Computer based controllers permitting the direct attachment of an optical library to a local area network are a result of the shift to computer based controllers.

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. The higher capacity drives entering the market in 1995 and 1996 will restimulate customer interest for products in this group, resulting in a reversal of a declining sales trend.

1995 DISK/TREND REPORT

TABLE 48

OPTICAL LIBRARIES, 40-69 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	4.3	5.3	5.1	6.3	5.4	6.9	5.5	7.3
PCM/Reseller	--	.5	2.3	3.8	3.3	5.4	3.5	5.8	3.8	6.3
OEM/Integrator	3.8	3.8	7.5	9.6	10.3	13.1	11.5	14.6	12.4	15.8
TOTAL U.S. REVENUES	3.8	4.3	14.1	18.7	18.7	24.8	20.4	27.3	21.7	29.4
Non-U.S. Manufacturers										
Captive	--	5.9	--	6.3	--	6.8	--	7.2	--	7.5
PCM/Reseller	3.7	7.7	3.8	8.1	6.7	13.6	7.0	14.3	7.3	14.8
OEM/Integrator	3.8	10.3	3.5	9.9	3.4	11.7	2.3	12.7	2.2	12.8
TOTAL NON-U.S. REVENUES	7.5	23.9	7.3	24.3	10.1	32.1	9.3	34.2	9.5	35.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	11.3	28.2	21.4	43.0	28.8	56.9	29.7	61.5	31.2	64.5
OEM Average Price ($000)		15.6		15.2		16.0		15.0		13.9

TABLE 49

OPTICAL LIBRARIES, 40-69 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	--	--	157	193	205	253	235	300	260	344
PCM/Reseller	--	28	139	228	200	330	235	385	265	437
OEM/Integrator	254	254	495	630	686	868	816	1,033	951	1,210
TOTAL U.S. SHIPMENTS	254	282	792	1,052	1,091	1,451	1,286	1,718	1,476	1,991
Non-U.S. Manufacturers										
Captive	2	186	--	189	--	195	--	200	--	201
PCM/Reseller	341	716	380	810	425	864	453	922	482	976
OEM/Integrator	277	648	273	650	190	684	122	787	116	842
TOTAL NON-U.S. SHIPMENTS	620	1,550	654	1,649	615	1,743	575	1,909	598	2,019
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	874	1,832	1,446	2,701	1,706	3,194	1,861	3,627	2,074	4,010
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	5	11	7	14	8	17	10	21	12	25

TABLE 50

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues		Forecast							
			1995		1996		1997		1998	
	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS										
Captive	--	--	--	5.3	--	6.3	--	6.9	--	7.3
PCM/Reseller	--	.5	--	3.8	--	5.4	--	5.8	--	6.3
OEM/Integrator	--	3.8	--	9.6	.2	12.9	.3	14.3	.3	15.5
TOTAL U.S. REVENUES	--	4.3	--	18.7	.2	24.6	.3	27.0	.3	29.1
NON-U.S. MANUFACTURERS										
Captive	2.9	3.0	3.0	3.3	3.2	3.6	3.4	3.8	3.4	4.1
PCM/Reseller	--	7.7	--	8.1	--	13.6	--	14.3	--	14.8
OEM/Integrator	1.2	9.1	.6	9.3	.8	10.9	1.1	11.6	1.4	11.4
TOTAL NON-U.S. REVENUES	4.1	19.8	3.6	20.7	4.0	28.1	4.5	29.7	4.8	30.3
WORLDWIDE RECAP										
Captive	2.9 --	3.0 +50.0%	3.0 +3.4%	8.6 +186.7%	3.2 +6.7%	9.9 +15.1%	3.4 +6.3%	10.7 +8.1%	3.4 --	11.4 +6.5%
PCM/Reseller	-- --	8.2 -3.5%	-- --	11.9 +45.1%	-- --	19.0 +59.7%	-- --	20.1 +5.8%	-- --	21.1 +5.0%
OEM/Integrator	1.2 -87.1%	12.9 -53.4%	.6 -50.0%	18.9 +46.5%	1.0 +66.7%	23.8 +25.9%	1.4 +40.0%	25.9 +8.8%	1.7 +21.4%	26.9 +3.9%
Total Revenues	4.1 -56.8%	24.1 -36.9%	3.6 -12.2%	39.4 +63.5%	4.2 +16.7%	52.7 +33.8%	4.8 +14.3%	56.7 +7.6%	5.1 +6.3%	59.4 +4.8%
ANNUAL SHARE, BY DIAMETER	14.5%	85.5%	8.4%	91.6%	7.4%	92.6%	7.8%	92.2%	7.9%	92.1%

TABLE 51

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments		Forecast							
			1995		1996		1997		1998	
	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS										
Captive	--	--	--	193	--	253	--	300	--	344
PCM/Reseller	--	28	--	228	--	330	--	385	--	437
OEM/Integrator	--	254	--	630	6	862	9	1,024	14	1,196
TOTAL U.S. SHIPMENTS	--	282	--	1,052	6	1,445	9	1,709	14	1,977
NON-U.S. MANUFACTURERS										
Captive	52	134	54	135	56	139	58	142	56	145
PCM/Reseller	--	716	--	810	--	864	--	922	--	976
OEM/Integrator	30	618	13	637	16	668	22	765	28	814
TOTAL NON-U.S. SHIPMENTS	82	1,468	67	1,582	72	1,671	80	1,829	84	1,935
WORLDWIDE RECAP										
Captive	52	134	54	328	56	392	58	442	56	489
	--	+35.4%	+3.8%	+145.1%	+3.7%	+19.3%	+3.6%	+12.8%	-3.4%	+10.6%
PCM/Reseller	--	744	--	1,038	--	1,194	--	1,307	--	1,413
	--	+47.0%	--	+39.6%	--	+15.0%	--	+9.5%	--	+8.1%
OEM/Integrator	30	872	13	1,267	22	1,530	31	1,789	42	2,010
	-87.2%	-56.3%	-55.0%	+45.3%	+63.0%	+20.7%	+40.9%	+16.9%	+35.5%	+12.4%
Total Shipments	82	1,750	67	2,634	78	3,116	89	3,538	98	3,912
	-65.5%	-32.7%	-17.7%	+50.5%	+15.6%	+18.3%	+14.1%	+13.5%	+10.1%	+10.6%
ANNUAL SHARE, BY DIAMETER	4.5%	95.5%	2.5%	97.5%	2.4%	97.6%	2.5%	97.5%	2.4%	97.6%

TABLE 52

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1994		Forecast							
	--Shipments--		-----1995----		-----1996----		-----1997----		-----1998----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	--		193.5		253.0		300.0		344.0	
Rewritable	--	--	193.5	100.0%	253.0	100.0%	300.0	100.0%	344.0	100.0%
Noncaptive Total	282.0		858.6		1,198.0		1,418.0		1,647.0	
Write-once	--	--	--	--	6.0	.5%	9.0	.6%	14.0	.9%
Rewritable	282.0	100.0%	858.6	100.0%	1,192.0	99.5%	1,409.0	99.4%	1,633.0	99.2%
Total U.S.	282.0		1,052.1		1,451.0		1,718.0		1,991.0	
Write-once	--	--	--	--	6.0	.4%	9.0	.5%	14.0	.7%
Rewritable	282.0	100.0%	1,052.1	100.0%	1,445.0	99.6%	1,709.0	99.5%	1,977.0	99.3%
NON-U.S. MANUFACTURERS										
Captive Total	186.0		189.0		195.0		200.0		201.0	
Write-once	52.0	28.0%	54.0	28.6%	56.0	28.7%	58.0	29.0%	56.0	27.9%
Rewritable	134.0	72.0%	135.0	71.4%	139.0	71.3%	142.0	71.0%	145.0	72.1%
Noncaptive Total	1,364.0		1,460.7		1,548.0		1,709.0		1,818.0	
Write-once	78.0	5.7%	74.7	5.1%	74.0	4.8%	70.0	4.1%	68.0	3.7%
Rewritable	1,286.0	94.3%	1,386.0	94.9%	1,474.0	95.2%	1,639.0	95.9%	1,750.0	96.3%
Total Non-U.S.	1,550.0		1,649.7		1,743.0		1,909.0		2,019.0	
Write-once	130.0	8.4%	128.7	7.8%	130.0	7.5%	128.0	6.7%	124.0	6.1%
Rewritable	1,420.0	91.6%	1,521.0	92.2%	1,613.0	92.5%	1,781.0	93.3%	1,895.0	93.9%
WORLDWIDE RECAP										
Total Worldwide Shipments	1,832.0		2,701.8		3,194.0		3,627.0		4,010.0	
	-35.3%		+47.5%		+18.2%		+13.6%		+10.6%	
Write-once	130.0	7.1%	128.7	4.8%	136.0	4.3%	137.0	3.8%	138.0	3.4%
	-61.1%		-.9%		+5.7%		+.7%		+.7%	
Rewritable	1,702.0	92.9%	2,573.1	95.2%	3,058.0	95.7%	3,490.0	96.2%	3,872.0	96.6%
	-31.9%		+51.2%		+18.8%		+14.1%		+10.9%	

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

READ/WRITE OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

1995 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
ATG Cygnet	Cygnature
Borett Automation Technology	MMAS (5.25")
DISC	D255-1, D510-2, D1050-2
DSM	5100, 6300
Fujitsu	F6445/A1, F6445/A2, F6445/A2X2
Hewlett-Packard	C1705T, 100st, 300st
IBM	3995-143, 3995-133
K&S	Megastore
Kubik Enterprises	MO-120
NK-EXA	N-5160U
Plasmon Data Systems	Multi II, Multi III, Multi IIIE

12" and 14" disk diameter

ATG Cygnet	1800
Borett Automation Technology	MMAS (12")
Eastman Kodak	2000 ADL+
FileNet	Model 0150, Model 0140, Model 0161
Sony	WDA-E930, WDA-E550

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, but Hewlett-Packard has now achieved leadership, with 5.25" libraries. Sony entered the fray in 1992 and holds second place. 5.25" libraries now dominate the group, with several suppliers in production and more likely to enter the market during the forecast period.

Market status

1994 unit shipments increased 50.2% to 2,749 optical libraries. Shipment gains were recorded for both 12" and 5.25" optical libraries, but 5.25" system shipments outpaced 12" systems and captured 76.1% of the units shipped. Shipments of 5.25" units increased by 58%, while shipments of 12" units rose

almost 30%. 1994 worldwide revenues reversed their 1993 trend and rose to $131.8 million, reflecting both strong demand and the effect of a stronger yen. Stronger PCM/Reseller segment sales also helped. 71.8% of this product group's revenues were generated from sales in the United States, and 70.3% of worldwide revenues were generated by U.S. manufacturers, still the highest U.S. manufacturer revenue percentage among the library product groups, but down a bit from 1993.

Hewlett-Packard repeated as the shipment leader for the group in 1993, followed distantly by Sony and 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 has influenced the other system manufacturers and their customers and stimulated sales of 5.25" systems.

OEM/Integrator channel shipments were 62.1% of the total, down from 69.7% in 1993. Captive shipments rose to 20.2%, while PCM/Reseller activity for the libraries in this group decreased to 17.6% 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 remains difficult, especially in light of the weaker dollar. The strongest challenge from non-U.S. firms in the 5.25" optical library segment is from NK-EXA, which began shipments in 1992 in this group, and from ATG Cygnet, with shipments of 12" optical libraries.

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

Shipment growth to 5,130 units in 1998 is expected, with 5.25" library shipments growing at a faster rate than 12" shipments. About 72% will be shipped to U.S. markets. As before, U.S. suppliers are expected to remain predominant because of their very strong system support capabilities for larger computing systems and the price advantage afforded by the current weak dollar. No 3.5" libraries in this product group are anticipated through 1998, although it is conceivable some 12 centimeter libraries with PD drives might appear.

1998 revenue for this group is expected to exceed $206 million, with 65% 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 presence of new models in the product group and an expected weak dollar. The appearance of higher capacity optical drives over the next several years will tend to keep library subsystem prices from declining rapidly, but may also be a brake on the tendency for library size to increase, since fewer drives will be needed for a given on-line capacity at any time.

12" libraries are expected to retain 20.4% of 1998 unit shipments, but will account for 47.9% of 1998 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 strongly oriented toward 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 76.2% in 1994 to 80.8% in 1998. 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 1998, the 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, although data warehousing applications are expected to increase use in corporate environments as well.

The IBM 3995 optical library introduced in 1991 (based on the Hewlett-Packard library) represented a response to customer pressures for a library and the competitive pressure of Storage Technology's model 4400 tape-based library system. Many 3995 library models have been introduced for use with various systems, and IBM's support for the 3995 as a virtual 3390 disk subsystem under System Managed Storage further 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 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. Libraries capable of handling multiple types of media units represent an emerging trend, as evidenced by ATG Cygnet's Cygnature model, due to ship in late 1995, which will be able to handle tape, optical cartridges and CD-ROM disks in caddies simultaneously.

5.25" drives with capacities of 2.6 gigabytes (1.3 gigabytes per side) are expected to appear in quantity in 1996. 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.

Pinnacle Micro's new 2.3 gigabyte per side drive is also expected to find use in this product group for the same reason. 12" drive storage capabilities have increased to the 10-20 gigabyte per cartridge range, advantageous in archival applications and in systems where frequent accesses to the same mounted data volume are likely to occur.

Optical library reliability in this product group is increasing, with some libraries in this group offering over 200,000 MSBF (Mean Swaps Between Failure) in response to increasing MIS demands for improved data availability.

Modular systems are becoming increasingly prominent in this product class. Manufacturers including DISC, DSM and others offer a semicustom 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.

Most of the libraries in this group use a linear elevator mechanism, but Kubik has introduced a library in this product group using a rotary mechanism. It is based on the firm's CD-ROM library designs.

Forecasting assumptions

1. The appearance of higher capacity 5.25" drives will continue to drive the movement to 5.25" drive usage 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. Governments, financial institutions and other large users will continue to be the primary market for libraries in this product group.

TABLE 53

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994		Forecast							
	Revenues		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	32.6	41.7	35.3	46.9	36.4	50.3	37.3	53.3	36.9	54.9
PCM/Reseller	8.8	10.9	10.1	12.6	11.6	14.8	12.4	15.8	12.8	16.2
OEM/Integrator	31.9	40.1	39.5	54.4	44.9	62.0	47.6	66.2	49.8	69.4
TOTAL U.S. REVENUES	73.3	92.7	84.9	113.9	92.9	127.1	97.3	135.3	99.5	140.5
Non-U.S. Manufacturers										
Captive	--	8.0	--	9.4	--	11.8	--	13.7	--	15.5
PCM/Reseller	2.8	5.0	4.6	7.4	6.0	9.2	7.1	10.9	8.3	12.6
OEM/Integrator	18.5	26.1	20.6	29.1	23.9	33.9	25.2	35.8	26.5	38.0
TOTAL NON-U.S. REVENUES	21.3	39.1	25.2	45.9	29.9	54.9	32.3	60.4	34.8	66.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	94.6	131.8	110.1	159.8	122.8	182.0	129.6	195.7	134.3	206.6
OEM Average Price ($000)		38.8		40.6		39.3		36.2		33.5

TABLE 54

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1994 Shipments		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	403	509	430	553	466	611	507	674	545	735
PCM/Reseller	309	384	376	470	465	591	540	688	610	771
OEM/Integrator	1,025	1,281	1,166	1,534	1,388	1,840	1,596	2,131	1,816	2,433
TOTAL U.S. SHIPMENTS	1,737	2,174	1,972	2,557	2,319	3,042	2,643	3,493	2,971	3,939
Non-U.S. Manufacturers										
Captive	--	49	--	72	--	92	--	114	--	138
PCM/Reseller	52	100	118	180	135	196	165	237	196	280
OEM/Integrator	287	426	357	521	412	601	467	683	527	773
TOTAL NON-U.S. SHIPMENTS	339	575	475	773	547	889	632	1,034	723	1,191
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,076	2,749	2,447	3,330	2,866	3,931	3,275	4,527	3,694	5,130
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	5	6	7	10	10	14	13	18	17	23

TABLE 55

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues		Forecast							
	1995		1996		1997		1998			
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	24.9	16.8	28.2	18.7	30.9	19.4	32.7	20.6	34.5	20.4
PCM/Reseller	--	10.9	--	12.6	--	14.8	--	15.8	--	16.2
OEM/Integrator	12.2	27.9	18.8	35.6	20.8	41.2	22.1	44.1	23.4	46.0
TOTAL U.S. REVENUES	37.1	55.6	47.0	66.9	51.7	75.4	54.8	80.5	57.9	82.6
NON-U.S. MANUFACTURERS										
Captive	--	8.0	--	9.4	--	11.8	--	13.7	--	15.5
PCM/Reseller	3.1	1.9	4.3	3.1	5.7	3.5	7.0	3.9	8.2	4.4
OEM/Integrator	23.7	2.4	25.8	3.3	29.6	4.3	31.1	4.7	32.7	5.3
TOTAL NON-U.S. REVENUES	26.8	12.3	30.1	15.8	35.3	19.6	38.1	22.3	40.9	25.2
WORLDWIDE RECAP										
Captive	24.9 +54.7%	24.8 +140.8%	28.2 +13.3%	28.1 +13.3%	30.9 +9.6%	31.2 +11.0%	32.7 +5.8%	34.3 +9.9%	34.5 +5.5%	35.9 +4.7%
PCM/Reseller	3.1 +244.4%	12.8 +77.8%	4.3 +38.7%	15.7 +22.7%	5.7 +32.6%	18.3 +16.6%	7.0 +22.8%	19.7 +7.7%	8.2 +17.1%	20.6 +4.6%
OEM/Integrator	35.9 +43.0%	30.3 +50.0%	44.6 +24.2%	38.9 +28.4%	50.4 +13.0%	45.5 +17.0%	53.2 +5.6%	48.8 +7.3%	56.1 +5.5%	51.3 +5.1%
Total Revenues	63.9 +51.8%	67.9 +80.1%	77.1 +20.7%	82.7 +21.8%	87.0 +12.8%	95.0 +14.9%	92.9 +6.8%	102.8 +8.2%	98.8 +6.4%	107.8 +4.9%
ANNUAL SHARE, BY DIAMETER	48.6%	51.4%	48.3%	51.7%	47.9%	52.1%	47.6%	52.4%	47.9%	52.1%

Note: 12" libraries include 14" libraries.

TABLE 56

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments		Forecast							
			1995		1996		1997		1998	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	137	372	138	415	148	463	158	516	169	566
PCM/Reseller	--	384	--	470	--	591	--	688	--	771
OEM/Integrator	120	1,161	181	1,353	204	1,636	226	1,905	249	2,184
TOTAL U.S. SHIPMENTS	257	1,917	319	2,238	352	2,690	384	3,109	418	3,521
NON-U.S. MANUFACTURERS										
Captive	--	49	--	72	--	92	--	114	--	138
PCM/Reseller	43	57	60	120	78	118	97	140	117	163
OEM/Integrator	356	70	393	128	431	170	469	214	510	263
TOTAL NON-U.S. SHIPMENTS	399	176	453	320	509	380	566	468	627	564
WORLDWIDE RECAP										
Captive	137	421	138	487	148	555	158	630	169	704
	-.7%	+136.5%	+.7%	+15.7%	+7.2%	+14.0%	+6.8%	+13.5%	+7.0%	+11.7%
PCM/Reseller	43	441	60	590	78	709	97	828	117	934
	+258.3%	+94.3%	+39.5%	+33.8%	+30.0%	+20.2%	+24.4%	+16.8%	+20.6%	+12.8%
OEM/Integrator	476	1,231	574	1,481	635	1,806	695	2,119	759	2,447
	+34.1%	+33.8%	+20.6%	+20.3%	+10.6%	+21.9%	+9.4%	+17.3%	+9.2%	+15.5%
Total Shipments	656	2,093	772	2,558	861	3,070	950	3,577	1,045	4,085
	+29.9%	+58.0%	+17.7%	+22.2%	+11.5%	+20.0%	+10.3%	+16.5%	+10.0%	+14.2%
ANNUAL SHARE, BY DIAMETER	23.9%	76.1%	23.2%	76.8%	21.9%	78.1%	21.0%	79.0%	20.4%	79.6%

Note: 12" libraries include 14" libraries.

TABLE 57

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1994 --Shipments--		Forecast 1995		1996		1997		1998	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	509.0		553.0		611.0		674.0		735.0	
Write-once	137.0	26.9%	138.0	25.0%	148.0	24.2%	158.0	23.4%	169.0	23.0%
Rewritable	372.0	73.1%	415.0	75.0%	463.0	75.8%	516.0	76.6%	566.0	77.0%
Noncaptive Total	1,665.0		2,004.0		2,431.0		2,819.0		3,204.0	
Write-once	126.0	7.6%	187.0	9.3%	210.0	8.6%	231.0	8.2%	253.0	7.9%
Rewritable	1,539.0	92.4%	1,817.0	90.7%	2,221.0	91.4%	2,588.0	91.8%	2,951.0	92.1%
Total U.S.	2,174.0		2,557.0		3,042.0		3,493.0		3,939.0	
Write-once	263.0	12.1%	325.0	12.7%	358.0	11.8%	389.0	11.1%	422.0	10.7%
Rewritable	1,911.0	87.9%	2,232.0	87.3%	2,684.0	88.2%	3,104.0	88.9%	3,517.0	89.3%
NON-U.S. MANUFACTURERS										
Captive Total	49.0		72.0		92.0		114.0		138.0	
Rewritable	49.0	100.0%	72.0	100.0%	92.0	100.0%	114.0	100.0%	138.0	100.0%
Noncaptive Total	526.0		701.0		797.0		920.0		1,053.0	
Write-once	390.0	74.1%	432.0	61.6%	475.0	59.6%	519.0	56.4%	563.0	53.5%
Rewritable	136.0	25.9%	269.0	38.4%	322.0	40.4%	401.0	43.6%	490.0	46.5%
Total Non-U.S.	575.0		773.0		889.0		1,034.0		1,191.0	
Write-once	390.0	67.8%	432.0	55.9%	475.0	53.4%	519.0	50.2%	563.0	47.3%
Rewritable	185.0	32.2%	341.0	44.1%	414.0	46.6%	515.0	49.8%	628.0	52.7%
WORLDWIDE RECAP										
Total Worldwide Shipments	2,749.0		3,330.0		3,931.0		4,527.0		5,130.0	
	+50.2%		+21.1%		+18.0%		+15.2%		+13.3%	
Write-once	653.0	23.8%	757.0	22.7%	833.0	21.2%	908.0	20.1%	985.0	19.2%
	+28.5%		+15.9%		+10.0%		+9.0%		+8.5%	
Rewritable	2,096.0	76.2%	2,573.0	77.3%	3,098.0	78.8%	3,619.0	79.9%	4,145.0	80.8%
	+58.5%		+22.8%		+20.4%		+16.8%		+14.5%	

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

OPTICAL DISK DRIVE SPECIFICATIONS

1995 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 technology: The type of recording layer is indicated (magneto-optic, phase change, dye-polymer, etc.), except that the recording technology for CD-ROM is given as "Replication".

Operating mode: Drive operating mode is indicated as write once, rewritable or multifunction. Rewritable drives use magneto-optic technology unless otherwise indicated. Drives characterized as "Multifunction" handle write once or rewritable media. Multifunction drives operating with phase change media are indicated as "Multifunction-(PC)". Where the drive is a magneto-optic type and supports multi-functionality using MO-WORM (CCW) media, the designation "Multifunction-(MO)" is used.

Interface: Specific interfaces are listed for most of the drives. The abbreviation "HPAC" means an auxiliary interface channel for use with Hewlett-Packard auto-changers or compatible equipment is provided.

Speed control: The following abbreviations are used:

CAV = constant angular velocity.
CLV = constant linear velocity.
ZCAV = zoned constant angular 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 and ZCAV 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: Optical disk drives have compound head positioning systems. A coarse movement positions the head near the track to be located. A fine, or vernier, actuator then positions the head on the desired track and also maintains correct focus. Unless otherwise indicated, a vernier actuator is always present.

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 individual drive manufacturers 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 list the nominal data transfer rate for the fastest operating mode (4X, 6X, etc.).

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.

1995 DISK/TREND optical disk product groups

For the 1995 report, products are classified in seven 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 format 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 more cartridge capacity.

See the specification section following this one for optical library data.

MANUFACTURER	ACER	ACER	ACER PERIPHERALS	ACER PERIPHERALS	AIWA
DRIVE	CD 525E	CD 743E	CDE 625A	CDE 645A	ACD-300
DISK/TREND GROUP	10	10	10	10	10
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	OEM, PCM	PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Compatibility	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS, PCD, MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	2160-800	1060-400	2120-800	1000-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	320	223	230	230	220
Average rotational delay (msec)	27	27	27	27	55
Average access time (msec)	347	250	257	257	275
Data transfer rate (KBytes/sec)	300 (2X)	600 (4X)	300 (2X)	600 (4X) 8330 PIO	300 (2X)
Buffer/cache size (Kbytes)	128*	128	256	128	256
SIZE (mm: H x W x D)	42 x 149 x 202	42 x 146 x 211	42 x 146 x 211	42 x 146 x 211	63.2 x 175 x 196
FIRST CUSTOMER SHIPMENT	2Q95	2Q95	4Q94	3Q95	1994
COMMENTS	Sony mechanism *256 K option	Sony mechanism	Philips mechanism	Philips mechanism	External mount Tray loading

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MANUFACTURER	ALCO DIGITAL DEVICES	ASACA	ATG CYGNET	ATG CYGNET	ATG CYGNET
DRIVE	CDR 968	AMD-1341NS	GD 6000	GD 6001	GD 9001
DISK/TREND GROUP	10	11	12	12	12
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm	130 mm	300 mm	300 mm	300 mm
Recording technology	Replication	Magneto-Optic	Ablative	Ablative	Ablative
DRIVE: Operating mode	CD-ROM	Rewritable	Write Once	Write Once	Write Once
Interface	PCMCIA	SCSI-2	SCSI	SCSI	SCSI, SCSI-2
Compatibility					
Speed control & zones	CLV	CAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 598	F: 3200	F: 3200	F: 4500
Capacity per track (Bytes)	F: N/A	F: N/A	F: 52428	F: 52428	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20800	62500	62500	82000
Track density (TPI)	15875	16933	25400	25400	25400
Maximum linear density (BPI)	27600	34795	28200	28200	25400
Rotational speed (RPM)	1060-400	3000	1143	1143	914
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, Voice Coil	Linear Motor	Linear Motor	Linear Motor
Servo type	Continuous	Continuous	Sampled	Sampled	Sampled
Average positioning time (msec)	325	160	90	90	90
Average rotational delay (msec)	55	10	26.2	26.2	33
Average access time (msec)	380	170	116.2	116.2	123
Data transfer rate (KBytes/sec)	300 (2X)	12240/10000*	1000	1000	1000
Buffer/cache size (Kbytes)	64				
SIZE (mm: H x W x D)		430 x 312 x 600	174 x 440 x 530	174 x 440 x 530	177 x 482 x 532.5
FIRST CUSTOMER SHIPMENT	1995	3/93	3Q89	4Q90	1991
COMMENTS	Top loading Purchased mechanism	Proprietary format *Maximum SCSI rate		Differs from GD 6000 in the cartridge (single operation loading)	Can read GD 600 disks

MANUFACTURER	ATG CYGNET	AZTECH LABS	AZTECH LABS	AZTECH LABS	AZTECH LABS
DRIVE	GD 9001/S	CDA 268-01A Zeta	CDA 268-031/SE	CDA 468-011	CDA 668-011
DISK/TREND GROUP	12	10	10	10	10
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	300 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Ablative	Replication	Replication	Replication	Replication
DRIVE: Operating mode	Write Once	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI, SCSI-2	IDE	IDE	IDE/ATAPI	IDE/ATAPI
Compatibility		MS, PCD, CD-I*	MS, PCD, MPC-2	MS, PCD, CD-I*	MS, PCD, CD-I*
Speed control & zones	ZCAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 5100	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1
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	82000	20750	20750	20750	20750
Track density (TPI)	25400	15875	15875	15875	15875
Maximum linear density (BPI)	25400	27600	27600	27600	27600
Rotational speed (RPM)	914	1060-400	1060-400	2120-800	3180-1200
PERFORMANCE					
Positioner type	Linear Motor	Linear	Linear	Linear	Linear
Servo type	Sampled	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	90	350	300	235	207
Average rotational delay (msec)	33	55	55	27	18
Average access time (msec)	123	405	355	262	225
Data transfer rate (KBytes/sec)	1000	307.2 (2X)	307.2 (2X)	614 (4X)	921 (6X)
Buffer/cache size (Kbytes)		256	1128	256	256
SIZE (mm: H x W x D)	177 x 482 x 532.5	41.3 x 146.1 x 201	41.3 x 146.1 x 201	41.5 x 146 x 208	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	2Q92	1Q94	2Q94	4Q94	1995
COMMENTS	Can read GD 6000 disks and read/write GD 9001	*MPC-2 compliant Tray loading Audio output	Tray loading Audio output	*MPC-2 compliant Tray loading Audio output	*MPC-2 compliant Tray loading Audio output

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MANUFACTURER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BIRDY ELECTRONICS	CANON	CANON
DRIVE	CDD-110	CDD-139	CA 101	MO-5001S	OM-500D
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	Captive, OEM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Recording technology	Replication	Replication	Replication	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	Rewritable	Rewritable
Interface	Sony CDU 31A	IDE/ATAPI	Various	SCSI	Modified ESDI
Compatibility	MS, MPC-2	MS,PCD,XA,MPC-2	MS,MPC-2,XA,PCD		
Speed control & zones	CLV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	682 Mode 2 F: 540 Mode 1	F: 256	F: 256
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 16384	F: 16384
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	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	335	260	325	80	80
Average rotational delay (msec)	55	55	55	10	10
Average access time (msec)	380	315	380	90	90
Data transfer rate (KBytes/sec)	307.2 (2X)	307.2 (2X)	300 (2X)	1138	1138
Buffer/cache size (Kbytes)	64		64		
SIZE (mm: H x W x D)	41.5 x 146 x 208	42 x 149 x 210.5	41.3 x 148 x 201	137 x 185 x 365	82.6 x 146.1 x 203
FIRST CUSTOMER SHIPMENT	3Q94	4Q94	12/94	3/90	4Q88
COMMENTS	Tray loading Wearnes mechanism	Tray loading	Tray loading	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 1100/ATe	CRI 1100/ATi	CRI 1100/SCSIe	CRI 1400	CDA-535 CDS-535 CDX-535
DISK/TREND GROUP	10	10	10	10	10
MARKET	PCM	PCM	PCM	PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE	IDE	SCSI	SCSI	SCSI-2
Compatibility	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	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	2120-800	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	365	365	365	200	165
Average rotational delay (msec)	110	110	110	27	55
Average access time (msec)	475	475	475	227	220
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	300 (2X)	600 (4X)	300 (2X)
Buffer/cache size (Kbytes)	64	64	64	256	256
SIZE (mm: H x W x D)		41.3 x 146.1 x 203.2		41.3 x 146.1 x 203.2	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	1994	1994	1994	2Q95	1Q93
COMMENTS	External mount		External mount		CDA is for Mac CDX is external mount

MANUFACTURER	CHINON	CHINON	CHINON	CHINON	CHINON
DRIVE	CDS-525I	CDS-525S	CDS-545S	CDS-545i	CDS-565i
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Compatibility	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 650	F: 650	F: 650	F: 650
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-200	1060-200	2120-800	2120-200	3180-1200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	265	265	185	185	127
Average rotational delay (msec)	55	55	45	45	18
Average access time (msec)	320	320	230	230	145
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	600 (4X)	600 (4X)	900 (6X)
Buffer/cache size (Kbytes)	64	64	128	128	256
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	41.4 x 146 x 203	41.4 x 146 x 203	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	4Q94	4Q94	4Q95
COMMENTS	Tray loading	Tray loading	Tray loading	Tray loading	Tray loading

MANUFACTURER	CHINON	CHINON	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK
DRIVE	CDS-565S	MOA300DX MOD300DX MOX300DX	PCD Writer 600	PCD Writer 200 PCD Writer 200+ PCD Writer 225	System 2000
DISK/TREND GROUP	10	11	11	11	12
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Disk diameter	120 mm	86 mm	120 mm	120 mm	356 mm
Recording technology	Replication	Magneto-Optic	Dye Polymer	Dye Polymer	Phase Change
DRIVE: Operating mode	CD-ROM	Rewritable	Write Once	Write Once	Write Once
Interface	SCSI-2	SCSI-2	SCSI	SCSI	SCSI-2
Compatibility	MS,PCD,XA,MPC-2		MS, PCD, XA	MS,PCD,XA,CD-I	
Speed control & zones	CLV	CAV	CLV	CLV	MCAV-S
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 128	F: 580/682	F: 682	F: 7412
Capacity per track (Bytes)	F: N/A	F: 12800	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	20750	20750	104824
Track density (TPI)	15875	15875	15875	15875	25399
Maximum linear density (BPI)	27600	24440	27600	27600	25200
Rotational speed (RPM)	3180-1200	3000	3646-1165	1000-428	1362-654
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Sampled
Average positioning time (msec)	127	42	1271	945	137
Average rotational delay (msec)	18	10	17	55	33
Average access time (msec)	145	52	1288	1000	170
Data transfer rate (KBytes/sec)	900 (6X)	625	921.6 4000 synch.	307.2 1500 asynch.	1000
Buffer/cache size (Kbytes)	256	256	1000-8000	256	128
SIZE (mm: H x W x D)	41.4 x 146 x 203	42 x 146 x 200	145 x 430 x 380	118 x 420 x 334	800 x 455 x 714*
FIRST CUSTOMER SHIPMENT	4Q95		2Q94	3Q92	3Q94
COMMENTS	Tray loading	Internal cache	75 disk loader option Tray loading	Tray loading	*Includes controller

1995 DISK/TREND REPORT

MANUFACTURER	ELITEGROUP COMPUTER SYSTEMS	ELITEGROUP COMPUTER SYSTEMS	ELITEGROUP COMPUTER SYSTEMS	FUJITSU	FUJITSU
DRIVE	VERTOS 300HPD	VERTOS 300	VERTOS 400HID	F6445A11	IFD1300A
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive	PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Recording technology	Replication	Replication	Replication	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	Rewritable	Multifunct-(MO)
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I		
Speed control & zones	CLV	CLV	CLV	CAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 660	F: 660	F: 660	F: 326.4	F: 595/652*
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 17408	F: 17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	18751	21600
Track density (TPI)	15875	15875	15875	15875	18273
Maximum linear density (BPI)	27600	27600	27600	24923	29540
Rotational speed (RPM)	1060-400	1060-400	2120-800	5400	3000
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	265	295	223	35	39
Average rotational delay (msec)	55	55	27	5.6	10
Average access time (msec)	320	350	250	40.6	49
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	600 (4X)	2080 4100 synch.	2000 max.
Buffer/cache size (Kbytes)	128	128	128*		1000
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 203	82 x 146.1 x 208	
FIRST CUSTOMER SHIPMENT	1Q95	3Q94	3Q95	6/92	1995
COMMENTS	*MPC-2 compliant Hitachi mechanism	*MPC-2 compliant Sony mechanism Tray loading	*256 K option Hitachi mechanism	Direct overwrite, 3 beam head Sold in Japan	*512/1024 bytes per sector Purchased mechanism. Sold in Europe

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2511A DynaMO 128	M2512A DynaMO 230	M2541B DynaMO 230 Portable	MO City	SMB230B SMB230M
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	OEM, PCM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2	*
Compatibility					
Speed control & zones	CAV	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 128	F: 128/230	F: 128/230	F: 128/230	F: 128/230
Capacity per track (Bytes)	F: 12800	F: 12800/N/A	F: 12800/N/A	F: 12800/N/A	F: 12800/N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	10000/17940	10000/17940	10000/17940	10000/17940
Track density (TPI)	15875	15875/18273	15875/18273	15875/18273	15875/18273
Maximum linear density (BPI)	24400	24400/29296	24400/29296	24400/29296	24400/29296
Rotational speed (RPM)	3600	3600	2700	2700	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	30	30	50	50	30
Average rotational delay (msec)	8.3	8.3	11	11	8.3
Average access time (msec)	38.3	38.3	61	61	38.3
Data transfer rate (KBytes/sec)	1090 4000 synch.	1300-2100 5000 synch.	975-1575	975-1575	1300-2100 5000 synch.
Buffer/cache size (Kbytes)	256	256	128	128	
SIZE (mm: H x W x D)	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	17 x 101.6 x 140		25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1992	3/94	10/95	1995	7/95
COMMENTS	DynaMO is external subsystem	DynaMO is external subsystem	DynaMO is external subsystem Direct overwrite	Sold in Europe	*230B is for DOS/V PC 230M is for Macintosh

MANUFACTURER	FUNAI ELECTRIC	FUNAI ELECTRIC	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.
DRIVE	E2880OUA	PL1359	GCD-R320B	GCD-R340B	GCD-R520B
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE	IDE	SCSI-2	SCSI-2	IDE/ATAPI
Compatibility	MS, PCD, MPC-2	MS, PCD, MPC-2	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 680	635 Mode 2 F: 535 MOde 1	635 Mode 2 F: 535 Mode 1
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)	1000-200	2000-200	1060-400	2120-800	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	320	250	250	193	175
Average rotational delay (msec)	55	28	55	27	55
Average access time (msec)	375	278	305	220	230
Data transfer rate (KBytes/sec)	307.2 (2X)	614.4 (4X)	300 (2X)	600 (4X)	300 (2X)
Buffer/cache size (Kbytes)	64	256	64	256	256
SIZE (mm: H x W x D)	41.3 x 146.1 x 193	41.3 x 146.1 x 193	41.3 x 146.1 x 180	41.5 x 146 x 189	41.5 x 146 x 189
FIRST CUSTOMER SHIPMENT	3/95	8/95	1Q94		12/94
COMMENTS	Spin up: 2.5 seconds Video CD ready	Spin up: 2.5 seconds Video CD ready	*MPC-2 compliant Tray loading	*MPC-2 compliant Motorized tray loading	*MPC-2 compliant Motorized tray loading

MANUFACTURER	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.	GOLDSTAR CO., LTD.	GROUP SENSE
DRIVE	GCD-R540B	GDI-750 GDI-1000	GDO-101M	GPI-1200	CDAT300iB
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	PCM	PCM	PCM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	Audio/Video	Audio/Video		Panasonic
Compatibility	MS,PCD,XA,CD-I*	PCD, CD-I	MS, PCD, 3DO	PCD, CD-I, XA	MS,PCD,CD-I,XA
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 635 Mode 2 535 Mode 1	F: 680	F: 680	F: 540	F: 630 Mode 2 540 Mode 1
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)	2120-800		1060-400		1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear	Linear	Linear	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	163				265
Average rotational delay (msec)	27				55
Average access time (msec)	190				320
Data transfer rate (KBytes/sec)	600 (4X)		300 (2X)		300 (2X)
Buffer/cache size (Kbytes)	128/256				64
SIZE (mm: H x W x D)	41.5 x 146 x 189	67 x 299 x 190	82 x 300 x 271	70 x 172 x 160	42.2 x 148 x 214
FIRST CUSTOMER SHIPMENT		5/95	1995	7/95	6/95
COMMENTS	*MPC-2 compliant Motorized tray loading	Tray loading	3DO standalone player	CD-I player	Tray loading

MANUFACTURER	GROUP SENSE	GROUP SENSE	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI
DRIVE	CDAT300XB	CDIDE300i-305	C1716T	C2550A C2550B Model 1300t	CDR 6750
DISK/TREND GROUP	10	10	11	11	10
MARKET	OEM	OEM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	130 mm	130 mm	120 mm
Recording technology	Replication	Replication	Magneto-Optic	Magneto-Optic	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	Multifunct-(MO)	Multifunct-(MO)	CD-ROM
Interface	IDE, Par. Port	IDE	SCSI-2	SCSI-2	SCSI
Compatibility	MS, PCD	MS,PCD,CD-I,XA*			MS, PCD, MPC-2
Speed control & zones	CLV	CLV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1	F: 650	F: 650	F: 682
Capacity per track (Bytes)	F: N/A	F: N/A	F: 17408	F: 17408	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	21600*	21600*	20750
Track density (TPI)	15875	15875	18273	18273	15875
Maximum linear density (BPI)	27600	27600	29540	29540	27600
Rotational speed (RPM)	1060-400	1060-400	2400	2400	1060-400
PERFORMANCE					
Positioner type	Linear, Stepping Motor	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil	Linear Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	445	295	23.5	23.5	190
Average rotational delay (msec)	55	55	12.5	12.5	55
Average access time (msec)	500	350	36	36	245
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	5000 synch. 1600 asynch.	5000 synch. 1600 asynch.	307.2 (2X) 5000 asynch.
Buffer/cache size (Kbytes)	64	64	512	512	256
SIZE (mm: H x W x D)	46.5 x 202 x 144.5	42.2 x 148 x 214	82.5 x 146.1 x 203.2	146.1 x 174 x 280	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	6/95	6/95	2Q93	2Q93	4Q93
COMMENTS	Top loading External transportable Sony mechanism	Tray loading *MPC-2 compliant Sony mechanism	*37600 logical tracks. MO-WORM. DSP servo. Backward compatible	*37600 logical tracks External version of C1716T	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	CDR 7730	OD 101-1	OD 112-1	OD 152 OU 152	OD 301A-1
DISK/TREND GROUP	10	11	11	12	12
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	OEM, PCM	Captive, OEM
MEDIA: Disk diameter	120 mm	130 mm	130 mm	130 mm	300 mm
Recording technology	Replication	Ablative	Magneto-Optic	Magneto-Optic	Ablative
DRIVE: Operating mode	CD-ROM	Write Once	Rewritable	Multifunct-(MO)	Write Once
Interface	IDE/ATAPI	SCSI	SCSI	SCSI-2	SCSI, GPIB, SMD
Compatibility	MS, PCD, MPC-2				
Speed control & zones	CLV	CAV	CAV	ZCAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 742	F: 300	F: 322	F: 1012	F: 1310
Capacity per track (Bytes)	F: N/A	F: 16400	F: 17408	Varies by zone	F: 31700
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	18624	18751	22440	41300
Track density (TPI)	15875	16000	16000	18947	16000
Maximum linear density (BPI)	27600	24000	24000	45340*	19500
Rotational speed (RPM)	2120-800	1800	2400	3000	600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	213	93	62.5	40	200
Average rotational delay (msec)	27	16.7	12.5	10	50
Average access time (msec)	240	109.7	75	50	250
Data transfer rate (KBytes/sec)	600 (4X) 8300 PIO Mode 2	690	925	1540-3020	440
Buffer/cache size (Kbytes)	128				
SIZE (mm: H x W x D)	41.3 x 146 x 190	83 x 146.1 x 213	107 x 146.1 x 220	41.3 x 146.1 x 203.2	160 x 380 x 650
FIRST CUSTOMER SHIPMENT	2Q95	2Q87	7/89	4Q93	3Q85
COMMENTS	Tray loading		ISO standard	OU 152 is external *1,7 RLL Code	

MANUFACTURER	HITACHI	HITACHI	HONEYWELL	HONEYWELL	HOPAX INDUSTRIES
DRIVE	OD 321-1 OD 321-2	OL F152	AN/MU-928	DDU	520/E
DISK/TREND GROUP	12	12	11	11	10
MARKET	Captive, OEM	Captive, OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	300 mm	130 mm	130 mm	130 mm	120 mm
Recording technology	Ablative	Magneto-Optic	Ablative	Magneto-Optic	Replication
DRIVE: Operating mode	Write Once	Multifunct-(MO)	Write Once	Rewritable	CD-ROM
Interface	SCSI	SCSI-2	Modified SCSI	1553, SCSI-2	IDE
Compatibility				Proprietary	PCD, MPC-2
Speed control & zones	ZCAV	ZCAV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 3500	F: 1012	F: 260	F: 300	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	F: N/A	Varies by zone	F: 20480	F:	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	48035	22440	12695	20000	20750
Track density (TPI)	17000	18947	NS	--	15875
Maximum linear density (BPI)	33200	45340	NS	--	27600
Rotational speed (RPM)	1000	3000	1800	1800	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Stepping Motor	Stepping Motor	Linear, DC Motor
Servo type	Continuous	Continuous	Sector	Sector	Continuous
Average positioning time (msec)	120	40	125	65	245
Average rotational delay (msec)	30	10	17	17	55
Average access time (msec)	150	50	142	82	300
Data transfer rate (KBytes/sec)	1160-2220	1540-3020	562	625	300 (2X)
Buffer/cache size (Kbytes)					64
SIZE (mm: H x W x D)	160 x 430 x 660	82.5 x 146.1 x 203.2			41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	1Q91	1Q94	2Q89	2Q95	3Q94
COMMENTS	Pit edge recording. Glass substrate 321-2 used in libraries	For Hitachi libraries	Embedded controller Militarized	Militarized	Tray loading Purchased mechanism

MANUFACTURER	HOPAX INDUSTRIES	HOPAX INDUSTRIES	HOPAX INDUSTRIES	IBM	IBM
DRIVE	520SI	962H	964H	0632-C2X MCC51300	0632-CHA 0632-CHB
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	OEM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Recording technology	Replication	Replication	Replication	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	Rewritable	Multifunct-(MO)
Interface	IDE	IDE/ATAPI	IDE/ATAPI	SCSI	SCSI
Compatibility	PCD, MPC-2	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I		
Speed control & zones	CLV	CLV	CLV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	F: 595/652*	F: 595/650*
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 17408	F: 17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	21600**	21600**
Track density (TPI)	15875	15875	15875	18273	18273
Maximum linear density (BPI)	27600	27600	27600	29540	29540
Rotational speed (RPM)	1060-400	1060-400	2120-800	2400	3500
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	245	223	223	55	29
Average rotational delay (msec)	55	55	27	12.5	8.6
Average access time (msec)	300	278	250	67.5	37.6
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	600 (4X)	1561* 4000 synch.	2079/2280 5000 synch.
Buffer/cache size (Kbytes)	64	128	256		1000
SIZE (mm: H x W x D)	41.5 x 146 x 208	41.5 x 146 x 208	41.5 x 146 x 208	82.5 x 146 x 205.5	41.3 x 146 x 205.2
FIRST CUSTOMER SHIPMENT	3Q94	4Q95	3Q95	2Q93	2Q94
COMMENTS	Tray loading Purchased mechanism	Tray loading Purchased mechanism	Tray loading Purchased mechanism	*512/1024 bytes per sector. **37600 logical tracks. MCC51300 is external mount	*512/1024 bytes per sector. **37600 logical tracks. 1 MB cache 4 MB option

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0632-CHC	4153 Imagestar	7209-001	7209-002	MTA-3230
DISK/TREND GROUP	11	11	11	11	11
MARKET	Captive, OEM	Captive,OEM,PCM	Captive, OEM	Captive	Captive,OEM,PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	86 mm
Recording technology	*	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunction	Multifunct-(MO)	Rewritable	Rewritable	Rewritable
Interface	SCSI	SCSI-2	SCSI	SCSI	SCSI-2
Compatibility					
Speed control & zones	ZCAV	ZCAV	CAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 595/652	F: 595/652*	F: 595	F: 595	F: 230
Capacity per track (Bytes)	F: N/A	F:21600/37600**	F: 17408	F: 17408	F: 12800*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600/37600**	21600**	18751	21600*	11510/17853*
Track density (TPI)	18273	18273	15900	18273	18273
Maximum linear density (BPI)	29540	29540	24900	29540	29540
Rotational speed (RPM)	2400	3500	2400	3500	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	29	29	70	29	40
Average rotational delay (msec)	12.5	8.7	12.5	8.6	8.3
Average access time (msec)	41.5	37.7	82.5	37.6	48.3
Data transfer rate (KBytes/sec)	1561 5000 synch.	3280 5000 synch.	620 4000 synch.	1079 4000 synch.	1475 max. 5000 synch.
Buffer/cache size (Kbytes)	1000	1000			256
SIZE (mm: H x W x D)	41.3 x 146 x 205.5	41.3 x 146 x 205.2	41.3 x 146.1 x 205.2	122.3 x 280 x 290	25.4 x 101.6 x 169
FIRST CUSTOMER SHIPMENT	3Q93	2Q95	4Q92	3Q93	5/94
COMMENTS	*Uses MO or ablative WORM media **Logical tracks	*512/1024 bytes per sector. **37600 logical tracks. PC srvr PC300/ 700 & ValuePnt	For RS/6000 External mount	For RS/6000 External mount *Logical tracks	*Logical tracks Read only and partial read only modes

MANUFACTURER	IPC PERIPHERALS	JVC	JVC	KAIMEI (JAMICON)	LASERBYTE
DRIVE	MCD242	XR-S201	XR-W2001	Dual Speed	LB4230
DISK/TREND GROUP	10	11	11	10	11
MARKET	OEM	OEM	OEM	PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	86 mm
Recording technology	Replication	Organic Dye	Organic Dye	Replication	Magneto-Optic
DRIVE: Operating mode	CD-ROM	Write Once	Write Once	CD-ROM	Rewritable
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	SCSI, SCSI-2
Compatibility	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS, PCD, XA	
Speed control & zones	CLV	CLV	CLV	CLV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 580/680	F: 580/680	F: 540	F: 229.1
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	17900
Track density (TPI)	15875	15875	15875	15875	18273
Maximum linear density (BPI)	27600	27600	27600	27600	24300
Rotational speed (RPM)	2120-800	1060-400	1060-400	1060-400	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	250	245	245	265	40
Average rotational delay (msec)	27	55	55	55	8.3
Average access time (msec)	277	300	300	320	48.3
Data transfer rate (KBytes/sec)	600 (4X)	307.2	307.2	300 (2X)	920-1470
Buffer/cache size (Kbytes)	128	1000	1000	128	256
SIZE (mm: H x W x D)	41.5 x 146 x 208	71 x 265 x 294	41.3 x 146 x 205	41.5 x 146 x 208	25 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	2Q95	3/95	10/94	1Q95	6/95
COMMENTS	Tray loading *MPC-2 compliant	Caddy External mount	Caddy	Tray loading	Read only and partial read only modes

1995 DISK/TREND REPORT

MANUFACTURER	LION OPTICS	LION OPTICS	LION OPTICS	LION OPTICS	LION OPTICS
DRIVE	XC 200A1	XC 200E1	XC 200PC	XC 400EI	XC 400PE
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface			PCMCIA	IDE/ATAPI	Parallel Port
Compatibility	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I
Speed control & zones	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	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
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	2120-800	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	233	233	250	210	310
Average rotational delay (msec)	55	55	55	27	27
Average access time (msec)	288	288	305	237	337
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	300 (2X)	600 (4X) 11.1 PIO	600 (4X)
Buffer/cache size (Kbytes)	128	256	256	256	256
SIZE (mm: H x W x D)	41.5 x 146 x 208	41.5 x 146 x 208		41.5 x 146 x 208	60 x 160 x 290
FIRST CUSTOMER SHIPMENT	1994	1994	7/95	1994	1995
COMMENTS	Tray loading	Tray loading	Top loading Portable player	Tray loading	Tray loading

MANUFACTURER	LION OPTICS	LION OPTICS	LION OPTICS	LONGSHINE ELECTRONICS	LONGSHINE ELECTRONICS
DRIVE	XC 400PP	XC 400SI	XE 600EI	LCS 7260	LCS 7260I
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	Parallel Port	SCSI-2	IDE/ATAPI	IDE	IDE/ATAPI
Compatibility	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I	MPC-2	MS,PCD,XA,CD-I*
Speed control & zones	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	635 Mode 2 F: 553 Mode 1	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2120-800	2120-800	3180-1200	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	233	250	210	330	300
Average rotational delay (msec)	27	55	18	60	50
Average access time (msec)	260	305	228	390	350
Data transfer rate (KBytes/sec)	600 (4X)	600 (4X)	900 (6X) 11.1 PIO	300 (2X)	300 (2X) 8330 PIO
Buffer/cache size (Kbytes)	256	256	256	64	128/256
SIZE (mm: H x W x D)	40 x 180 x 196	41 x 146 x 203	41.5 x 146 x 208	42.3 x 148.5 x 205	42.3 x 148.5 x 205
FIRST CUSTOMER SHIPMENT	1995	2Q94	1995	1Q94	3Q94
COMMENTS	Tray loading Portable Optional PCMCIA interface card	*MPC-2 compliant Tray loading	Tray loading	Tray loading Audio output	*MPC-2 compliant Tray loading Audio output

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MANUFACTURER	LONGSHINE ELECTRONICS	LONGSHINE ELECTRONICS	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LCS 7260P	LCS 7460I	CR-503	CR-533	CR-562
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm/80 mm	120 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	Parallel Port	SCSI-2	SCSI-2	SCSI, SCSI-2	IDE
Compatibility	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 682	F: 682	F: 682
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27900
Rotational speed (RPM)	1060-400	1060-400	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	DC Motor, Lead Screw	DC Motor, Rack & Pinion	DC Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	330	308	265	290	265
Average rotational delay (msec)	60	27	55	55	55
Average access time (msec)	390	335	320	345	320
Data transfer rate (KBytes/sec)	300 (2X)	600 (4X) 8330 PIO	300 (2X)	300 (2X)	300 (2X)
Buffer/cache size (Kbytes)	64	256	256	128/256	64
SIZE (mm: H x W x D)	60 x 170 x 265	42.3 x 148.5 x 205	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 190
FIRST CUSTOMER SHIPMENT	1Q94	5/95	2Q90	2Q93	5/93
COMMENTS	Tray loading Audio output	Tray loading Audio output			Tray loading

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	CR-563	CR-571B	FZ-10	KXL-D720 KXL-DN720A** KXL-DX720A*	LK-MC509S
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE	IDE/ATAPI	Proprietary	PCMCIA, SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2		MS, PCD, MPC-2	MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 682	F: 680	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27900	27600	27600	27600
Rotational speed (RPM)	1060-400	1060-400	2120-800	1060-400	1060-400
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	DC Motor, Lead Screw	Linear	DC Motor, Lead Screw	DC Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	265	265	200	250	225
Average rotational delay (msec)	55	55	27	55	55
Average access time (msec)	320	320	227	305	280
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	600 (4X)	300 (2X)	300 (2X)
Buffer/cache size (Kbytes)	64	256		128	256
SIZE (mm: H x W x D)	41.3 x 146 x 190	41.3 x 146 x 203		35.6 x 140 x 207.3	41.3 x 146 x 208.3
FIRST CUSTOMER SHIPMENT	2Q93	3Q94	6/95	1995	
COMMENTS	Tray loading	Tray loading	3DO player	Top loading *For DOS/V PC **For Macintosh	Tray loading

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MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LK-MC579BP	LK-MC604S	LK-MC684BP	LK-RC504	LK-RC562AB LK-RC562NM
DISK/TREND GROUP	10	10	10	10	10
MARKET	PCM	PCM	PCM	PCM	Captive, OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	Proprietary
Compatibility	MPC-2	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	635 Mode 2 F: 553 Mode 1	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	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	3120-800	3120-800	2120-800	1060-400
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	Linear	Linear	Linear	DC Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	225	175	175	200	265
Average rotational delay (msec)	55	27	27	27	55
Average access time (msec)	280	202	202	227	320
Data transfer rate (KBytes/sec)	300 (2X)	600 (4X)	600 (4X)	600 (4X)	300 (2X)
Buffer/cache size (Kbytes)	256	256	256	256	64
SIZE (mm: H x W x D)	41.3 x 146 x 208.3		41.5 x 146 x 209	41.3 x 146 x 209	57 x 158 x 314
FIRST CUSTOMER SHIPMENT		3Q95	3Q95	1995	4Q93
COMMENTS	Tray loading	Tray loading External mount	Tray loading	Tray loading	Tray loading External models Sold in Japan

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LF-1000AB LF-1000JA* LF-1000JD PD Drive	LF-1004AB LF-1004JD* LF-1094 PD Drive	LF-3100 LF-3104	LF-3200JA	LF-3200JD
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm	120 mm	86 mm	86 mm	86 mm
Recording technology	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI
Compatibility	PD, CD-ROM	PD, CD-ROM			
Speed control & zones	ZCAV/CLV**	ZCAV/CLV**	CAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	668 PC F: 540 CD-ROM	668 F: 540 CD-ROM	F: 128	F: 229.1	F: 229.1
Capacity per track (Bytes)	F: N/A	F: N/A	F: 12800	F: 12800*	F: 12800*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	27200/20750**	27200/20750**	10000	11510/17853*	11510/17853*
Track density (TPI)	21166/15875**	--/15875**	15875	18273	18273
Maximum linear density (BPI)	29195/27600**	--/27600**	24440	29540	29540
Rotational speed (RPM)	2026/2120-800**	2026/2120-800**	3000	3600	3600
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	Linear, Voice Coil	Linear, Voice Coil	Voice Coil	Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	165/195**	165/195**	40	35	35
Average rotational delay (msec)	12.5/27**	12.5/27**	10	8.3	8.3
Average access time (msec)	177/222**	177/222**	50	43.3	43.3
Data transfer rate (KBytes/sec)	518-1141 (PC) 600 (CD-ROM)	1141 max. (PC) 600 (CD-ROM)	906 1500 avg.	2100 5000 synch.	2100 5000 synch.
Buffer/cache size (Kbytes)	256	512		256	256
SIZE (mm: H x W x D)	58 x 158 x 318	41.3 x 146.1 x 196	41.3 x 101.6 x 146	56 x 168 x 240	56 x 168 x 240
FIRST CUSTOMER SHIPMENT	1Q95	1Q95	3Q91	3Q94	3Q94
COMMENTS	*For Macintosh. **For CD-ROM mode Tray loading External mount	*For Macintosh **For CD-ROM mode Tray loading	LF-3100 is external mount Sold in Japan	*Logical tracks External mount For use with Macintosh	*Logical tracks External mount. For use w/DOS, PC-9800 and Panacom systems

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LF-3294	LF-5300A	LF-7300A LF-7300J1	LF-7304	LF-7394
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	86 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Ablative	Phase Change	Phase Change	Phase Change
DRIVE: Operating mode	Rewritable	Write Once	Multifunct-(PC)	Multifunct-(PC)	Multifunct-(PC)
Interface	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility					
Speed control & zones	ZCAV	MCAV	ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 229.1	F: 700	F: 750	F: 750	F: 750/700*
Capacity per track (Bytes)	F: 12800*	F:	F: N/A	F: N/A	F: NA
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11510/17853*	25920	25920	25920	25920
Track density (TPI)	18273	21770	21770	21770	21700
Maximum linear density (BPI)	29540	--			
Rotational speed (RPM)	3600	2400	2400	2400	2400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35	45	45	45	45
Average rotational delay (msec)	8.3	12.5	12.5	12.5	12.5
Average access time (msec)	43.3	57.5	57.5	57.5	57.5
Data transfer rate (KBytes/sec)	2100 5000 synch.	740-1440 5000 synch.	780-1560 5000 synch.	780-1560 5000 synch.	780-1560 740-1440*
Buffer/cache size (Kbytes)	256				
SIZE (mm: H x W x D)	41.3 x 101.6 x 151.5	74 x 220 x 323	74 x 220 x 323	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2Q94	4Q93	4Q93	4Q93	4Q93
COMMENTS	*Logical tracks	External mount	External mount J1 version sold in Japan		*With WORM media

MANUFACTURER	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS
DRIVE	EBP-201	EBP-401	EBP-504	EBP-506	EBP-508
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	Centronics	Proprietary	Proprietary	Proprietary	Proprietary
Compatibility					
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	530-200	530-200	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	DC Motor, Lead Screw	Stepping Motor, Lead Screw	Stepping Motor, Lead Screw	Stepping Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	1590	1590	320	320	285
Average rotational delay (msec)	110	110	55	55	55
Average access time (msec)	1700	1700	375	375	340
Data transfer rate (KBytes/sec)	153.6 (1X)	153.6 (1X)	307.2 (2X)	307.2 (2X)	307.2 (2X)
Buffer/cache size (Kbytes)					
SIZE (mm: H x W x D)			29 x 130 x 223.5	29 x 130 x 203.5	42 x 146 x 203.5
FIRST CUSTOMER SHIPMENT	1Q89	2Q91	3Q93	1Q94	2Q94
COMMENTS	Standalone model	For automobile use	Tray loading	Tray loading	Tray loading

MANUFACTURER	MATSUSHITA ELECTRONIC COMPONENTS	MAXOPTIX	MAXOPTIX	MEDIA VISION	MITSUMI ELECTRIC
DRIVE	EBP-602	T3-1300	T4-1300	Reno	CRMC-FX001DE
DISK/TREND GROUP	10	11	11	10	10
MARKET	OEM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Disk diameter	120 mm	130 mm	130 mm	120 mm	120 mm
Recording technology	Replication	Magneto-Optic	Magneto-Optic	Replication	Replication
DRIVE: Operating mode	CD-ROM	Multifunct-(MO)	Multifunct-(MO)	CD-ROM	CD-ROM
Interface	Proprietary	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI
Compatibility				MPC-2	MS, PCD, MPC-2
Speed control & zones	CLV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 650/512/326	F: 650/512/322	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F:	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	37600/25000	37600/25000	20750	20750
Track density (TPI)	15875	18273/16933	18273/16933	15875	15875
Maximum linear density (BPI)	27600	29540*	29540*	27600	27600
Rotational speed (RPM)	1060-400	3375/4000/4800	3000	1060-400	1000-400
PERFORMANCE					
Positioner type	Stepping Motor, Lead Screw	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	320	19	39	180	250
Average rotational delay (msec)	55	6.25/7.5/8.9	10	55	55
Average access time (msec)	375	25.25	49	235	305
Data transfer rate (KBytes/sec)	307.2 (2X)	2200/1100	2000 4000 synch.	300 (2X)	300 (2X)
Buffer/cache size (Kbytes)		1000-4000	1000	64	128
SIZE (mm: H x W x D)	23 x 96 x 151	82.6 x 146 x 203	41.3 x 146 x 203		42 x 148 x 201
FIRST CUSTOMER SHIPMENT	1Q94	5/93	1/95	4/94	2Q94
COMMENTS	For pop-up model CD-ROM module	*2,7 RLL Code	*2,7 RLL Code	External mount	Auto tray loading

MANUFACTURER	MITSUMI ELECTRIC	MOST	MOST	MOST	MOUNTAIN OPTECH
DRIVE	CRMC-FX400	RMD 5200-S	RMD 5300-S	TRITON	SE-250 R/W SI-250 R/W ST-250 R/W
DISK/TREND GROUP	10	11	11	12	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	120 mm	86 mm	86 mm	130 mm	86 mm
Recording technology	Replication	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	CD-ROM	Rewritable	Rewritable	Multifunct-(MO)	Rewritable
Interface	IDE/ATAPI	SCSI-1/2	SCSI-2	SCSI, SCSI-2	SCSI
Compatibility	MS,PCD,XA,MPC-2			--	
Speed control & zones	CLV	CAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 128/256*	F: 230*/256/384	F: 325/650/1300	F: 230
Capacity per track (Bytes)	F: N/A	F: 12800/**	**	--	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	12900	*	11510/17853*
Track density (TPI)	15875	15875	18273	22087	18273
Maximum linear density (BPI)	27600	15875/39625	42900		29540
Rotational speed (RPM)	2000-800	2400	2400	2000	3600
PERFORMANCE					
Positioner type	Motor, Lead Screw	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	230	35.2	35.2	24	40
Average rotational delay (msec)	27	12.5	12	15.8	8.3
Average access time (msec)	257	47.7	47.2	39.8	48.3
Data transfer rate (KBytes/sec)	600 (4X)	512/820-1228	512/860-1500	2100 5000 synch.	1475 max.
Buffer/cache size (Kbytes)	128	128			64
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	41.3 x 146 x 203.2	
FIRST CUSTOMER SHIPMENT	9/94	2Q92	3Q94	3Q95	1Q95
COMMENTS	Tray loading	*Zoned recording. **Varies by zone. OROM support	*Also operates with 128 MB media **Varies by format	*75721 logical tracks Updatable microcode	Ruggedized *Logical tracks

MANUFACTURER	MOUNTAIN OPTECH	MOUNTAIN OPTECH	NEC	NEC	NEC
DRIVE	CS-1000 M/F SE-1000 M/F SS-1000 M/F ST-1000 M/F SEL-1000 M/F	RM-2000 M/F	CDR-272	CDR-401 MultiSpin 3XP+	CDR-501 MultiSpin 4Xi
DISK/TREND GROUP	11	11	10	10	10
MARKET	OEM	OEM	OEM	PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Recording technology	Magneto-Optic	Magneto-Optic	Replication	Replication	Replication
DRIVE: Operating mode	Rewritable	Rewritable	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI	SCSI	IDE	SCSI-2	IDE
Compatibility					
Speed control & zones	ZCAV	ZCAV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 512/326.4	F: 512/326.4	F: 680	F: 540/680	F: 540/680
Capacity per track (Bytes)	F: 25000/17408	F: 25000/17408	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	25000	25000	20750	20750	20750
Track density (TPI)	16933	16933	15875	15875	15875
Maximum linear density (BPI)	25000	25000	27600	27600	27600
Rotational speed (RPM)	2200	2200	2120-800	2000-800	2000-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35	35	195	200	193
Average rotational delay (msec)	13.6	13.6	55	40	27
Average access time (msec)	48.6	48.6	250	240	220
Data transfer rate (KBytes/sec)	1250/880	1250/880	300 (2X)	500	600 (4X)
Buffer/cache size (Kbytes)	4000	4000	128	256	256
SIZE (mm: H x W x D)			41.3 x 149 x 208	55.9 x 154 x 257	42.8 x 149 x 219.7
FIRST CUSTOMER SHIPMENT	2Q91	3Q95	1992		4Q94
COMMENTS	Ruggedized version of Maxtor Tahiti SE-1000 is for military use	2 ruggedized drives in 19" rack	Internal		

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	CDR-502 MultiSpin 6Xi	CDR-601 CDR-6014 MultiSpin 4Xe	CDR-602 PC-CD600 MultiSpin 6Xe	ODX1-CD ROM Mode	PC-CD 160S
DISK/TREND GROUP	10	10	10	10	10
MARKET	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM	OEM, PCM	Captive
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI-2	IDE	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,CD-I		MS,PCD,XA,CD-I	MS, PCD, MPC-2	MS,PCD,XA,CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	680 Mode 2 F: 540 Mode 1	F: 540/680	680 Mode 2 F: 540 Mode 1	F: 650	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	2000-800	3180-1200	2120-800	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Gear Drive	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	130	193	127	180	225
Average rotational delay (msec)	15	27	18	15	55
Average access time (msec)	145	220	145	195	280
Data transfer rate (KBytes/sec)	900 (6X)	600 (4X)	900 (6X)	600 (4X) 5000 synch.	307.2 (2X)
Buffer/cache size (Kbytes)	256	256	256	256	
SIZE (mm: H x W x D)	42.8 x 149 x 219.7	76.2 x 175 x 331	76.2 x 175 x 331	41.3 x 146 x 196	77 x 178 x 321
FIRST CUSTOMER SHIPMENT	2Q95	4Q94	2Q95	4Q95	1Q94
COMMENTS		CDR-6014 is 4 drive stack	Caddy		Tray loading

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	PC-CD 170	PC-CD 170N	PC-CD 180	PC-CD 180X	PC-CD 60
DISK/TREND GROUP	10	10	10	10	10
MARKET	PCM	Captive	PCM	PCM	PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS, PCD, XA	MS,PCD,XA,CD-I	MS, PCD, XA	MS, PCD, XA	MS, PCD, XA
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1590-600	1590-600	2120-800	2120-800	1060-400
PERFORMANCE					
Positioner type	Linear	Linear, Voice Coil	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	195	250	180	230	330
Average rotational delay (msec)	37	55	27	27	55
Average access time (msec)	232	305	207	257	385
Data transfer rate (KBytes/sec)	460.8 (3X)	460.8 (3X)	600 (4X)	600 (4X)	300 (2X)
Buffer/cache size (Kbytes)	256	256	256	256	256
SIZE (mm: H x W x D)	77 x 178 x 324	177 x 178 x 324	79 x 185 x 371	42.8 x 149 x 210	77 x 178 x 321
FIRST CUSTOMER SHIPMENT	1994	1Q94	1994	1994	1994
COMMENTS	Tray loading	Top loading	Tray loading	Tray loading	Caddy

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	PC-CD 60D	PC-CD 60F	MMS-155 N1137-58	N1137-04 N7915-11 N7915-84 PC-0D102	N1137-57 N7915-85 0DD-155 PC-0D502
DISK/TREND GROUP	10	10	11	11	11
MARKET	PCM	PCM	PCM	Captive	Captive
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	130 mm	130 mm	130 mm
Recording technology	Replication	Replication	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	CD-ROM	CD-ROM	Rewritable	Rewritable	Rewritable
Interface	Proprietary	SCSI	SCSI	SCSI	SCSI
Compatibility	MS, PCD, XA	MS, PCD, XA	--		
Speed control & zones	CLV	CLV	ZCAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 2600	F: 305	F: 680/325
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: 17408	F: N/A
Data surfaces per spindle	1	1	4	1	1
Tracks per surface	20750	20750	21600*	18751	21600*
Track density (TPI)	15875	15875	18273	15375	18273
Maximum linear density (BPI)	27600	27600	29540	25000	29540
Rotational speed (RPM)	1060-400	1060-400	4200/3000	3000	4200/3000
PERFORMANCE					
Positioner type	Linear	Linear	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	330	330	32	60	32
Average rotational delay (msec)	55	55	7-10	10	10/7
Average access time (msec)	385	385	39-42	70	42/39
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	1940	1500	1940
Buffer/cache size (Kbytes)	256	256			
SIZE (mm: H x W x D)	42.8 x 149 x 208.5	49 x 133.5 x 213.7	180 x 227 x 552	130 x 170 x 280	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1994	1994	2Q93	1Q91	3Q93
COMMENTS	Tray loading	Tray loading	Incorporates 4 0DD-155 *37600 logical tracks		*37600 logical tracks 0DD-155 is external package

MANUFACTURER	NEC	NEC	NEC	NIKON	OLYMPUS
DRIVE	OD-1301	ODX1-PD Mode	N6513-23 N7913	DD121-1AJ DD121-1AS	230MO Plus* 230MO Turbo
DISK/TREND GROUP	11	11	12	12	11
MARKET	PCM	OEM, PCM	Captive	OEM	OEM, PCM
MEDIA: Disk diameter	130 mm	120 mm	300 mm	300 mm	86 mm
Recording technology	Magneto-Optic	Phase Change	Ablative	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Rewritable	Write Once	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	Prop., SCSI	SCSI-2	SCSI-2
Compatibility	--	--			
Speed control & zones	CAV	CAV	MCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 600/300	F: 668	F: 2500	F: 4000*	F: 230/128
Capacity per track (Bytes)	F: N/A	F: N/A	F: NS	F:102442/108222	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	27200	49000	41881/41196	11500
Track density (TPI)	18273	21167	16940	15875	18273
Maximum linear density (BPI)	29540	28400	25000	30600	29300
Rotational speed (RPM)	4200/3000	2026	600	1000	4200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Gear Drive	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	29	180	150	73	28
Average rotational delay (msec)	10/7	15	50	30	7.1
Average access time (msec)	39/36	195	200	103	35.1
Data transfer rate (KBytes/sec)		1141 RD/300 WR 5000 synch.	900	1770/2010	1075-1720/896
Buffer/cache size (Kbytes)	1000	256		256	1000*
SIZE (mm: H x W x D)	75 x 170 x 310	41.4 x 146 x 203		400 x 630 x 170	
FIRST CUSTOMER SHIPMENT		4Q95	6/90	1Q94	10/94
COMMENTS	*37600 logical tracks Externally packaged OD-155			*Sector size 512B/1024B AJ model is for optical library	*Includes cache

1995 DISK/TREND REPORT

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
DRIVE	CD-R2	MOS320E MOS320S MOS321E* MOS321S*	MOS500E MOS500D	MOS520E MOS520S	MOS525E
DISK/TREND GROUP	11	11	11	11	11
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm	86 mm	130 mm	130 mm	130 mm
Recording technology	Dye Polymer	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Write Once	Rewritable	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,CD-I				
Speed control & zones	CLV	CAV/ZCAV	CAV	CAV/ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 580/680	F: 230/128	F: 650	F: 650/325	F: 595/650*
Capacity per track (Bytes)	F: N/A	F: 12800	F: 17408	F: 17408	F: 17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	11500**	18751	18750*	21600**
Track density (TPI)	15875	18273	15875	18273/15875	18273
Maximum linear density (BPI)	27600	29300	24902	31005/27597	29540
Rotational speed (RPM)	1060-400	4500	3000	3000/4500	3500
PERFORMANCE					
Positioner type		Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	225	26	--	56/54	29
Average rotational delay (msec)	55	7.1	10	10/6.67	8.57
Average access time (msec)	280	33.1	--	66/60.67	37.57
Data transfer rate (KBytes/sec)	300 3000 synch.	1075-1840/896		1200-2300/1000	1750
Buffer/cache size (Kbytes)	1000	256*		1000**	1000***
SIZE (mm: H x W x D)	119 x 173 x 274.3	41.3 x 101.6 x 160	82.6 x 146.1 x 205	82.6 x 146.1 X 205	41.3 x 146.1 x 205
FIRST CUSTOMER SHIPMENT	2Q95	2Q94	1993	11/93	5/94
COMMENTS	Sold only in U.S.	*1 MB optional **17900 logical tracks	D version less controller Sold only in Japan	*37600 log.trks **4 MB optional S version is external mount. Sold only in Japan	***4 MB cache. Sold only in US *512/1024 byte sector. **37600 logical tracks

MANUFACTURER	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE
DRIVE	Dolphin 8000	Dolphin 8001	Stingray 8422	Stingray 8322	Stingray 8222
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, PCD, CD-I	MS, PCD, CD-I	MS, PCD, CD-I	MS, PCD, CD-I	MS, PCD, CD-I
Speed control & zones	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	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
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	4240-1600	3180-1200	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	310	265	196	192	203
Average rotational delay (msec)	55	55	14	18	27
Average access time (msec)	365	320	210	210	230
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	1200 (8X)	900 (6X)	600 (4X)
Buffer/cache size (Kbytes)	64	128	256	256	128
SIZE (mm: H x W x D)	41.3 x 146 x 210	41.3 x 146 x 210	41.3 x 146 x 210	41.3 x 146 x 210	41.3 x 146 x 210
FIRST CUSTOMER SHIPMENT	4Q93	2Q94	3Q95	2Q95	4Q94
COMMENTS	Purchased mechanism Tray loading	Purchased mechanism Tray loading	Purchased mechanism Tray loading	Purchased mechanism Tray loading	Purchased mechanism Tray loading

MANUFACTURER	PHILIPS	PHILIPS	PHILIPS	PHILIPS	PHILIPS
DRIVE	CDI 210 CDI 220	CDI 350	CDI 450 CDI 550	CDI 604	CDI 605T
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	Serial	Serial	Serial	Serial	Serial
Compatibility	CD-I	CD-I	CD-I	CD-I	CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-200	500-200	500-200	500-200	500-200
PERFORMANCE					
Positioner type	Rotary Galvonometer	Rotary Galvonometer	Rotary Galvonometer	Rotary Galvonometer	Rotary Galvonometer
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	790	800	790	800	800
Average rotational delay (msec)	110	110	110	110	110
Average access time (msec)	900	910	900	910	910
Data transfer rate (KBytes/sec)	153.6/175.2 (1X)	153.6/175.2 (1X)	153.6/175.2 (1X)	153.6/175.2 (1X)	153.6/175.2 (1X)
Buffer/cache size (Kbytes)					
SIZE (mm: H x W x D)	90 x 420 x 400	52 x 190 x 292	67 x 300 x 190	90 x 420 x 400	90 x 420 x 400
FIRST CUSTOMER SHIPMENT	3Q92	4/93	7/94	2/94	1/94
COMMENTS	Desktop CD-I player "Thumbstick" remote control	Portable CD-I player with LCD screen	Top loading External mount CD-I player	Tray loading	Tray loading

MANUFACTURER	PHILIPS	PHILIPS	PHILIPS	PHILIPS	PHILIPS
DRIVE	CM 206	CM 207	CM 405ABK CM 425ABK	CDD 2000	CDD 521
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Dye Polymer	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	Write Once	Write Once
Interface	IDE	IDE/ATAPI	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS, PCD	MS, PCD, MPC-2	MS, PCD	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I
Speed control & zones	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: 645	630 Mode 2 F: 550 Mode 1	635 Mode 2 F: 553 Mode 1
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)	1000-400	1000-400	1000-400	2160-400	1000-400*
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Worm Gear/Lead Screw		Linear, Worm Gear/Lead Screw	Linear, Worm Gear/Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	325	235	265	350	1055
Average rotational delay (msec)	55	55	55	27 RD/55 WR	55
Average access time (msec)	380	290	320	377 RD/405 WR	1110
Data transfer rate (KBytes/sec)	307.2 Mode 1 352.8 Mode 2	307.2 Mode 1 352.8 Mode 2	307.2 (2X)	600 RD/300 WR	307.2/153.6
Buffer/cache size (Kbytes)	64	256	64	1000	256
SIZE (mm: H x W x D)	41.5 x 146 x 208	41.5 x 146 x 208		41.5 x 146 x 206	118 x 420 x 334
FIRST CUSTOMER SHIPMENT	3Q93	2Q94	2Q93	2Q95	3/92
COMMENTS	Tray loading	Tray loading	425ABK is external mount	Tray loading	*500-200 with 153.6 KB data rate Tray loading External mount

MANUFACTURER	PHILIPS	PHILIPS LMS	PHILIPS LMS	PINNACLE MICRO	PINNACLE MICRO
DRIVE	CDD 522	LD 4100	LD 6100	RCD 1000	Sierra
DISK/TREND GROUP	11	12	12	11	11
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
MEDIA: Disk diameter	120 mm	300 mm	300 mm	120 mm	130 mm
Recording technology	Dye Polymer	Ablative	Ablative	Dye Polymer	Magneto-Optic
DRIVE: Operating mode	Write Once	Write Once	Write Once	Write Once	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,CD-I	--	--	MS,PCD,XA,CD-I	
Speed control & zones	CLV	CAV	CAV	CLV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	F: 5600	F: 12000	681 Mode 2 F: 580 Mode 1	F: 325/650 F: 325/650
Capacity per track (Bytes)	F: N/A	F: 49808	F: NS	F: N/A	F: 17408/NA
Data surfaces per spindle	1	2	2	1	1
Tracks per surface	20750	57301	63000	20750	37600/21600
Track density (TPI)	15875	16925-23132	NS	15875	18273
Maximum linear density (BPI)	27600	NS	NS	27600	28540
Rotational speed (RPM)	1000-400*	858	858	1060-400	4500/3000
PERFORMANCE					
Positioner type	Linear, Worm Gear/Lead Screw	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Sampled	Sampled	Continuous	Continuous
Average positioning time (msec)	1055	90	100	300	NA
Average rotational delay (msec)	55	35	35	55	6.6/10
Average access time (msec)	1110	125*	135	355	NA
Data transfer rate (KBytes/sec) -	307.2/153.6	800	2700 10000 synch.	300 (2X) 5000 synch.	2000 5000 synch.
Buffer/cache size (Kbytes)	2000-32000		2000	1000	
SIZE (mm: H x W x D)	110 x 420 x 334	118 x 475 x 653	178 x 475 x 683	60 x 200 x 255	93 x 186 x 254.2
FIRST CUSTOMER SHIPMENT	3Q94	2Q90	2Q95	1994	1993
COMMENTS	*500-200 with 153.6 KB data rate Tray loading External mount	*Includes command latency Dual head drive	Dual head drive	Purchased mechanism	Purchased mechanism

MANUFACTURER	PINNACLE MICRO	PINNACLE MICRO	PINNACLE MICRO	PIONEER	PIONEER
DRIVE	Apex	Apex (A/V)	ORRAY	DR-S104X DR-U104X	DR-U124X
DISK/TREND GROUP	12	12	12	10	10
MARKET	OEM	OEM	PCM	OEM, PCM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Replication	Replication
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Rewritable	CD-ROM	CD-ROM
Interface	SCSI-2/HPAC	SCSI-2/HPAC	SCSI-2	SCSI-2	SCSI-2
Compatibility					MS,PCD,XA,MPC-2
Speed control & zones	ZCAV	CLV	CAV/ZCAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 2301	F: 2697	F: 1300/2600	F: 540	F: 540
Capacity per track (Bytes)	F: 38912/88064	F: 45600/103300	F: 17408/NA	F: N/A	F: N/A
Data surfaces per spindle	1	1	4	1	1
Tracks per surface	36300 (user)	36300 (user)	37600/21600	20750	20750
Track density (TPI)	25400	25400	18273	15875	15875
Maximum linear density (BPI)	63342*	63342*	28540	27600	27600
Rotational speed (RPM)	3755	3755-5000	4500/3000	2120-800	2332-880
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	17	17	NA	190	110
Average rotational delay (msec)	8	7	6.6/10	55	24.5
Average access time (msec)	25	24	NA	245	134.5
Data transfer rate (KBytes/sec)	2498-5967	3800-5121	8000	614.4 (4X)	676 (4.4X)
Buffer/cache size (Kbytes)	1000	1000	9000-68000		128
SIZE (mm: H x W x D)	41.3 x 146 x 211.3	41.3 x 146 x 211.3	440 x 188 x 389	41.3 x 146 x 202	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	3Q95	3Q95	2Q94	3Q94	1Q95
COMMENTS	*1,7 RLL Code Direct overwrite Prelim. spec.	*1,7 RLL Code Direct overwrite Prelim. spec.	Purchased mechanism	DR-S104X is external model	

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
DRIVE	DR-UA124X	DRD-504X	DRM-1804X	DRM-624X	DE-SH7101 DE-UH7101
DISK/TREND GROUP	10	10	10	10	11
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Recording technology	Replication	Replication	Replication	Replication	Magneto-Optic
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Multifunct-(MO)
Interface	IDE/ATAPI		SCSI	SCSI-2	SCSI
Compatibility	MS,PCD,XA,MPC-2	MS, PCD, XA	MS, PCD	MS,PCD,XA,MPC-2	
Speed control & zones	CLV	CLV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 550	F: 540	F: 540	F: 327
Capacity per track (Bytes)	F: N/A	F: NA	F: N/A	F: N/A	F: 16384
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	19958
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	15875
Rotational speed (RPM)	2120-800	2120-800	2120-200	2332-880	1800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Sampled
Average positioning time (msec)	110	280	300	110	53.3
Average rotational delay (msec)	27	27	28	18.7	16.7
Average access time (msec)	137	307	328	128.7	70
Data transfer rate (KBytes/sec)	614.4 (4X)	614.4 (4X)	614.4 (4X)	614.4 (4X)	635
Buffer/cache size (Kbytes)	128	1000	256	128	
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	198 x 262 x 422	88.3 x 210 x 370	41.3 x 146 x 203.2
FIRST CUSTOMER SHIPMENT	2Q95	1Q95	1994	2Q95	2Q93
COMMENTS		For use with CD library	Integral with 18 disk changer		Multifunction

MANUFACTURER	PIONEER	PIONEER	PIONEER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
DRIVE	DR-504X	DW-S114X	DE-SH2200 DE-UH2200	PX 43CH 4 Plex	PX 43CS 4 Plex
DISK/TREND GROUP	11	11	12	10	10
MARKET	OEM, PCM	OEM	OEM, PCM	PCM	PCM
MEDIA: Disk diameter	120 mm	120 mm	130 mm	120 mm	120 mm
Recording technology	Dye Polymer	Dye Polymer		Replication	Replication
DRIVE: Operating mode	Write Once	Write Once	Rewritable	CD-ROM	CD-ROM
Interface		SCSI-2	SCSI	SCSI-2	SCSI-2
Compatibility	MS, PCD, XA	MS, PCD, XA	--	MS, PCD, CD-I	MS, PCD, CD-I
Speed control & zones	CLV	CLV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 550	F: 550	F: 1100	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	F: NA	F: NA	F:	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750		20750	20750
Track density (TPI)	15875	15875		15875	15875
Maximum linear density (BPI)	27600	27600		27600	27600
Rotational speed (RPM)	2120-800	2120-800		2120-800	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous		Continuous	Continuous
Average positioning time (msec)	110	110		193	133
Average rotational delay (msec)	27	27		27	27
Average access time (msec)	137	137		220	160
Data transfer rate (KBytes/sec)	614.4 (4X)	614.4 (4X)		600 (2X)	600 (4X) 2500 asynch.
Buffer/cache size (Kbytes)	1000	1000		1000	256
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	41 x 5.75 x 8	41.3 x 146.1 x 202	41.3 x 146.1 x 202
FIRST CUSTOMER SHIPMENT	1Q95	3Q95	1Q95	6/94	
COMMENTS	For use with CD library		DE-SH2200 is external mount		

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	RICOH
DRIVE	PX 45CH 4 Plex	PX 45CS 4 Plex	PX 63CS 6 Plex	PX 65CS 6 Plex	RI-600M/S
DISK/TREND GROUP	10	10	10	10	11
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Write Once
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS, PCD, CD-I	MS, PCD, CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	CD-I, XA
Speed control & zones	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	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	F: 780/600
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)	2120-800	2120-800	3180-1200	3180-1200	530-200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	193	133	127	127	390
Average rotational delay (msec)	27	27	18	18	110
Average access time (msec)	220	160	145	145	500
Data transfer rate (KBytes/sec)	600 (4X)	600 (4X) 2500 asynch.	922 (6X) 5000 synch.	922 (6X) 5000 synch.	150
Buffer/cache size (Kbytes)	1000	256	256	256	1200
SIZE (mm: H x W x D)	56.9 x 177.8 x 305.6	56.9 x 177.8 x 305.6	41.3 x 146.1 x 202	56.9 x 177.8 x 305.6	335 x 220 x 325*
FIRST CUSTOMER SHIPMENT	6/94		2Q95	6/95	4/94
COMMENTS	External mount	External mount		External mount	Subsystem-has 1 CD-ROM and 1-21 CD-R drives. *Minimum configuration

MANUFACTURER	RICOH	RICOH	RICOH	RICOH	RICOH
DRIVE	RO-1060C RS-1060C	RO-3012E RS-3102E Transporter 2	RO-3020E RS-3020E	RO-5031E RS-9200EX	RO-5060E RS-5060E
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM, PCM	OEM	OEM, PCM	OEM	Captive, OEM
MEDIA: Disk diameter	120 mm	86 mm	86 mm	130 mm	130 mm
Recording technology	Dye Polymer	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Write Once	Rewritable	Rewritable	Rewritable	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI-2
Compatibility	MS, PCD				
Speed control & zones	CLV	CAV	CAV/ZCAV	CAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 780/660	F: 127.4	F: 230	F: 297/326	F: 326.2/652.3
Capacity per track (Bytes)	F: N/A	F: 12740	F:	F: 15872/17408	F: 17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	10000	17940	18750	18751/21600*
Track density (TPI)	15875	15875	18273	15875	15900/18273
Maximum linear density (BPI)	27600	24440	29296	24923	24900/29540
Rotational speed (RPM)	1060-400	3000	3600	3600	4500/3000
PERFORMANCE					
Positioner type	Linear	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	300	45	40	29	29
Average rotational delay (msec)	35	10	8.3	8.3	6.7/10
Average access time (msec)	335	55	48.3	37.3	35.4/39
Data transfer rate (KBytes/sec)	300	640	5000 synch. 2500 asynch.	1250	5000 synch. 3300 asynch.
Buffer/cache size (Kbytes)	512	256	243	480	512
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 101.6 x 149.8	32 x 117 x 202	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q95	3/93	1Q95	4Q91	1Q94
COMMENTS	Caddy loading RS-1060C is external version	RS-3012E is external version	RS-3020E is external version	Embedded SCSI controller. Split optics. RS-9200EX is external version.	*37600 logical tracks

1995 DISK/TREND REPORT

MANUFACTURER	RICOH	RICOH	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SANYO ELECTRIC
DRIVE	RO-5061E	RS-9200CD	SCDR-530	SCR-630	CDR 254P
DISK/TREND GROUP	11	11	10	10	10
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Magneto-Optic	Dye Polymer	Replication	Replication	Replication
DRIVE: Operating mode	Rewritable	Write Once	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility		MS	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I
Speed control & zones	CAV/ZCAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 326/652	F: 650	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	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	1060-400	3120-800	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35.4	390	495	190	200
Average rotational delay (msec)	10	110	55	27	27
Average access time (msec)	45.4	500	550	227	227
Data transfer rate (KBytes/sec)	5000 synch. 3300 asynch.	150	300 (2X)	600 (4X)	600 (4X)
Buffer/cache size (Kbytes)		1200	256	256	256
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	125 x 210 x 310	42.5 x 148.5 x 203	42 x 148 x 215	41.5 x 146 x 210.3
FIRST CUSTOMER SHIPMENT	2Q94	1Q93	1994	3Q95	
COMMENTS	*37600 logical tracks	CD format	*MPC-2 compliant Tray loading	*MPC-2 compliant Tray loading	Tray loading

MANUFACTURER	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC
DRIVE	CDR 450P	CDR 93 CRD 400I	CDR H93 CRD 400E	CDR H94A	CDR H94S
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE	SCSI-2
Compatibility	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	1060-400	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	280	265	295	250	250
Average rotational delay (msec)	55	55	55	55	55
Average access time (msec)	335	320	350	305	305
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	300 (2X)	300 (2X)	300 (2X)
Buffer/cache size (Kbytes)	256	256	256	64	256
SIZE (mm: H x W x D)	41.5 x 146 x 210.3	41.5 x 146 x 210.3	48 x 140 x 255	42.3 x 146 x 208	42.3 x 146 x 208
FIRST CUSTOMER SHIPMENT		2Q94	3Q94		
COMMENTS	Tray loading	Tray loading CDR has PC AT interface	Top loading CDR has PC AT interface	Tray loading	Tray loading

MANUFACTURER	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC	SEIKO EPSON
DRIVE	CRD 244P	CRD 254S	MDT-8014	CRD-R24S	OMD 6020
DISK/TREND GROUP	10	10	10	11	11
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	86 mm
Recording technology	Replication	Replication	Replication	Dye Polymer	Magneto-Optic
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	Write Once	Rewritable
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS, PCD	MS, PCD, XA	
Speed control & zones	CLV	CLV	CLV	CLV	ZCAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	635 Mode 2 F: 553 Mode 1	F: 640	F: 230
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: 12800*
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	17853*
Track density (TPI)	15875	15875	15875	15875	18273
Maximum linear density (BPI)	27600	27600	27600	27600	29540**
Rotational speed (RPM)	2120-800	2120-800	1060-400	2120-800	3600
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	200	200	340	300	28
Average rotational delay (msec)	27	27	55	27	8.3
Average access time (msec)	227	227	395	327	36.3
Data transfer rate (KBytes/sec)	600 (4X)	600 (4X)	300 (2X)	600 (4X)	900-1440
Buffer/cache size (Kbytes)	256	256	256		500
SIZE (mm: H x W x D)	41.5 x 146 x 195	42.3 x 146 x 208	43 x 146 x 210	41.3 x 146 x 188.5	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT					4Q94
COMMENTS		Tray loading	Tray loading	Tray loading	*Logical tracks **2,7 RLL Code Split optics

MANUFACTURER	SHARP	SHARP	SHARP	SIERRA TECHNOLOGIES	SONY
DRIVE	PU-CDI	JY-750 JY-7500	JY-800 JY-8000***	525 GB+ 525 GBX2+	CDU-50E
DISK/TREND GROUP	10	11	11	11	10
MARKET	PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	80 mm	130 mm	130 mm	130 mm	120 mm
Recording technology	Replication	Magneto-Optic	Magneto-Optic	Ablative	Replication
DRIVE: Operating mode	CD-ROM	Multifunct-(MO)	Multifunct-(MO)	Write Once	CD-ROM
Interface	Proprietary	SCSI, SCSI-2	SCSI, SCSI-2	SCSI-2	IDE/ATAPI
Compatibility					MS,PCD,XA,MPC-2
Speed control & zones	CLV	CAV	CAV/ZCAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 200	F: 297/326*	F: 595/652*	F: 640	F: 540
Capacity per track (Bytes)	F: N/A	F: 17408	F: 17408	F: 20000	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	8750	18751	21600**	32000	20750
Track density (TPI)	15875	15875	18273	35000	15875
Maximum linear density (BPI)	27600	24944	29540	32000	27600
Rotational speed (RPM)	500-300	3000	3000	1800	1160-400
PERFORMANCE					
Positioner type	NS	Linear, Voice Coil	Linear, Voice Coil	Stepping Motor	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Sector	Continuous
Average positioning time (msec)	NS	40	39	90	135
Average rotational delay (msec)	NS	10	10	16.7	55
Average access time (msec)	NS	50	49	106.7	190
Data transfer rate (KBytes/sec)	NS	870.4 4000 synch.	2000 max. 5000 synch.	812.5	300 (2X)
Buffer/cache size (Kbytes)		256	1000		256
SIZE (mm: H x W x D)		41.3 x 146 x 203	41.3 x 146 x 203	82.6 x 146.1 x 208.2	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	1993	10/92	1Q94	4/88	1994
COMMENTS	Sold only in Japan for Electronic Organizer	*CCW compatible *512/1024 bytes per sector. JY-7500 is external mount	*512/1024 bytes per sector. **37600 logical tracks. ***External mnt Write cache	525 GBX2+ is external mount; dual drive available	Tray loading

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	CDU-76E CSD-760E	CDU-76S CSD-76S CSD-760S	CSD-7611M	DD-20 DD-22 Data Discman	DD-25
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive	PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	80 mm	80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	SCSI-2	SCSI-2	--	Proprietary
Compatibility	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,CD-I		--
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	635 Mode 2 F: 553 Mode 1	F: 184	F: 184
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: NA
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	9062	9062
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2320-800	2320-800	2120-800	500-300	
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, DC Motor	Linear	Linear, DC Motor	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	223	163	163	NS	NS
Average rotational delay (msec)	27	27	27	65	
Average access time (msec)	250	190	190	NS	NS
Data transfer rate (KBytes/sec)	600 (4X)	600 (4X)	600 (4X)	NS	NS
Buffer/cache size (Kbytes)	256	256	1000		
SIZE (mm: H x W x D)	41.4 x 146 x 203	41.4 x 146 x 203	70 x 210 x 293	40 x 166 x 113	41 x 166 x 113
FIRST CUSTOMER SHIPMENT	1995	1995	2Q95	1993	1994
COMMENTS	Tray loading	Tray loading	Tray loading External mount For Macintosh		

1995 DISK/TREND REPORT

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	DD-30 DD-30DBZ Data Discman	DD-55	DD-DR1 Data Discman	PRD-100 PRD-105SC	PRD-150
DISK/TREND GROUP	10	10	10	10	10
MARKET	Captive	Captive	Captive	PCM	PCM
MEDIA: Disk diameter	80 mm	80 mm	80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	RS232C	Proprietary	RS232C	Parallel Port	PCMCIA
Compatibility		--		MS ,PCD, MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 184	F: 184	F: 184	F: 540	F: 540
Capacity per track (Bytes)	F: N/A	F: NA	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	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	NS	NS		
Average rotational delay (msec)	65	65	65		
Average access time (msec)	NS	NS	NS		
Data transfer rate (KBytes/sec)	NS	NS		300 (2X)	300 (2X)
Buffer/cache size (Kbytes)					
SIZE (mm: H x W x D)	34 x 160 x 111	37 x 165 x 110	35 x 110 x 173		26.5 x 132.5 x 167.9
FIRST CUSTOMER SHIPMENT	1993	1994		3/95	7/95
COMMENTS				Preliminary specification	Preliminary specification

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	PRD-155SB	SCPH1000 Playstation	CDU-920S CSP-920S CSP-9211S Spressa 920	CDU-921S	CDW-900E
DISK/TREND GROUP	10	10	11	11	11
MARKET	PCM	OEM, PCM	OEM, PCM	OEM	Captive
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Dye Polymer	Dye Polymer	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	Write Once	Write Once	Write Once
Interface	PCMCIA	Proprietary	SCSI-2	SCSI-2	SCSI
Compatibility	MS, PCD, XA	--	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY Total capacity (Mbytes)	F: 540	650 Mode 2 F: 533 Mode 1	650 Mode 2 F: 533 Mode 1	650 Mode 2 F: 533 Mode 1	F: 680
Capacity per track (Bytes)	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	NS	1060-400	1060-400	1000-200
PERFORMANCE Positioner type	Linear, DC Motor	Linear, DC Motor	Linear	Linear	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		NS	245	245	NS
Average rotational delay (msec)	55	NS	55	55	NS
Average access time (msec)		NS	300	300	NS
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	300 (2X)	300 (2X)	150-300 (2X)
Buffer/cache size (Kbytes)	128		1000	1000	
SIZE (mm: H x W x D)	41.4 x 146 x 203	60 x 270 x 188	41.4 x 146.1 x 203.2	70 x 210 x 293	88 x 424 x 411
FIRST CUSTOMER SHIPMENT	7/95	4Q94	1Q95	1Q95	1992
COMMENTS			Caddy required CSP-9211S is external mount	External mount Caddy required	Sold only with mastering system

1995 DISK/TREND REPORT

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	HS-D650	MDH-10	MDM-111	MDMII-AI	RMO-S330
DISK/TREND GROUP	11	11	11	11	11
MARKET	OEM	PCM	PCM	PCM	PCM
MEDIA: Disk diameter	86 mm	64 mm	64 mm	64 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rd.Only,Rewrit.	Rd.Only,Rewrit.	Rd.Only,Rewrit.	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility		--		--	
Speed control & zones	ZCAV	CLV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 140	F: 140	F: 140	F: 128
Capacity per track (Bytes)	F: N/A	F: NA	F: NA	F: NA	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface		10000	10000	10000	10000
Track density (TPI)	21800	15875	15875	15875	15875
Maximum linear density (BPI)		39827	39827	39827	24420
Rotational speed (RPM)		940-422	940-422	940-422	1800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, DC Motor	Linear, Stepping Motor	Linear, Stepping Motor	Linear, Voice Coil
Servo type	Sampled	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		455	255	255	120
Average rotational delay (msec)		45	45	45	16.6
Average access time (msec)		500	300	300	136.6
Data transfer rate (KBytes/sec)	2000 max.	150 2500 asynch.	150 2500 synch.	150	375 4000 synch.
Buffer/cache size (Kbytes)					128
SIZE (mm: H x W x D)	25.4 x 101 x 146	25.4 x 101.6 x 149	25.4 x 101.6 x 149	25.4 x 101.6 x 149	52.4 x 160 x 240
FIRST CUSTOMER SHIPMENT	4Q95	3Q94	2Q94	1995	7/94
COMMENTS	Preliminary specification 680 nm laser			For IBM ThinkPad docking station	External subsystem

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	RMO-S570 SMO-S521	RMO-S580	SMO-531/81 SMO-F531	SMO-F331	WDD-530
DISK/TREND GROUP	11	11	11	11	12
MARKET	Captive,OEM,PCM	PCM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	86 mm	300 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Phase Change
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Write Once
Interface	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility		SMO-F521, F531	SMO-F521, S580		WDD600,WDD930**
Speed control & zones	ZCAV	CAV/ZCAV	CAV/ZCAV	CAV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 650	F: 650	F: 650	F: 128	F: 15000
Capacity per track (Bytes)	F: N/A	F: 17408	F: 17408	F: 12800	F: N/A
Data surfaces per spindle	1	1	1	1	2
Tracks per surface	21600*	21600*	21600*	10000	
Track density (TPI)	18273	18273	18273	15875	
Maximum linear density (BPI)	29540	29540	29540	24420	
Rotational speed (RPM)	3000	3600	3600	1800	920/920-440
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	40	39	39	120	150/600
Average rotational delay (msec)	10	8.3	8.3	16.6	32.6/44.1
Average access time (msec)	50	47.3	47.3	136.6	182.6/644.1
Data transfer rate (KBytes/sec)	1000-2000	1200-2400 5000 synch.	1200-2400 5000 synch.	375 4000 synch.	1300-2700 10000 synch.
Buffer/cache size (Kbytes)	1000	4000	4000	128	512*
SIZE (mm: H x W x D)	70 x 211 x 293	70 x 211 x 293	41.4 x 146 x 203.2	52.4 160 x 240	177 x 412 x 514
FIRST CUSTOMER SHIPMENT	2Q94	4/95	3/95	7/94	3Q95
COMMENTS	*37600 logical tracks	External mount *37600 logical tracks	531/81 used for optical library *37600 logical tracks		2 optical heads *Option to 16MB Includes read cache. **Option, CLV mode

MANUFACTURER	SONY	SONY	SONY	TEAC	TEAC
DRIVE	WDD-531	WDD-600	WDD-930-01 WDD-931	CD-40E	CD-40S
DISK/TREND GROUP	12	12	12	10	10
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA: Disk diameter	300 mm	300 mm	300 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Phase Change	Phase Change	Phase Change	Replication	Replication
DRIVE: Operating mode	Write Once	Write Once	Write Once	CD-ROM	CD-ROM
Interface	SCSI-2	SCSI	SCSI-2	IDE/ATAPI	SCSI-2
Compatibility	WDD600,WDD930**			MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	CAV/CLV	CAV/CLV	CAV/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 15000	F: 2182/3276	F: 2182/3276	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	F: N/A	F: N/A	F: N/A	F: N/A	F: N/A
Data surfaces per spindle	2	1	1	1	1
Tracks per surface		43750	43750	20750	20750
Track density (TPI)		15875	15875	15875	15875
Maximum linear density (BPI)		49874	49874	27600	27600
Rotational speed (RPM)	920/920-440	360-1440	540-2160	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	150/600	180/600	180/600	350	350
Average rotational delay (msec)	32.6/44.1	41/55	27/36.7	55	55
Average access time (msec)	182.6/644.1	221/455	207/636.7	405	405
Data transfer rate (KBytes/sec)	1300-2700 10000 synch.	600	900	300 (2X)	300 (2X)
Buffer/cache size (Kbytes)	512*	64	512*	64	128
SIZE (mm: H x W x D)	177 x 375 x 528	180 x 375 x 520*	180 x 480 x 540	19 x 131 x 140.5	19 x 131 x 145.2
FIRST CUSTOMER SHIPMENT	3Q95	3Q89	2Q92		
COMMENTS	2 optical heads *Option to 16MB Includes read cache **Option, CLV mode	Downward compatible with WDD-3000 *Drive unit only	Downward compatible with WDD-600 & WDD-3000 *Option to 4 MB	Tray loading For notebook computer	Tray loading For notebook computer

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	CD-44E	CD-44S	CD-55A	CD-55E	CD-56E
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE/ATAPI	SCSI-2	IDE	IDE/ATAPI	IDE/ATAPI
Compatibility	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	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	635 Mode 2 F: 553 Mode 1	F: 635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
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)	2120-800	2120-800	2120-800	2120-800	3180-1200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	350	350	195	165	110
Average rotational delay (msec)	27	27	27	27	18
Average access time (msec)	377	377	222	192	128
Data transfer rate (KBytes/sec)	600 (4X)	600 (4X)	600 (2X)	600 (4X)	900 (6X)
Buffer/cache size (Kbytes)	128	128	64	128	256
SIZE (mm: H x W x D)	17 x 131 x 140.5	17 x 131 x 140.5	25.4 x 146 x 203	25.4 x 146 x 203	41.3 x 146 x 192
FIRST CUSTOMER SHIPMENT	3Q95	3Q95	4Q94	4Q94	3Q95
COMMENTS	For notebook computer	For notebook computer	Tray loading	Tray loading	Tray loading

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TOSHIBA
DRIVE	CD-56S	CF-506A	OD 3000	OD 5000	TXM-3501A4
DISK/TREND GROUP	10	10	11	11	10
MARKET	OEM	OEM, PCM	PCM	PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	86 mm	86 mm	120 mm/80 mm
Recording technology	Replication	Replication	Magneto-optic	Magneto-optic	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	Rewritable	Rewritable	CD-ROM
Interface	SCSI-2		SCSI-2	SCSI-2	SCSI-2
Compatibility	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2			MPC-2
Speed control & zones	CLV	CLV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	635 Mode 2 F: 553 Mode 1	F: 128	F: 128	F: 540
Capacity per track (Bytes)	F: N/A	F: N/A	F: 12800	F: 12800	F: N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	10000	10000	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	24423	24423	25400
Rotational speed (RPM)	3180-1200	2120-800	3000	3000	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Rack & Pinion
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	110	195	42	42	120
Average rotational delay (msec)	18	27	10	10	30
Average access time (msec)	128	222	52	52	150
Data transfer rate (KBytes/sec)	900 (6X)	600 (4X)	640	640	600 (4X) 4200 synch.
Buffer/cache size (Kbytes)	256		128	128	256
SIZE (mm: H x W x D)	41.3 x 146 x 192		41.5 x 101.6 x 146	41.5 x 101.6 x 153.5	317.5 x 190.5 x 317.5
FIRST CUSTOMER SHIPMENT	3Q95		4Q91	2Q93	4Q94
COMMENTS	Tray loading	Packaged with 3.5" 2 MB floppy drive			4 drive subsystem

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	TXM-3501E XM-3501B	TXM-4101L XM-4101B	TXM-5201D XM-5201B	XM-1102B	XM-3601B
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2
Compatibility	MPC-2	MPC-2	MPC-2	MS, PCD, MPC-2	PCD, MPC-2, XA
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1
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	21250	21250	21250	21250
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	25400	25400	25400	25400	25400
Rotational speed (RPM)	2120-800	1060-400	1800-680	1060-400	2332-880
PERFORMANCE					
Positioner type	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Lead Screw	Linear, Rack & Pinion
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	120	330	150	210	120
Average rotational delay (msec)	30	50	40	55	20
Average access time (msec)	150	385	190	265	140
Data transfer rate (KBytes/sec)	600 (4X) 4200 synch.	300 (2X)	510 (3-4X)	300 (2X)	660 (4.4X) 4200 synch.
Buffer/cache size (Kbytes)	256	64	64	128	256
SIZE (mm: H x W x D)	41.5 x 146 x 203	25.4 x 146 x 190	41.5 x 146 x 190	17 x 128.8 x 140.6	41.5 x 146 x 196
FIRST CUSTOMER SHIPMENT	4Q94	4Q93	4Q94	1Q95	1Q95
COMMENTS	XM-3501E is external version	TXM-4101L is external mount	5201D is external mount Tray loading	Tray loading	Tray loading

MANUFACTURER	TOSHIBA	TOSHIBA	TXC	TXC	TXC
DRIVE	XM-5301B	XM-5302B	CD-1000	CD-1400	TXCD-A4
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	SCSI-2	IDE/ATAPI	PCMCIA	PCMCIA	IDE
Compatibility	MS,PCD,MPC-2,CD	MS, PCD, MPC-2	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 540 Mode 1	F: 540	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 540 Mode 1
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	21250	21250	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	25400	25400	27600	27600	27600
Rotational speed (RPM)	2120-800	2120-800	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	150	150	295	208	195
Average rotational delay (msec)	40	40	55	27	55
Average access time (msec)	190	190	350	235	250
Data transfer rate (KBytes/sec)	600 (4X)	600 (4X)	300 (2X)	600 (4X)	300 (2X)
Buffer/cache size (Kbytes)	256	256	128	256	64
SIZE (mm: H x W x D)	41.5 x 146 x 190	41.3 x 144.8 x 190.5	55 x 136 x 175		42.5 x 146 x 216.5
FIRST CUSTOMER SHIPMENT	2Q95	1Q95	3Q94	4Q94	1Q94
COMMENTS	Tray loading	Tray loading	Top loading Philips mechanism	Top loading Philips mechanism	Tray loading Philips mechanism

MANUFACTURER	TXC	TXC	TXC	UMAX DATA SYSTEMS	UMAX DATA SYSTEMS
DRIVE	TXCD-I1	TXCD-PCM1	TXCD-PCM3	CD-AS201	CD-IS201
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE	PCMCIA	PCMCIA	IDE	IDE/ATAPI
Compatibility	MS, PCD	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*
Speed control & zones	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	635 Mode 2 F: 553 Mode 1	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1
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	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	195	295	295	295	295
Average rotational delay (msec)	55	55	55	55	55
Average access time (msec)	250	350	350	350	350
Data transfer rate (KBytes/sec)	300 (2X)	300 (2X)	300 (2X)	300 (2X)	300 (2X)
Buffer/cache size (Kbytes)	64	64	128		
SIZE (mm: H x W x D)	42.5 x 146 x 216.5	42.5 x 146 x 216.5	42.5 x 146 x 216.5	43 x 151 x 210	43 x 151 x 210
FIRST CUSTOMER SHIPMENT	3Q94	2Q94	3Q94	4Q94	1Q95
COMMENTS	Tray loading Philips mechanism	Tray loading Philips mechanism	Tray loading Philips mechanism	*MPC-2 compliant Philips mechanism	*MPC-2 compliant Philips mechanism

MANUFACTURER	UMAX DATA SYSTEMS	WEARNES TECHNOLOGY	WEARNES TECHNOLOGY	WEARNES TECHNOLOGY	WEARNES TECHNOLOGY
DRIVE	CD-IS401	CDD-120X	CDD-220	CDD-320	ECD-120X
DISK/TREND GROUP	10	10	10	10	10
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Interface	IDE	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*	MS,PCD,XA,CD-I*	MS,PCD,XA,MPC-2	MS,PCD,XA,MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	630 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
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)	2120-800	1060-400	2120-800	3180-1200	1060-400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	200	250	185	190	250
Average rotational delay (msec)	27	55	27	18	55
Average access time (msec)	227	305	212	208	305
Data transfer rate (KBytes/sec)	600 (4X)	300 (2X)	600 (4X)	900 (6X)	300 (2X)
Buffer/cache size (Kbytes)		128	128	256	128
SIZE (mm: H x W x D)		41.5 x 146 x 208	41.5 x 146 x 208	41.5 x 146 x 208	48.3 x 173 x 234
FIRST CUSTOMER SHIPMENT	3Q95	1Q94	3Q94	3Q95	1Q94
COMMENTS	*MPC-2 compliant Philips mechanism	Tray loading *MPC-2 compliant	Tray loading *MPC-2 compliant	Tray loading	Tray loading External

MANUFACTURER	YAMAHA	YAMAHA	YAMAHA	YUNG FU (LXYCON)	YUNG FU (LXYCON)
DRIVE	CDE-100 CDE-100 H10	CDE-100II	CDR-100	CDE-300	CDM-420
DISK/TREND GROUP	11	11	11	10	10
MARKET	OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Replication	Replication
DRIVE: Operating mode	Write Once	Write Once	Write Once	CD-ROM	CD-ROM
Interface	SCSI-2	SCSI-2	SCSI-2	Parallel Port	IDE/ATAPI
Compatibility				MS,PCD,XA,CD-I	MS,PCD,XA,CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	661 Mode 2 F: 580 Mode 1	661 Mode 2 F: 580 Mode 1	661 Mode 2 F: 580 Mode 1	F: 635	F: 635
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)	29870	29870	29870	27600	27600
Rotational speed (RPM)	2000-800	2000-800	2000-800	1060-400	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	
Average positioning time (msec)	NS	NS	NS	270	180
Average rotational delay (msec)	NS	NS	NS	55	27
Average access time (msec)	500	500	500	325	207
Data transfer rate (KBytes/sec)	614/307/153 3000 asynch.	614/307/153 3000 asynch.	614/307/153 3000 asynch.	300 (2X)	600 (4X)
Buffer/cache size (Kbytes)	512	512	512		
SIZE (mm: H x W x D)	114 x 180 x 333	61.7 x 170 x 315	41.3 x 146 x 203	60 x 170 x 265	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	1Q94	3Q95	1Q94	4Q94	3Q95
COMMENTS	H10 includes 1 GB HDD External mount Caddy loading	External mount Caddy loading Cost reduced CDE-100	Caddy loading	Tray loading External mount	Tray loading *MPC-2 compliant

1995 DISK/TREND REPORT

OPTICAL LIBRARY SPECIFICATIONS

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

Drive type: Drives are indicated as write once, rewritable or multifunction. Rewritable drives use magneto-optic technology unless otherwise indicated. Drives characterized as "Multifunction" handle write once or rewritable media. Multifunction drives operating with phase change media are indicated as "Multifunction-(PC)". Where the drive is a magneto-optic type and supports multifunctionality using MO-WORM (CCW) media, the designation "Multifunction-(MO)" is used. CD-ROM format libraries may have CD-ROM drives, CD-R drives or both.

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

1995 DISK/TREND optical disk product groups

For the 1995 report, products are classified in seven 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 format 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 more cartridge capacity.

See the previous specification section for optical disk drive data.

MANUFACTURER	AISIN SEIKI	AIWA	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY
LIBRARY	JC2000	ACD-630	Rotostar CD 252 Rotostar CD 262	Rotostar CD 452	Rotostar CD 462
DISK/TREND GROUP	51	50	50	50	50
MARKET	OEM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	600-650	540	540	540	540
Cartridge type	ANSI/ISO	None	Caddy	Caddy	Caddy
DRIVE: Type	Wr.Once,Rewrit.	CD-ROM	CD-R	CD-ROM	CD-ROM
Drive models	Various	Aiwa	JVC, Yamaha, Ricoh	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	20	1	52	52	62
Maximum disk capacity (units)	20	3	62	52	62
Number of drives: Maximum	2	1	2	4	4
Interface: Library Drive	SCSI, RS232C Drive dependent	SCSI-2 SCSI-2	RS232 SCSI	RS232 SCSI	RS232 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	12-13	1.8	33.5	28.1	33.5
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Rotary	Rotary	Rotary	Rotary
Pickers per positioner	1	N/A	1	1	1
Average media exchange time (sec)	5	2	8	8	8
Spin-up + drive ready time (sec)	Drive dependent	2	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	1	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	200	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	Drive dependent	3	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	Drive dependent	600	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	1 or 2	1	2	2	2
FIRST CUSTOMER SHIPMENT	2Q88	1995	2Q94	2Q94	2Q94
COMMENTS		Preliminary specification External mount CD-ROM/audio player	Mini silo Can be expanded to 124 disks	Mini silo Can be expanded to 104 disks	Mini silo Can be expanded to 124 disks

MANUFACTURER	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY	AMBER TECHNOLOGY
LIBRARY	Rotostar CD 742	Rotostar 121	Rotostar 242	Rotostar 252	Rotostar 262
DISK/TREND GROUP	50	51	52	52	52
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	540	1300	512	650/1000/1300	1300
Cartridge type	Caddy	ISO	ISO	ISO	ISO
DRIVE: Type	CD-ROM	Wr.Once,Rewrit.	Rewritable	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Various	Pansonic, Sony SMO F521	Canon	Panasonic, H-P	Sony SMO F521
LIBRARY MECHANISM					
Minimum disk capacity (units)	42	21	42	52	62
Maximum disk capacity (units)	42	21	42	52	62
Number of drives: Maximum	7	1	2	2	2
Interface: Library	RS232	RS232	RS232	RS232	RS232
Drive	SCSI	SCSI	SCSI	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	22.7	27.3	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	6	8	8	8
Spin-up + drive ready time (sec)	Drive dependent	2.5	2.5	Drive dependent	2.5
Spin-down time (sec)	Drive dependent	2	2	Drive dependent	2
Average drive access time (msec)	Drive dependent	30	90	Drive dependent	50
Non-queued access time (sec)	Drive dependent	5.5	6.5	Drive dependent	6.5
Drive data transfer rate (KB/s)	Drive dependent	2500	1138	Drive dependent	2000
Number of drive data paths: Max.	2	1	2	2	2
FIRST CUSTOMER SHIPMENT	2Q94	3Q94	2Q94	1993	2Q94
COMMENTS	Mini silo Can be expanded to 84 disks	Mini silo	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	AMBER TECHNOLOGY	ASACA	ASM	ASM	ASM
LIBRARY	Rotostar 452	ADL-450	CDR 100	CDR 1000	CDR 1100
DISK/TREND GROUP	52	53	50	50	50
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	1300	1200*/1300	540	540	540
Cartridge type	ISO	ANSI/ISO	Caddy	Caddy	Caddy
DRIVE: Type	Wr.Once,Rewrit.	Rewritable	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Panasonic, Sony SMO F521	AMD-1341NS* H-P C1716T	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	52	450	100	152	212
Maximum disk capacity (units)	52	626	100	168	228
Number of drives: Maximum	4	24/4*	2	6	8
Interface: Library Drive	RS232 SCSI	RS232C, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	67.6	814	54	90.7	123
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Rotary	X-Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	2	1	2	2
Average media exchange time (sec)	8	15		6	
Spin-up + drive ready time (sec)	2.5	6*/2.8	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	2	3*/1.4	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	30	130*/31.8	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	6.5	13.5*/10.3	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	2500	12240*/1600	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	4	4*/24	2	2	2
FIRST CUSTOMER SHIPMENT	3Q94	2Q94			
COMMENTS	Mini silo	*With Asaca 1341NS drive			

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
LIBRARY	CDR 1200	CDR 1300	CDR 1400	CDR 200	CDR 300
DISK/TREND GROUP	50	50	50	50	50
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
Nominal disk capacity (MB)	540	540	540	540	540
Cartridge type	Caddy	Caddy	Caddy	Caddy	Caddy
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	643	965	1394	200	300
Maximum disk capacity (units)	667	1037	1514	200	300
Number of drives: Maximum	16	27	42	4	6
Interface: Library Drive	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	360	560	818	108	166
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	1	1
Average media exchange time (sec)			10		
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.	2-3	2-5	2-7	2	2
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	ASM	ASM	ASM	ASM	ATG CYGNET
LIBRARY	CDR 40	CDR 500	CDR 80	CDR 900	Cygnature
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	540	540	540	540	650
Cartridge type	Caddy	Caddy	Caddy	Caddy	Caddy
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	40	500	72	72	252
Maximum disk capacity (units)	44	500	84	80	1544
Number of drives: Maximum	2	10	4	4	28
Interface: Library Drive	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	23.8	270	45.4	43.2	1000
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	2	1*
Average media exchange time (sec)					11.5, 7.5*
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	7.5
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	2	2-3	2	2	4
FIRST CUSTOMER SHIPMENT					1Q96
COMMENTS					*Dual positioners optional

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
LIBRARY	1602	ASM-123W	ASM-149M	ASM-176M	ASM-224W
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	Drive dependent	5600/12000	6800	8000	10200
Cartridge type	Drive dependent	Philips LMS	Nikon	Nikon	ATG Cygnet
DRIVE: Type	Wr.Once,Rewrit.	Write Once	Rewritable	Rewritable	Write Once
Drive models	ATG, LMS, Sony, Nikon	LD 4100	DD121-1AJ	DD121-1AJ	GD 9001/S
LIBRARY MECHANISM					
Minimum disk capacity (units)	29	22	22	22	22
Maximum disk capacity (units)	29	22	22	22	22
Number of drives: Maximum	2	2	2	2	2
Interface: Library Drive	RS232C, SCSI-2 SCSI	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	295*/232**	123.2	149	176	224.4
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	6.5	7.2	8	8	7.2
Spin-up + drive ready time (sec)	Drive dependent	3.5	4	4	2.6
Spin-down time (sec)	Drive dependent	1.5	2.2	2.2	2
Average drive access time (msec)	Drive dependent	115	76	76	116
Non-queued access time (sec)	Drive dependent	7.1	8	8	7.1
Drive data transfer rate (KB/s)	Drive dependent	1000	1100	1100	1500
Number of drive data paths: Max.	2	2 (1 per drive)	2 (1 per drive)	2 (1 per drive)	2 (1 per drive)
FIRST CUSTOMER SHIPMENT	10/91	2Q94	1994	2Q94	2Q94
COMMENTS	*With ATG drive **With Nikon 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	5600/12000	8000
Cartridge type	Proprietary	ATG	Hitachi	LMSI	Nikon
DRIVE: Type	Write Once	Write Once	Write Once	Write Once	Rewritable
Drive models	GD 6001 GD 9001 GD 9001S	ATG GD 9001S	Hitachi OD 321	Philips LMS4100 Philips LMS6100	Nikon DD121-1AJ
LIBRARY MECHANISM					
Minimum disk capacity (units)	6	61	61	61	61
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	789.6/1692	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 1802, 1803

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	BORETT AUTOMATION TECHNOLOGIES	BORETT AUTOMATION TECHNOLOGIES
LIBRARY	1800/S2	CASS	Cygnature	MMAS (CD)	MMAS (12")
DISK/TREND GROUP	53	53	53	50	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	130 mm	120 mm	12"
Nominal disk capacity (MB)	6550/15000	10200	1300	600	Drive dependent
Cartridge type	Sony	ATG Cygnet	ISO	Caddy/None	Any
DRIVE: Type	Write Once	Write Once	Multifunct-(MO)	CD-ROM, CD-R	Wr.Once,Rewrit.
Drive models	Sony WDD 930 Sony WDD 531	ATG GD 9001S	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	61	111	184	100	128
Maximum disk capacity (units)	141	131	1544	7000/16000**	1792
Number of drives: Maximum	5	4	14	100	28
Interface: Library Drive	RS232C SCSI-2	IBM channel --	SCSI-2 SCSI-2	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	923/2115	1132	2000	4570*/14784	17920
Import/export module (disks)	1		1	1/100	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	Rotary* Industrial Robot	Rotary* Industrial Robot
Pickers per positioner	2	2	1*	1, 2	1, 2
Average media exchange time (sec)	8	7.2	11.5, 7.5*	10	10
Spin-up + drive ready time (sec)	2.4	2.6	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	1.2	2	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	207	116	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	6.4	7.1	7.5	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	900	1500	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	5 (1 per drive)	4 (1 per drive)	2	NS	NS
FIRST CUSTOMER SHIPMENT	3Q93	1995	4Q95	--	--
COMMENTS	Includes model 1802 and 1803 assemblies	ESCON option	Also accommodates DLT or 3480/90 tape drives. *Dual positioners optional	Can mix media types. *Can slide on track. **Multiple stations	Can mix media types *Can slide on track

MANUFACTURER	BORETT AUTOMATION TECHNOLOGIES	CD INTERNATIONAL	CD INTERNATIONAL	DISC	DISC
LIBRARY	MMAS (5.25")	CDJ2800	CDJ2801	D300	D600
DISK/TREND GROUP	53	50	50	50	50
MARKET	OEM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	1300	650	650	640	640
Cartridge type	Any	N/A	N/A	Caddy	Caddy
DRIVE: Type	Wr.Once,Rewrit.	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R	CD-ROM, CD-R*
Drive models	Various	Includes 4 Nakamichi mechanisms	Includes 4 Nakamichi mechanisms	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	288	28	28	249	498
Maximum disk capacity (units)	8064	28	28	361	722
Number of drives: Maximum	100	4	4	18	36
Interface: Library Drive	RS232C, SCSI-2 SCSI	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	16934	18.7	18.7	235	469
Import/export module (disks)	1	1	1	1	2
PERFORMANCE					
Positioner type	Rotary* Industrial Robot	Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1, 2	1	1	2	2
Average media exchange time (sec)	10	3	3	7	7
Spin-up + drive ready time (sec)	Drive dependent	2	2	1-3	1-3
Spin-down time (sec)	Drive dependent	1	1	2-3	2-3
Average drive access time (msec)	Drive dependent	200	200	150	150
Non-queued access time (sec)	Drive dependent	5.2	5.2	8	8
Drive data transfer rate (KB/s)	Drive dependent	600	600	600	600
Number of drive data paths: Max.	NS	1	1	2-18	4-36
FIRST CUSTOMER SHIPMENT	--	2Q95	2Q95	7/94	7/94
COMMENTS	Can mix media types *Can slide on track	Includes 1 GB rigid disk drive	Includes 1 GB rigid disk drive		*Can mix CD ROM and 5.25" drives plus media in library

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
LIBRARY	D630	D1260	D255-1	D350-1	D510-2
DISK/TREND GROUP	50	50	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	640	640	650/1300	650/1300	650/1300
Cartridge type	Caddy	Caddy	Drive dependent	Drive dependent	Drive dependent
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R*	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	585	1170	227	300	454
Maximum disk capacity (units)	739	1478	257	350	514
Number of drives: Maximum	24	48	4	6	8
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)	480	961	295-334	390-455	590-668
Import/export module (disks)	1	2	1	1	2
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)	1-3	1-3	2-3	2-3	2-3
Spin-down time (sec)	2-3	2-3	2-3	2-3	2-3
Average drive access time (msec)	150	150	19-35	19-35	19-35
Non-queued access time (sec)	8	8	8	8	8
Drive data transfer rate (KB/s)	600	600	1800	1800	1800
Number of drive data paths: Max.	2-24	4-48	1-4	1-6	2-8
FIRST CUSTOMER SHIPMENT	7/94	7/94	12/91	5/92	5/92
COMMENTS		*Can mix CD ROM and 5.25" drives plus media in library	Custom configurations available	Custom configurations available	Custom configurations available

MANUFACTURER	DISC	DISC	DISC	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	D525-1	D700-2	D1050-2	CDR 40 CDR 51 TERASTORE	CDR 53 CDR 55 TERASTORE
DISK/TREND GROUP	53	53	53	50	50
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	650/1300	650/1300	650/1300	600 (Mode 1)	600 (Mode 1)
Cartridge type	Drive dependent	Drive dependent	Drive dependent	Caddy	Caddy
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	457	600	914	28 (CDR 40)	142 (CDR 53)
Maximum disk capacity (units)	527	700	1054	54 (CDR 51)	179 (CDR 55)
Number of drives: Maximum	8	12	16	2	6
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	RS232C SCSI	RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	594-685	910	1188-1370	42.8	121.7
Import/export module (disks)	1	2	2	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7	7	7	3	6.5
Spin-up + drive ready time (sec)	2-3	2-3	2-3	Drive dependent	Drive dependent
Spin-down time (sec)	2-3	2-3	2-3	Drive dependent	Drive dependent
Average drive access time (msec)	19-35	19-35	19-35	Drive dependent	Drive dependent
Non-queued access time (sec)	8	8	8	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	1800	1800	1800	Drive dependent	Drive dependent
Number of drive data paths: Max.	1-8	2-12	2-16	1-2	2-8
FIRST CUSTOMER SHIPMENT	5/92	5/92	5/92	1/94	7/94
COMMENTS	Custom configurations available	Scalable and upgradable Compatible with most 5.25" optical drives	Custom configurations available		

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	CDR 71 CDR 72 CDR 73 CDR 74 TERASTORE	28 28-U TERASTORE	4000 5100 TERASTORE	48 TERASTORE	100-2000 TERASTORE
DISK/TREND GROUP	50	51	51	52	53
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	12"	130 mm	12"	12"
Nominal disk capacity (MB)	600 (Mode 1)	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Cartridge type	Caddy	Proprietary	ANSI/ISO	Proprietary	Proprietary
DRIVE: Type	CD-ROM, CD-R	Write Once	Wr.Once,Rewrit.	Write Once	Write Once
Drive models	Various	ATG, Optimem Sony, Toshiba, LMSI 4100	Various	ATG Gigadisc, Optim.,LMSI4100 Sony WDD600	ATG, Optimem, Sony, Hitachi, LMSI, Toshiba
LIBRARY MECHANISM					
Minimum disk capacity (units)	273 (CDR 77)	28	24 (4000)	48	54
Maximum disk capacity (units)	7435 (CDR 74)	28	54 (5100)	48	2380
Number of drives: Maximum	2	2	2*	2	120
Interface: Library Drive	RS232C SCSI	RS232C SCSI	RS232C SCSI	RS232C SCSI	RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	976	Drive dependent	Drive dependent	Drive dependent	Drive dependent
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)	4-6	6	3	7	8-12
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	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.	2	2	1-2	2	Variable
FIRST CUSTOMER SHIPMENT	2/95	11/89	4/92	11/89	9/87
COMMENTS		Model 28-U is upgradable to model 48	*Option up to 5 drives		

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DYNATEK AUTOMATION	EASTMAN KODAK	EASTMAN KODAK
LIBRARY	5300 5500 TERASTORE	7100 7200 7300 7400 TERASTORE	InfiniDISC	CD ADL-150	PCD Jukebox 100
DISK/TREND GROUP	53	53	50	50	50
MARKET	OEM	OEM	OEM		
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	Drive dependent	Drive dependent	650	600	600
Cartridge type	ANSI/ISO	ASI/ISO	None	None	None
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	CD-ROM	CD-ROM	CD-ROM
Drive models	Various	Various	Various	Toshiba	Toshiba
LIBRARY MECHANISM					
Minimum disk capacity (units)	96 (5300)	234 (7700)	250	50	50
Maximum disk capacity (units)	179 (5500)	1435 (7400)	2750	150	100
Number of drives: Maximum	6	42	44*	1	4
Interface: Library Drive	RS232C SCSI	RS232C SCSI	SCSI-2 SCSI-2	RS232 SCSI	RS232 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	1780		
Import/export module (disks)	1	1	1/250	1/50	1/50
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Rotary	Y axis	Y axis
Pickers per positioner	2	2	1	1	
Average media exchange time (sec)	6.5	4-6	7	4	6
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	2	2
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	1	1
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent		
Non-queued access time (sec)	Drive dependent	Drive dependent	Drive dependent	4	5
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	600 (4X)	300 (2X)
Number of drive data paths: Max.	2 to 8	2 to 8	1-7	1	1
FIRST CUSTOMER SHIPMENT	11/89	3/93	4Q95	2Q95	
COMMENTS			*4 CD-ROM or 2 CD-ROM per 250 disk module	NSM mechanism	NSM mechanism

MANUFACTURER	EASTMAN KODAK	EASTMAN KODAK	FILENET	FILENET	FILENET
LIBRARY	560E	2000 ADL+	Model 0140 OSAR GTX	Model 0150 OSAR 107/144 GT	Model 0161 OSAR 288 X
DISK/TREND GROUP	52	53	53	53	53
MARKET	Captive,OEM,PCM	Captive, OEM	Captive, OEM	Captive,OEM,PCM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	14"	12"	12"	12"
Nominal disk capacity (MB)	654/1300	14824	7000	12000	7000
Cartridge type	Various	ANSI/ISO	Hitachi	LMSI	Hitachi
DRIVE: Type	Wr.Once,Rewrit.	Write Once	Write Once	Write Once	Write Once
Drive models	Various	2000	Hitachi OD 301	LMSI LD 6100	Hitachi OD 321
LIBRARY MECHANISM					
Minimum disk capacity (units)	18	25	96	107	288
Maximum disk capacity (units)	60(with 1 drv.)	134	125	144	288
Number of drives: Maximum	5	2	6	6	4
Interface: Library Drive	RS232C, SCSI-2 SCSI-2	SCSI-2, RS232 SCSI-2	RS232, RS422 SCSI	RS232, RS422 SCSI-2	RS232, RS422 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	78	1983	875	1728	2016
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	2	2	2
Average media exchange time (sec)	6-8	6.5	4.0	4.0	8.3
Spin-up + drive ready time (sec)	Drive dependent	2.5	3.0	3.0	3.0
Spin-down time (sec)	Drive dependent	1.5	2.5	1.5	2.5
Average drive access time (msec)	Drive dependent	170	150	130	150
Non-queued access time (sec)	Drive dependent	6.1	6.0	6.0	9.5
Drive data transfer rate (KB/s)	Drive dependent	1000	4000	4000	4000
Number of drive data paths: Max.	5	2	6	6	4
FIRST CUSTOMER SHIPMENT	3Q92	3Q94	6/91	3/91	7/91
COMMENTS		Expandable in modules of 25 disks Depopulated versions available	Maximum capacity with 2 drives	Maximum capacity with 2 drives	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
LIBRARY	M2522/AX	M2531A	M2531B	F6445/A1 M255X/A1	F6445/A2 M255X/A2
DISK/TREND GROUP	51	51	51	53	53
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	86 mm	86 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	230	230	644	644
Cartridge type	ANSI/ISO	ISO	ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	M2504B	M2512	M2512	M2507L	M2507L
LIBRARY MECHANISM					
Minimum disk capacity (units)	28	35	35	390	780
Maximum disk capacity (units)	28	35	35	390	780
Number of drives: Maximum	2	2	2	6	11
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*
Library capacity (Gbytes) (with maximum disk capacity)	36	8.1	8.1	251.2	502.3
Import/export module (disks)	1	35	35	10/10	10/10
PERFORMANCE					
Positioner type	Y axis	X axis	X axis	Rotary Drum Y axis picker	Rotary Drum (2) 2 Y axis picker
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	5	5	10	10
Spin-up + drive ready time (sec)	5.5	5	5	5.5	5.5
Spin-down time (sec)	3.5	4	4	4.5	4.5
Average drive access time (msec)	40	35	35	40.6	40.6
Non-queued access time (sec)	9.5	7.4	7.4	10.5	10.5
Drive data transfer rate (KB/s)	1000-2000	1300-2100	1300-3100	2080	2080
Number of drive data paths: Max.	1	1	1	2	2
FIRST CUSTOMER SHIPMENT	2Q95	1Q95	1Q95	4Q91	4Q91
COMMENTS		Includes 532 MB rigid disk drive		Single pass write *With DIR (M109X/F1785)	Single pass write *With DIR (M109X/F1785)

MANUFACTURER	FUJITSU	FUJITSU	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	F6445/A2X2 M255X/A2X2	M2522/BX	40st	C1100A/B C1101A C1103 Model 20xt	C1700T C1710T Model 40T
DISK/TREND GROUP	53	53	51	51	51
MARKET	Captive, OEM	OEM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	644	1300	1300	1300	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	M2507L	M2504B	H-P C1716T	H-P C1716T	H-P C1716T
LIBRARY MECHANISM					
Minimum disk capacity (units)	1560	78	32	16	32
Maximum disk capacity (units)	1560	78	32	16	32
Number of drives: Maximum	10	4	2	1	2
Interface: Library Drive	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2 SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2* SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1004.6	101	41.6	20.8	41.6
Import/export module (disks)	10/10	1*	1	1	1
PERFORMANCE					
Positioner type	Rotary Drum (4) 4 Y axis picker	Rotary Drum Y axis picker	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	2	1	1
Average media exchange time (sec)	10	9	6	8	7
Spin-up + drive ready time (sec)	5.5	5.5	2.5	2.5	2.5
Spin-down time (sec)	4.5	3.5	2	2.0	2.0
Average drive access time (msec)	40.6	40	36	36	36
Non-queued access time (sec)	10.5	10	8.5	6.5	6.0
Drive data transfer rate (KB/s)	2080	1000-2000	1600	1600	1600
Number of drive data paths: Max.	2	1	1	1	2
FIRST CUSTOMER SHIPMENT	4Q91	4Q94	1Q95	4/94	5/93
COMMENTS	Single pass write *With DIR (M109X/F1785)	*20 cartridges Available with DEE option	LAN connect optional Upgradable to 80st	*C1100A is single ended C1101A is differential C1103 is OEM version	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	C1713T Model 20T	80st	100st	300st	C1704T C1714T Model 120T
DISK/TREND GROUP	51	52	53	53	53
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	1300	1300/2600*	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	H-P C1716T	H-P C1716T	H-P C1716T	H-P C1716T	H-P C1716T
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	64	76	238	88
Maximum disk capacity (units)	16	64	76	238	88
Number of drives: Maximum	1	4	2	6	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	20.8	83.2	98.8	309.4/618.8	114
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	2	2	2	1
Average media exchange time (sec)	7	6	6	3.5	8
Spin-up + drive ready time (sec)	2.5	2.5	2.5	2.5	2.5
Spin-down time (sec)	2.0	2	2	2	2.0
Average drive access time (msec)	36	36	36	36	36
Non-queued access time (sec)	6.0	8.5	8.5	8.5	6.5
Drive data transfer rate (KB/s)	1600	1600	1600	1600	1600
Number of drive data paths: Max.	1	1	1	1-6	4
FIRST CUSTOMER SHIPMENT	5/93	1Q95	1Q95	9/95	5/93
COMMENTS	Upgradable to 40T	LAN connect optional	LAN connect optional	*When 2600 MB drives avail. Drives can be hot swapped	Upgradable to 200T

MANUFACTURER	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI	HITACHI
LIBRARY	C1705T C1715T Model 200T	OL101-11 OL101-21	OL112-11 OL112-21	A-6967 Series	OL101-12 OL101-22
DISK/TREND GROUP	53	51	51	52	52
MARKET	Captive,OEM,PCM	Captive, OEM	Captive, OEM	OEM, PCM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	600	644	2000	600
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	Hitachi	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Write Once	Rewritable	Rewritable	Write Once
Drive models	H-P C1716T	Hitachi OD101	Hitachi OD112-1	Hitachi OD152	Hitachi OD101
LIBRARY MECHANISM					
Minimum disk capacity (units)	144	24	24	48	48
Maximum disk capacity (units)	144	24	24	192	48
Number of drives: Maximum	4	2	2	2 to 4	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	187	14.4	15	121	28.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	X-Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	7.7	7.7	5.8	7.7
Spin-up + drive ready time (sec)	2.5	2.5	4.0	5	2.5
Spin-down time (sec)	2.0	2.5	3.5	3	2.5
Average drive access time (msec)	36	110	70	50	110
Non-queued access time (sec)	6.5	7.8	7.8	7.9	7.8
Drive data transfer rate (KB/s)	1600	1500	1500	1540-3020	1500
Number of drive data paths: Max.	4	1	1	1	2
FIRST CUSTOMER SHIPMENT	5/93	1987	1989	4Q94	1987
COMMENTS		-11 has single ended interface -21 has differential interface	-11 has single ended interface -21 has differential interface	HSM subsystem solution	-12 has single ended interface -22 has differential interface

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
LIBRARY	OL112-12 OL112-22	OL114-12 OL114-22	OL152-48 OL152-60	OL321-22	OL321-32
DISK/TREND GROUP	52	52	52	52	52
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	12"	12"
Nominal disk capacity (MB)	644	644	2022	7000	7000
Cartridge type	ANSI/ISO	ANSI/ISO	Hitachi	Proprietary	Proprietary
DRIVE: Type	Rewritable	Wr.Once,Rewrit.	Multifunct-(MO)	Write Once	Write Once
Drive models	Hitachi OD112-1	Hitachi	Hitachi OLF152	Hitachi OD321	Hitachi OD321
LIBRARY MECHANISM					
Minimum disk capacity (units)	48	48	48*	47	64
Maximum disk capacity (units)	48	48	60	47/127*	64/144*
Number of drives: Maximum	4	4	2	4	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	30	30	121	329/889*	448/1008*
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	2	2
Average media exchange time (sec)	7.7	7.7	5.8	6.5	6.5
Spin-up + drive ready time (sec)	3.7	4.0	5	3	3
Spin-down time (sec)	2.7	3.5	3	3	3
Average drive access time (msec)	70	70	50	150	150
Non-queued access time (sec)	7.8	7.8	7.9	8.5	8.5
Drive data transfer rate (KB/s)	1500	1500	1540-3020	1500/4000	1500/4000
Number of drive data paths: Max.	1	4	4	2	2
FIRST CUSTOMER SHIPMENT	1989	1991	1Q94	1Q91	1Q91
COMMENTS	-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	Dual picker *With expansion unit	Dual picker *With expansion unit

MANUFACTURER	HITACHI	IBM	IBM	IBM	IBM
LIBRARY	OL152-180 OL152-192	3995-023	3995-043	3995-063	3995-A23
DISK/TREND GROUP	53	51	51	51	51
MARKET	Captive, OEM	Captive, OEM	Captive	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2022	1300	1300	1300	1300
Cartridge type	Hitachi	ISO	ANSI/ISO	ISO	ISO
DRIVE: Type	Multifunct-(MO)	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	Hitachi OLF152	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC
LIBRARY MECHANISM					
Minimum disk capacity (units)	180*	32	32	32	16
Maximum disk capacity (units)	192	32	32	32	16
Number of drives: Maximum	2	2	2	2	1
Interface: Library Drive	SCSI-2 SCSI-2	LAN SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	388	40	40	40	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)	6	7	7	7	7
Spin-up + drive ready time (sec)	5	3	3	3	3
Spin-down time (sec)	3	1.3	1.3	1.3	1.3
Average drive access time (msec)	50	41.5	41.5	41.5	41.5
Non-queued access time (sec)	8	6.5	6.5	6.5	6.5
Drive data transfer rate (KB/s)	1540-3020	1561	1561	1561	1561
Number of drive data paths: Max.	4	2	2	2	1
FIRST CUSTOMER SHIPMENT	1Q94	8/93	6/94	8/93	10/93
COMMENTS	*With 4 drives Available with single-ended or differential SCSI	For LAN Hewlett-Packard mechanism Rewritable and WORM media	For AS/400 Hewlett-Packard mechanism Rewritable and WORM media	For RS/6000 Hewlett-Packard mechanism Rewritable and WORM media	For PS/2 with OS/2, AS/400 Hewlett-Packard mechanism Rewritable and WORM media

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-A43	3995-A63	3995-113	3995-123	3995-133
DISK/TREND GROUP	51	51	53	53	53
MARKET	Captive	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	1300	1300	1300	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	16	144	144	144
Maximum disk capacity (units)	16	16	144	144	144
Number of drives: Maximum	1	1	4	5	5
Interface: Library Drive	SCSI SCSI	SCSI-2 SCSI-2	SCSI SCSI	LAN SCSI	S/370* SCSI
Library capacity (Gbytes) (with maximum disk capacity)	20	20	188	188	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	7	8	8	8
Spin-up + drive ready time (sec)	3	3	3	3	3
Spin-down time (sec)	1.3	1.3	1.3	1.3	1.3
Average drive access time (msec)	41.5	41.5	41.5	41.5	41.5
Non-queued access time (sec)	6.5	6.5	7.1	7.1	7.1
Drive data transfer rate (KB/s)	1561	1561	1272	1561	1561
Number of drive data paths: Max.	1	1	4	5	4
FIRST CUSTOMER SHIPMENT	6/94	6/94	6/93	8/93	1Q94
COMMENTS	For AS/400 Hewlett-Packard mechanism Rewritable and WORM media	For RS/6000 Hewlett-Packard mechanism Rewritable and WORM media	Expansion unit for libraries. Hewlett-Packard mechanism. Rewritable and WORM media.	For LAN Hewlett-Packard mechanism Rewritable and WORM media	For MVS/ES systems. Hewlett-Packard mechanism. *OEMI channel, ESCON channel

MANUFACTURER	IBM	IBM	IBM	K&S	K&S
LIBRARY	3995-143	3995-153	3995-163	CDJ-30	CDJ-M
DISK/TREND GROUP	53	53	53	50	50
MARKET	Captive	Captive, OEM	Captive, OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm/80 mm.	120 mm
Nominal disk capacity (MB)	1300	1300	1300	540/600	650
Cartridge type	ANSI/ISO	ISO	ANSI/ISO	Caddy	Caddy
DRIVE: Type	Multifunction	Multifunction	Multifunction	CD-R	CD-ROM, CD-R
Drive models	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	Philips, other	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	144	144	144	30	50
Maximum disk capacity (units)	144	144	144	30	1600
Number of drives: Maximum	4	5	4	1	4*
Interface: Library Drive	SCSI SCSI	S/370* SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI, SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	188	178	188	18	1040
Import/export module (disks)	1	1	1	1/15	
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	8	30	
Spin-up + drive ready time (sec)	3.1	3	3	Drive dependent	Drive dependent
Spin-down time (sec)	1.3	1.3	1.3	Drive dependent	Drive dependent
Average drive access time (msec)	67.5	41.5	41.5	Drive dependent	Drive dependent
Non-queued access time (sec)	7.1	7.1	7.1	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	1561	1272	1561	Drive dependent	Drive dependent
Number of drive data paths: Max.	4	5	4	1	1
FIRST CUSTOMER SHIPMENT	6/94	3Q93	1Q94	1994	
COMMENTS	For AS/400 Hewlett-Packard mechanism Rewritable and WORM media	*OEMI channel, ESCON channel Hewlett-Packard mechanism Rewritable and WORM media	For RS/6000 Hewlett-Packard mechanism Rewritable and WORM media		Can hold from 50 to 1600 disks per module *Up to 8 modules per system possible

MANUFACTURER	K&S	K&S	K&S	K&S	KUBIK ENTERPRISES
LIBRARY	MCD-10	MCD-50	Megastore 1000	Megastore 1000/M	CD Tower
DISK/TREND GROUP	50	50	51	53	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	120 mm
Nominal disk capacity (MB)	650	650	654/1024	650/1500*	650
Cartridge type	Caddy	Caddy	ISO	ANSI	N/A
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	Rewritable	Rewritable	CD-ROM
Drive models	Various	Various	Various	Sony, Maxoptix, Matsushita LF7300Z, Ricoh	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	10	50	10	10	480
Maximum disk capacity (units)	10	50	10	80	1680
Number of drives: Maximum	1	8	1	4	28
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	RS232C, SCSI
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI, SCSI-2	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	6.5	32.5	6.5/10.2	120*	1092
Import/export module (disks)	1		1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	X-Y axis	Rotary
Pickers per positioner	1	1	1	1	1-4
Average media exchange time (sec)			18	18	7
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	1
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	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	Drive dependent	NS
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	614.4/921
Number of drive data paths: Max.	1	2	1	1	7
FIRST CUSTOMER SHIPMENT			9/91	1994	1995
COMMENTS				*With LF7300Z Available with 10, 20, 40 or 80 cartridges	Contains 2 to 7 CDR240

MANUFACTURER	KUBIK ENTERPRISES	KUBIK ENTERPRISES	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
LIBRARY	CDR240M CDR240MA	MO-120	LF-J7000A	LF-J7324A LF-J7324AN	LF-J7328A LF-J7328AN
DISK/TREND GROUP	50	53	52	52	52
MARKET	OEM	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	650	1000	1500	1500
Cartridge type	N/A	N/A	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM, CD-R	Rewritable	Rewritable	Multifunct-(PC)	Multifunct-(PC)
Drive models	Various	Sony, IBM	MEI LF-7012Z	MEI LF-7394	MEI LF-7394
LIBRARY MECHANISM					
Minimum disk capacity (units)	240	120	50	24	28
Maximum disk capacity (units)	240	120	50	24	28
Number of drives: Maximum	4	4	2	2	1
Interface: Library Drive	RS232C, SCSI SCSI	RS232C, SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	156	156	50	36	42
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Rotary	Rotary	Y axis	Y axis	Y axis
Pickers per positioner	1-4	1-4	1	1	1
Average media exchange time (sec)	7	8	8	6.5	6.5
Spin-up + drive ready time (sec)	1	2	4	6	6
Spin-down time (sec)	1	2	2.5	2.5	2.5
Average drive access time (msec)	Drive dependent	Drive dependent	107	57.5	57.5
Non-queued access time (sec)	NS	NS	8	9.25	9.25
Drive data transfer rate (KB/s)	614.4/921	Drive dependent	1500/4000*	1500/5000*	1500/5000*
Number of drive data paths: Max.	4	4	1/2	1/2	1
FIRST CUSTOMER SHIPMENT	1992	4Q95	7/91	3/94	1/94
COMMENTS	CDR240MA is rack mount version	Rack mount available No cartridge required	*SCSI synchronous mode	*SCSI synchronous mode Also available with 1400 MB WORM drive	*SCSI synchronous mode Also available with 1400 MB WORM drive

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MICROBOARDS	MICROBOARDS	NAKAMICHI	NAKAMICHI
LIBRARY	LF-J7350A	DataWrite	DataWrite 500	MBR-7	MBR-7.4
DISK/TREND GROUP	52	50	50	50	50
MARKET	Captive, OEM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm/80 mm	120 mm/80 mm
Nominal disk capacity (MB)	1500	600	600	600	600
Cartridge type	ANSI/ISO	None	None	None	None
DRIVE: Type	Multifunct-(PC)	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Drive models	MEI LF-7394	Sony	Pioneer	Nakamichi	Nakamichi
LIBRARY MECHANISM					
Minimum disk capacity (units)	50	360	500	7	7
Maximum disk capacity (units)	50	360	500	7	7
Number of drives: Maximum	2	2	4	1	1
Interface: Library Drive	SCSI-2 SCSI-2	RS232/SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	75	216	300	4.2	4.2
Import/export module (disks)	1	1	1, 100	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	7	11	18	2.5	2.5
Spin-up + drive ready time (sec)	6	2	3	--	--
Spin-down time (sec)	2.5	1	2	--	--
Average drive access time (msec)	57.5	350	230	380	350
Non-queued access time (sec)	9.5	7.5	12	NA	NA
Drive data transfer rate (KB/s)	1500/5000*	300	614	300	600
Number of drive data paths: Max.	1/2	1/2	1-4	1	1
FIRST CUSTOMER SHIPMENT	2/94	2Q94		3Q94	3Q95
COMMENTS	*SCSI synchronous mode Also available with 1400 MB WORM drive	Sony mechanism	Pioneer mechanism CD-R drives available	64 KB buffer 256 KB option Photo CD, XA, Multisession	128 KB buffer Photo CD, XA, Multisession

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
LIBRARY	CDR-C301 MultiSpin 2Xc CD Jukebox	N1137-06	N1137-58	N7923	N5817-31/32 N7925-82
DISK/TREND GROUP	50	51	51	51	52
MARKET	PCM	Captive	Captive	Captive	Captive
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	12"	130 mm
Nominal disk capacity (MB)	600	610	1300	5000	610
Cartridge type	None	ANSI/ISO	ANSI/ISO	Proprietary	ANSI/ISO
DRIVE: Type	CD-ROM	Rewritable	Rewritable	Write Once	Rewritable
Drive models	NEC MultiSpin 2	NEC N1137-04	NEC N1137-57	NEC N7913	NEC N7915 NEC N5817-11
LIBRARY MECHANISM					
Minimum disk capacity (units)	7	4	4	36	46
Maximum disk capacity (units)	7	4	4	36	67
Number of drives: Maximum	1	1	1	2	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	NEC Proprietary	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	4.2	2.4	5.2	180	40
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	2	1
Average media exchange time (sec)	2.1	10	6	11	10
Spin-up + drive ready time (sec)		4	8	6	4
Spin-down time (sec)		4	5	5	4
Average drive access time (msec)	360	60	42	200	60
Non-queued access time (sec)		8	11	12	9
Drive data transfer rate (KB/s)	300	1500	3000	553-1120	1500
Number of drive data paths: Max.	1	1	1	2	1
FIRST CUSTOMER SHIPMENT		1991	1993	6/90	1992
COMMENTS	64 KB buffer Nakamichi mechanism				

MANUFACTURER	NEC	NEC	NEC	NEC	NIKKYO
LIBRARY	N7925-83	N7925-84	OL5260	OL5453	NOL-102
DISK/TREND GROUP	52	52	52	52	51
MARKET	Captive	Captive	OEM	OEM	OEM
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	ISO	ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	NEC N7915-85	NEC	NEC	NEC	Sony SMO-F521, IBM 0632-C2D
LIBRARY MECHANISM					
Minimum disk capacity (units)	60	60	60	53	10
Maximum disk capacity (units)	60	60	60	53	10
Number of drives: Maximum	2	2	2	4	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	78	78	78	69	10.3
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	2	1
Average media exchange time (sec)	10	8	8	8	5
Spin-up + drive ready time (sec)	8	8	8	8	7
Spin-down time (sec)	5	5	5	5	4
Average drive access time (msec)	42	42	39	39	100
Non-queued access time (sec)	13	13	11	13	9.5
Drive data transfer rate (KB/s)	3000	3000	5000	5000	1200
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	1993	1995	1995	1995	4Q92
COMMENTS					Sold under Alaya brand

MANUFACTURER	NIKKYO	NIKKYO	NIKKYO	NIKKYO	NK-EXA (NKK)
LIBRARY	NOL-161	NOL-322	NOL-604	NOL-642	N-520
DISK/TREND GROUP	51	51	52	52	51
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	1300	1300	650/1000/1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	Sony SMO-F521, IBM 0632-C2D	Sony SMO-F521 IBM 0632-C2D	Sony SMO-F521 IBM 0632-C2D	Sony SMO-F521 IBM 0632-C2D	Sony, Maxoptix, IBM
LIBRARY MECHANISM					
Minimum disk capacity (units)	16	32	60	64	20
Maximum disk capacity (units)	16	32	60	64	20
Number of drives: Maximum	1	2	4	2	2
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	20.8			83.2	13/20/26
Import/export module (disks)	1	1	1	1/16	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	5	5	5	7
Spin-up + drive ready time (sec)	7	7	7	7	Drive dependent
Spin-down time (sec)	4	4	4	4	Drive dependent
Average drive access time (msec)	100	100	100	100	Drive dependent
Non-queued access time (sec)	9.5	9.5	9.5	9.5	Drive dependent
Drive data transfer rate (KB/s)	1200	1200	1200	1200	Drive dependent
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	3Q93	3Q94	2Q94	4Q93	4Q93
COMMENTS	Sold under Alaya brand	Sold under Alaya brand	Sold under Alaya brand	Sold under Alaya brand	Drive specific models available

MANUFACTURER	NK-EXA (NKK)	NK-EXA (NKK)	NSM	NSM	NSM
LIBRARY	N-556U	N-5160U	CDR 100 Recordable	CDR 100 XA	Mercury-20
DISK/TREND GROUP	52	53	50	50	50
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650-1700	650-1700	600	600	600
Cartridge type	ISO	ISO	NSM	NSM	None
DRIVE: Type	Rewritable	Rewritable	CD-R	CD-ROM	CD-ROM
Drive models	Sony, Maxoptix, IBM, Pioneer	Sony, Maxoptix, IBM, Pioneer	JVC	Toshiba	Toshiba
LIBRARY MECHANISM					
Minimum disk capacity (units)	56	144	100	100	150
Maximum disk capacity (units)	56	160	100	100	150
Number of drives: Maximum	2	4	1	1	2
Interface: Library	SCSI-2	SCSI-2	SCSI-2, RS232	SCSI-2, RS232	RS232
Drive	SCSI-2	SCSI-2	SCSI	SCSI	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	36/56/73/95	104/160/208/272	60	60	90
Import/export module (disks)	1/16	1/16	1/50	1/50	1/50
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	1	2	2	1
Average media exchange time (sec)	4	4	4.5	4.5	4
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	1.5	1.5	2.5
Spin-down time (sec)	Drive dependent	Drive dependent	1.0	1.0	2
Average drive access time (msec)	Drive dependent	Drive dependent	200	200	180
Non-queued access time (sec)	Drive dependent	Drive dependent	4.3	4.3	4.5
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	307.2	307.2	600
Number of drive data paths: Max.	1	1	1	1	1-2
FIRST CUSTOMER SHIPMENT	4Q93	1Q94	3/94	1/94	4Q94
COMMENTS	Drive specific models available	Drive specific models available			

MANUFACTURER	NSM	OLYMPUS	PFU	PFU	PHILIPS LMS
LIBRARY	Mercury-40	OLS 10NSS OLS S10	MC700A	MC700B	LF 4500
DISK/TREND GROUP	50	51	51	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	130 mm	86 mm	86 mm	12"
Nominal disk capacity (MB)	600	1300	230	230	5600
Cartridge type	None	ANSI/ISO	ISO	ISO	LMSI
DRIVE: Type	CD-ROM	Rewritable	Rewritable	Rewritable	Write Once
Drive models	Toshiba	Olympus MOS 525E	Fujitsu	Fujitsu	LMSI LD 4100
LIBRARY MECHANISM					
Minimum disk capacity (units)	150	10	32	32	5
Maximum disk capacity (units)	150	10	32	32	5
Number of drives: Maximum	4	1	1	2	1
Interface: Library Drive	RS232 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)	90	13	7.4	7.4	28
Import/export module (disks)	1/50	1	32	32	5
PERFORMANCE					
Positioner type	Y axis	Y axis	X axis	X axis	Moving Magazine
Pickers per positioner	1	1	1	1	N/A
Average media exchange time (sec)	4	6	3	6	3
Spin-up + drive ready time (sec)	2.5	4	2	2	2.5
Spin-down time (sec)	2	3	1	1	1.5
Average drive access time (msec)	180	33.5	30	30	90*
Non-queued access time (sec)	4.5	7	5	8	5.5
Drive data transfer rate (KB/s)	600	1200-2300	1300-2100	1300-2100	700/1800**
Number of drive data paths: Max.	1-4	1	1	1	1
FIRST CUSTOMER SHIPMENT	4Q94	2Q94	1994	1994	4Q91
COMMENTS			Purchased mechanism	Purchased mechanism	*Includes command overhead **Asynchronous mode. Dual head drive

MANUFACTURER	PHILIPS LMS	PHILIPS LMS	PHILIPS LMS	PIONEER	PIONEER
LIBRARY	LF 4502	LF 6600	LF 6602	DRJ-5004X	DRM-1804X
DISK/TREND GROUP	51	51	51	50	50
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	12"	12"	12"	120 mm	120 mm
Nominal disk capacity (MB)	5600	12000	12000	540	540
Cartridge type	LMSI	Philips LMS	Philips LMS	N/A	N/A
DRIVE: Type	Write Once	Write Once	Write Once	CD-ROM, CD-R	CD-ROM
Drive models	LMSI LD 4100	Philips LMS LD 6100	Philips LMS LD 6100	Pioneer D504X Pioneer R504X	Pioneer (integrated with drive)
LIBRARY MECHANISM					
Minimum disk capacity (units)	10	6	12	100	18
Maximum disk capacity (units)	10	6	12	500	18
Number of drives: Maximum	2	1	2	4	1
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	56	72	144	270	9.72
Import/export module (disks)	5	5	5	100	18
PERFORMANCE					
Positioner type	Moving Magazine	Moving Magazine	Moving Magazine	Y axis	NS
Pickers per positioner	N/A	N/A	N/A	1	1
Average media exchange time (sec)	3	2.5	2.5	18	5
Spin-up + drive ready time (sec)	2.5	3	3	3	3
Spin-down time (sec)	1.5	1.5	1.5	2	2
Average drive access time (msec)	90	100	100	300	300
Non-queued access time (sec)	5.5	4.5	4.5	12	NS
Drive data transfer rate (KB/s)	700/1800*	2700	2700	614	614.4/153.6
Number of drive data paths: Max.	2	1	2	4	1
FIRST CUSTOMER SHIPMENT	1Q92	2Q95	2Q95	3Q94	4Q93
COMMENTS	2 LF 4500 in single cabinet *Asynchronous mode Dual head drive	Dual head drive	Dual head drive	Photo CD Multisession	Photo CD Multisession

MANUFACTURER	PIONEER	PIONEER	PLASMON DATA	PLASMON DATA	PLASMON DATA
LIBRARY	DRM-5004X DRM-5004XR	DRM-624X	MiniMulti	MicroMulti	Multi I
DISK/TREND GROUP	50	50	51	51	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)	660	540	1300/1500	Drive dependent	1300/1500
Cartridge type	N/A	N/A	ANSI/ISO/Panas.	ANSI/ISO/Panas.	ANSI/ISO/Panas.
DRIVE: Type	CD-ROM, CD-R	CD-ROM	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Pioneer 4X	Pioneer (integrated with drive)	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	100	6	20	20	46
Maximum disk capacity (units)	500	6	30*	22*	60*
Number of drives: Maximum	4	1	2	2	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)	330	3.24	45	33 max.	90
Import/export module (disks)	100	6	1	1	1
PERFORMANCE					
Positioner type	Y axis	NS	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	29	5	4	5.2	4
Spin-up + drive ready time (sec)	2	NS	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	1	NS	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	300	150	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	31	NS	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (KB/s)	614	675.8	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	1	1		1	1
FIRST CUSTOMER SHIPMENT	4Q94	2Q95		2/94	11/93
COMMENTS	Photo CD Multisession DRM-5004X has CD-ROM only	Photo CD Multisession 128 K buffer	*Depends upon drive height	*Depends upon drive height	*Depends upon drive height

MANUFACTURER	PLASMON DATA	PLASMON DATA	PLASMON DATA	RICOH	RICOH
LIBRARY	Multi II	Multi III	Multi IIIE	RJ5210E	RJ5830E
DISK/TREND GROUP	53	53	53	51	52
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300/1500	1300/1500	1300/1500	1300	1300
Cartridge type	ANSI/ISO/Panas.	ANSI/ISO/Panas.	ANSI/ISO/Panas.	ANSI/ISO	ANSI/ISO
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Rewritable	Rewritable
Drive models	Various	Various	Various	Ricoh RO-5060E	Ricoh RO-5060E
LIBRARY MECHANISM					
Minimum disk capacity (units)	92	138	258	16	64
Maximum disk capacity (units)	120*	180*	300	16	64
Number of drives: Maximum	4	6	6	1	2
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	180	270	450	20.9	83.5
Import/export module (disks)	1	1	1	1	16/1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis w/pivot	Y axis	Y axis
Pickers per positioner	1	1		1	1
Average media exchange time (sec)	4	4		5	5
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	5.5	5.5
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	5	5
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	40.7	40.7
Non-queued access time (sec)	Drive dependent	Drive dependent	Drive dependent	8	8
Drive data transfer rate (KB/s)	Drive dependent	Drive dependent	Drive dependent	5000 synch.	5000 synch.
Number of drive data paths: Max.	1	1	1	1	1/2
FIRST CUSTOMER SHIPMENT	4/94	4/94	6/94	2Q94	2Q94
COMMENTS	*Depends upon drive height	*Depends upon drive height			

MANUFACTURER	SANYO	SONY	SONY	SONY	SONY
LIBRARY	CDR-C3G	OSL 2000	OSL 2000-10	OSL 2000-20	OSL-2001-10
DISK/TREND GROUP	50	51	51	51	51
MARKET	OEM	OEM, PCM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	540	650/1300	1300	1300	1300
Cartridge type	Proprietary	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	Sanyo 4X	Sony E521	Sony E521	Sony E521	Sony SMO-F531
LIBRARY MECHANISM					
Minimum disk capacity (units)	3	20	20	20	20
Maximum disk capacity (units)	3	20	20	20	20
Number of drives: Maximum	1	2	1	2	1
Interface: Library	IDE/ATAPI	RS232	RS232	RS232	
Drive		SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1.6	26	26	26	26
Import/export module (disks)	3	1, 10	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	5	5	5	5
Spin-up + drive ready time (sec)	2	2.5	2.5	2.5	2.5
Spin-down time (sec)	1	2	2	2	2
Average drive access time (msec)	250	50	50	50	50
Non-queued access time (sec)	5.3	5	5	5	5
Drive data transfer rate (KB/s)	614.4	2000	2000	2000	2000
Number of drive data paths: Max.	1	2	1	2	1
FIRST CUSTOMER SHIPMENT	1Q95	2Q94	2Q94	2Q94	3Q94
COMMENTS	256K buffer				

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
LIBRARY	OSL-2001-11	OSL-2001-20	OSL-2001-21	WDA-E330	WDA-610
DISK/TREND GROUP	51	51	51	51	52
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	12"	12"
Nominal disk capacity (MB)	1300	1300	1300	6552	6552
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	Proprietary	Proprietary
DRIVE: Type	Rewritable	Rewritable	Rewritable	Write Once	Write Once
Drive models	Sony SMO-F531	Sony SMO-F531	Sony SMO-F531	Sony WDD 930-01	Sony WDD 600-01
LIBRARY MECHANISM					
Minimum disk capacity (units)	20	20	20	12	50
Maximum disk capacity (units)	20	20	20	12	50
Number of drives: Maximum	1	2	2	1	2
Interface: Library	SCSI-2		SCSI-2	SCSI-2	SCSI
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	26	26	26	78.6	328
Import/export module (disks)	1/10	1	1/10	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	5	5	3.0	5
Spin-up + drive ready time (sec)	2.5	2.5	2.5	2.4	2.4
Spin-down time (sec)	2	2	2	2.5	1.1
Average drive access time (msec)	47	50	47	208/637	221/455
Non-queued access time (sec)	5	5	5	4	5
Drive data transfer rate (KB/s)	2400	2000	2400	900	600
Number of drive data paths: Max.	1	2	1	1	1
FIRST CUSTOMER SHIPMENT	1994	3Q94	1994	3Q92	9/89
COMMENTS					Can attach 7 units to 1 SCSI port

MANUFACTURER	SONY	SONY	SONY	TODD ENTERPRISES	
LIBRARY	WDA-E550	WDA-E930	WDA-EX5	TAJ-2000	
DISK/TREND GROUP	53	53	53	50	
MARKET	OEM	OEM	OEM	OEM	
MEDIA: Nominal disk diameter	12"	12"	12"	120 mm	
Nominal disk capacity (MB)	15000	6552	15000	680	
Cartridge type	Sony	Proprietary	Sony	Caddy	
DRIVE: Type	Write Once	Write Once	Write Once	CD-ROM	
Drive models	Sony WDD 530	Sony WDD 930-01	Sony WDD 530	Hitachi CDR-6750	
LIBRARY MECHANISM					
Minimum disk capacity (units)	46	47	48	174	
Maximum disk capacity (units)	76	77	78	203	
Number of drives: Maximum	4	4	3	14	
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	Ethernet SCSI	
Library capacity (Gbytes) (with maximum disk capacity)	1140	504	2310	132	
Import/export module (disks)	1	1	1	--	
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	X-Y axis	
Pickers per positioner	1	1	1	1	
Average media exchange time (sec)	5	5	6.5	12	
Spin-up + drive ready time (sec)	2.8	2.4	2.8	8-9	
Spin-down time (sec)	1.0	1.2	1.0	2	
Average drive access time (msec)	150/600	208/637	150/600	235	
Non-queued access time (sec)	5.3	4.9	6.1	14	
Drive data transfer rate (KB/s)	2700	900	2700	307.2	
Number of drive data paths: Max.	1	1	--		
FIRST CUSTOMER SHIPMENT	5/95	4Q92	5/95	1994	
COMMENTS			Expansion unit for WDA-E550	Photo CD Multisession UNIX server	

MANUFACTURER PROFILES

1995 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 1994, this figure is reported explicitly only for firms with major 1994 optical disk drive or library sales. "1994 total net sales" covers the fiscal year ending in 1994 for each manufacturer unless noted otherwise, or for the parent company if the manufacturer is a subsidiary. All fiscal years end on December 31, 1994, 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 1994 is used, as cited by the Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
Canada	Canadian dollar	1.37
France	French franc	5.55
Germany	Deutschmark	1.62
Hong Kong	Hong Kong dollar	7.73
Japan	Yen	102.2
Malaysia	Ringgit	2.62
Netherlands	Guilder	1.82
Singapore	Singapore dollar	1.53
South Korea	Won	807.0
Taiwan	Taiwan dollar	26.5
United Kingdom	Pound	.652

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

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 in 1994, but the relatively small capacity of the library discouraged use and ADIC withdrew the product.

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. As of mid-1995, the product line was in the process of being redesigned to improve flexibility and reduce costs.

CD INTERNATIONAL
58 Fore Street
Portland, ME 04101

A new company founded by data storage industry veterans, CDI is producing a family of CD-ROM library assemblies based upon the Nakamichi autochanger mechanism. A typical model contains multiple autochanger modules and a single utility reader or writer. A rigid disk drive buffer is included in some models. Positive air pressure and a filtration system are included as dust control features.

CD-ROM, INC.
1301 Arapahoe Street, Suite 7
Golden, CO 80401

CD-ROM, founded in 1988, is a U.S. owned and headquartered manufacturer of CD-ROM drives (using purchased mechanisms). The firm sells mostly to the U.S. government, although there are significant international sales. CD-ROM, Inc.

is also known as a distributor of other CD-ROM drives, tower assemblies, 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

1994 total net sales: $13,450,790,000 (FY ending 7/2/94) Net income: ($2,156,063,000)

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. An internal optical drive development effort has been discontinued.

DISC (Formerly Document Image Systems Corporation)
372 Turquoise Street
Milpitas, CA 95035

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. In early 1995, the company changed its name to DISC, expanded its operations and moved to larger quarters. CD-ROM libraries are becoming an increasingly important part of the firm's product mix.

DOCUPOINT CORPORATION (See Sigma Designs Imaging Systems)

DYNATEK AUTOMATION SYSTEMS, INC.
200 Bluewater Road
Bedford, Nova Scotia, B4B 1G9
Canada

Dynatek Automation is a privately owned firm established in 1985 as a system integrator. The firm specializes in packaged SCSI-based disk and tape storage subsystems used with a broad variety of hardware platforms. In November of 1994, the firm introduced the infiniDISC CD-ROM library, a modular system that can contain up to 44 CD-ROM/CD-R drives and up to 2,750 disks. Disk storage can be added in increments of 250 disks. Shipments are scheduled to begin in late 1995.

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1994 total net sales: $13,557,000,000 Net income: ($557,000)

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 is in production of its own 6X CD-R drive (Kodak also provides the media) 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 7.4 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. The firm is expected to introduce a two headed drive with 20-25 gigabyte capacity per disk in late 1995.

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

1994 total net sales: $179,693,000 (FY ending 1/1/95) Net income: $16,061,000

FileNet, founded in 1982, is a producer of document image storage systems and subsystems including optical libraries. Systems are sold primarily to end users, but 12" libraries are also sold on an OEM basis. OEM customers for libraries have included IBM, N. V. Philips, Eastman Kodak and others. International system sales are handled by foreign subsidiaries and by distributors, most notably Olivetti in Europe and Australia and Toyo Officemation, a Mitsui subsidiary, in Japan. The company is emphasizing its system business and de-emphasizing OEM library sales.

Production of optical libraries began in 1985. The FileNet product line is built around 12" drives, and offers some of the largest storage capacities available in a noncustomized optical library. Up to 340 disks can be stored in the largest FileNet system. FileNet has a major share of the 12" optical library market. The firm also sells 5.25" libraries purchased from other sources, most recently including Hewlett-Packard.

FileNet has shifted 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. However, the new generation of higher capacity 12" drives has caused the firm to reconsider the role of smaller 12" libraries in future systems.

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

1994 total net sales: $24,991,000,000 (FY ending 10/31/94) Net income: $1,599,000,000

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 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, Hewlett-Packard has increasingly moved 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 remains the leading revenue producer in the 5.25" optical library market, with a product line spanning the range from 16 to 144 cartridge capacities. Several cost reduced models were announced in 1995. The libraries are used in H-P systems, but H-P also sells them to OEM accounts and through resellers.

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 260 megabyte 5.25" write-once drive began shipping in 1989 for use in a USAF system, with production expected to continue. Honeywell subsequently developed a 300 megabyte militarized rewritable magneto-optic drive, also supplied in small quantities under specific contracts.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1994 total net sales: $64,052,000,000 Net income: $3,021,000,000

IBM started slowly in the optical storage area, but eventually manufactured or remarketed a variety of products, including CD-ROMs, write-once and erasable drives and optical libraries. IBM has been 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 relies on outside pur-

chases of CD-ROM drives 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.

IBM established its optical program in Tucson, Arizona, but some IBM optical products were made in locations other than Tucson, including Southeast Asia and the Philippines. In 1987, IBM announced the model 3363 5.25" write-once drive for use with its personal computers. The mechanism was obtained from Matsushita Electric, with IBM supplying the electronics, software, and final assembly. 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 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 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" MO drive developed in conjunction with Philips Key Module Group.

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 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 support for 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 and continues to update its library product line.

In the beginning of 1995, IBM completed a review of all of its product lines to determine which met its criteria for long range commitment of investments. The

optical drive activity did not meet IBM's internal criteria, and IBM is expected to sell off or shut down its optical drive activities. The 3995 optical library product line is expected to continue.

INTERNATIONAL DATA ENGINEERING (See Plasmon Data Systems, Ltd., in European Manufacturers section)

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. A library for 5.25" optical drives was introduced in 1995.

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.

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 (Reno) is manufactured for the company on a contract basis by one of the Matsushita companies. The company came under severe financial strain and entered Chapter 11 status in mid-1994, emerging in December, 1994.

MOST, INC.
11205 Knott Avenue
Cypress, CA 90630

MOST was formed in 1987. The firm, a subsidiary of Nakamichi, engaged in the design and manufacture of 3.5" MO rewritable disk drives. Sales to the VAR/VAD distribution channel were made (nonexclusively) through Ocean Microsystems, another Nakamichi subsidiary. In July, 1995, MOST's senior management acquired the company and Ocean Microsystems from Nakamichi.

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) went 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, most of which are sold to other manufacturers. MOST produced a significant fraction of all 5.25" optical drive mechanisms shipped in 1994.

In early 1995, MOST displayed a 2.6 gigabyte per cartridge 5.25" optical drive, the first of its breed. Production is scheduled for late 1995. 3.5" drives are being deemphasized in favor of the higher capacity 5.25" models.

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%. A nonruggedized 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. As of mid-1995, the optical drives were being produced only under contract for military programs, with all other models discontinued. However, the 1995 acquisition of Metrum by MountainGate may revive interest in optical drives, as Metrum's product line includes a recently announced large optical library.

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

1994 total net sales: $65,382,000 Net profit: $2,736,000

Rapidly growing Pinnacle Micro, founded in 1987, started as a subsystem producer and remarketer of optical drives and libraries, but in 1992 the firm began assembling 5.25" rewritable drives using purchased mechanisms and electronics supplied by Pinnacle Micro. The firm established a development center for optical products in Colorado Springs in 1993. In 1994, Pinnacle Micro began manufacturing the Orray, an array of 5.25" optical drives with a controller that can operate them concurrently, as well as a CD-R drive using a purchased mechanism.

As of mid-1995, Pinnacle Micro was in the process of starting up an optical drive factory, also in Colorado Springs, to produce complete high performance, high capacity 5.25" magneto-optical drives and other products.

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 media is plentiful. 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 primary library was the DP520 library, which held up to 10 drives and up to 288 5.25" cartridges. The library was introduced at the 1992 AIIM conference, with shipments beginning in early 1993. However, shipments remained low, and in 1994 the firm withdrew from the optical library market.

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, based upon a purchased mechanism, was not successful and was subsequently withdrawn.

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, 1994, unless otherwise noted. All companies are in Japan unless otherwise noted.)

ACER, INC.
7 Hsin An Road
Science Industrial Park
Hsinchu City
Taiwan

Acer was founded as Multitech International in 1976, and after a period of growth changed its name to Acer for improved recognition. The company is Taiwan's largest producer of personal computers. The company also produces its own CD-ROM drives based upon Sony mechanisms. Acer is establishing production in the Philippines, and is expected to manufacture CD-ROM drives in that location in the future.

ACER PERIPHERALS
6, Feng Shu Tsuen
Kweishan, Taoyuan
Taiwan

Acer Peripherals was started by Acer, Inc. in 1984. The company produces keyboards, fax machines, printers, monitors and CD-ROM drives, which are based upon Philips mechanisms. The company is expanding CD-ROM production and is preparing to occupy larger facilities in 1995.

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

1994 total net sales: $7,701,115,000 Net income: $87,593,000

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 were produced under Aisin's own name and were also produced for other firms on a contract basis. Only library units with 5.25" drives were produced. Both write-once and rewritable drives were used. Production started in 1988, but the first libraries with rewritable drives were not shipped until 1990. Production gradually declined, with the last production occurring in 1994.

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

1994 total net sales: $2,059,637,000 Net income: $45,431,000

Aiwa was formed in 1951 and originally was a producer of telephone and audio equipment. Sony holds a 51.2% share in the company. The firm today manufactures audio and video products, disk drive arrays, helical scan tape drives, modems and CD-ROM drives. Aiwa began shipping a double speed drive in 1994 and plans higher performance drives. A three disk rotary auto-changer began volume shipments in 1995.

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 double speed unit in 1994.

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

1994 total net sales: $3,854,178,000 Net income: ($90,431,000)

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 22% of revenues in 1994. 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, but subsequently withdrew its branded CD-ROM drive products.

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 in production.

AZTECH LABS
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, followed by a 4X drive later that year. Production of 6X drives is planned for the second half of 1995.

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. The company is upgrading its line of CD-ROM products and expects to be producing 6X drives in the future.

BIRDY ELECTRONICS
Unit 4, Block A, Po Lung Centre
11 Wang Chiu Road
Kowloon Bay
Hong Kong

Founded in 1987 as Swantronics, Birdy is a distributor and manufacturer of electronic assemblies, and performs contract manufacturing for a number of customers. The firm is an agent for Sony's CD-ROM mechanisms and assembles drives using locally manufactured electronics. Some of Birdy's production facilities are in China.

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

1994 total net sales: $18,916,928,000 (FY ending 12/31/94) Net income: $303,562,000

Canon is a major supplier of business machines, copiers, and cameras, but about 45% 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

1994 total net sales: $356,751,000 Net income: ($52,994,000)

Chinon is best known for its cameras and lenses, but 78% 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 was expanded in 1993 to include double speed drives. 4X drive production began in late 1994, and 6X production is scheduled for late 1995. A 128 megabyte 3.5" drive was announced in 1992 and began shipping in early 1993.

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 eventually begin producing its own drives using purchased mechanisms.

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 and has since produced a moderate number of double speed drives. 4X drives using Hitachi mechanisms are scheduled for production in the third quarter of 1995.

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

1994 total net sales: $30,777,745,000 Net income: ($369,333,000)

Fujitsu is Japan's largest producer of computer systems and also manufactures a wide variety of other electronic equipment. Computer products represented about 68% of Fujitsu's 1994 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 priced its 3.5" products aggressively. The firm was among the earliest to introduce a 230 megabyte 3.5" drive, has succeeded in capturing the largest share of the 3.5" market, and has expanded its production capacity for

3.5" drives. Fujitsu is expected to be one of the early introducers of the next generation 640 megabyte 3.5" MO drive. The firm has also introduced a 3.5" library, which went into production in 1995. The library mechanism is also used by PFU, a computer system and software company partially owned by Fujitsu.

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

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 began shipments in early 1995, and a quadruple speed drive is scheduled for production in the third quarter.

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

1994 total net sales: $72,551,029,000 Net income: $639,990,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major producer of computer systems. It manufactures rigid disk drives and other peripherals as well as processors. About 48% of 1994 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. Although Hitachi's OEM sales for CD-ROM drives had slackened since 1990, an effort is under way to revitalize the OEM oriented CD-ROM product line.

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, R.O.C.

Hopax got started in the CD-ROM business as a manufacturer of optical pickups. The firm has leveraged this experience with its own double speed drives starting in 1994, and with a quad speed drive in 1995.

IPC PERIPHERALS (PTE) LTD.
23 Tai Seng Drive
Singapore 1953

IPC is a manufacturer of CD-ROM drives and a distributor of certain other CD-ROM drives and storage products. Production of a 4X CD-ROM drive using a purchased mechanism began in 1995.

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 manufactured CD-ROM drives at facilities in China using Sanyo mechanisms. The drives were double speed models with SCSI interface. IDE versions were planned for future development, but the firm has since left the market.

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

1994 total net sales: $7,109,090,000 Net income: ($191,663,000)

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 which was introduced at the Japan Business Show in 1994.

KAIMEI ELECTRONIC CORP.
507 Yen Ping North Road, Section 6
Taipei, Taiwan
Republic of China

Kaimei, which markets under the Jamicon brand, manufactures computer systems and related products, including double speed CD-ROM drives that went into production beginning in 1994. Purchased mechanisms are used.

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, which it acquired completely in early 1995. 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 CO., LTD.
Subsidiary of Matsushita Electric Industrial Co.
4-1-62 Minoshima, Hakata-ku
Fukuoka 812

KME, which originally produced transformers and electric pumps, 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. In 1995, LaserByte acquired additional 3.5" optical drive designs from another company. The firm was also restructured in 1995 and new management brought in. Ownership is now split between Hyundai, Philips and private investors.

LG ELECTRONICS, INC. (formerly Goldstar Company, Ltd.)
20 Yoido-dong
Youngdungpo-gu
Seoul 150
Republic of Korea

1994 total net sales: $5,357,000,000 Net income: $81,000,000

All of the companies in the Lucky-GoldStar group adopted the "LG" name in early 1995. LG Electronics was founded in 1959, and is one of Korea's major producers of consumer electronics. The company's current strategy involves expansion of its industrial electronics divisions, including computers and peripherals. The company currently offers internal and external double speed and quadruple speed CD-ROM drives, and has announced a CD-I player, to be produced in Korea under a Philips license. A 3DO type player was introduced in 1995.

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 had a Sony-type AT bus interface, but subsequent products are available with SCSI and ATAPI interfaces as well. 4X drives went into production in 1994, and a 6X drive is scheduled to begin production in 1995.

LONGSHINE ELECTRONICS CORPORATION
245, Section 3
Roosevelt Road
Taipei
Taiwan

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. Production of 4X drives commenced in mid-1995.

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

1994 total net sales: $64,810,039,000 Net income: $239,658,000

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 optical 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 became 1994's largest producer of CD-ROM drives and mechanisms. Although a bit late in starting production of 4X drives, 1995 production by MKE has increased rapidly.

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. The 5.25" drive also accepts 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 rewritable 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-1995. However, the firm appears to be on the way to success with the PD drive, a 12 centimeter drive capable of reading CD-ROM disks and writing/reading phase change media, although the phase change media can be read only on PD drives. The PD drive technology has been licensed to NEC.

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

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-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 originally for Insite Peripherals, and CD-ROM drives. CD-ROM drive production, which commenced in 1992, has become quite large, making MKE the leading CD-ROM manufacturer. Much of MKE's CD-ROM output is marketed through Matsushita companies.

MAXOPTIX CORPORATION
Subsidiary of Kubota, Ltd.
2520 Junction Avenue
San Jose, CA 95134

Maxoptix began in 1986 as a research program within Maxtor Corporation. In March of 1989, Maxtor and Kubota, Ltd. formed Maxoptix, a joint venture 63% owned by Maxtor. The first 5.25" MO drives produced by Maxoptix were shipped in 1990. Kubota purchased Maxtor's share in early 1995. 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. Kubota now does the volume manufacturing of Maxoptix optical drives. Maxoptix retains design, sales and marketing responsibilities for optical disk drives, and is still a significant drive supplier, although emphasizing its system integration business.

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.

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

1994 total net sales: $1,820,861,000 (FY ending 1/30/94) Net income: $23,288,000

Mitsumi, founded in 1949, is primarily a manufacturer of electronic components, but 18% of 1994 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 since 1993. As of mid-1995, the firm was the leading producer of 4X CD-ROM drives, although it is being strongly challenged by Matsushita and Sony.

NAKAMICHI CORPORATION
1-153, Suzuki-cho
Kodaira City, Tokyo 187

1994 total net sales: $211,106,000 (FY ending 2/28/94) Net income: $14,159,000

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 2% of 1994 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 has aggressively priced the library and has captured significant market share, including some OEM accounts. Several small capacity, inexpensive follow-on models are planned.

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

1994 total net sales: $35,095,951,000 Net income: ($64,765,000)

NEC has defined its product area as communications and computers, with computer products accounting for about 48% of 1994 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 has also licensed Matsushita's PD drive and phase change technology. 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.

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. A 6X drive was introduced in 1995. 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. In 1995, the firm created a separate company, Nistec, to market its libraries. Nistec also has engineering responsibilities for libraries.

NIKON CORPORATION
3-2-3, Marunouchi
Chiyoda-ku, Tokyo 100

1994 total net sales: $2,408,659,000 Net income: ($42,632,000)

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. A 5.25" MO drive, developed in conjunction with Hitachi, has been demonstrated but is not yet in production.

NK-EXA
Subsidiary of NKK Corporation
1-1-2 Marunouchi
Chiyoda-ku, Tokyo 100

1994 total net sales: $17,396,233,000 Net income: ($394,706,000)

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.

NK-EXA 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 was 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. In 1992, a larger library with a maximum capacity of 160 cartridges was added to the NK-EXA 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

1994 total net sales: $2,343,943,000 Net income: $5,440,000

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, including libraries and CD-R drives.

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. Production began in late 1993. Subsequent products include 4X (production started in late 1994), 6X and 8X drives scheduled for 1995 production.

PFU LIMITED
98-2 Unoke, Unoke-machi
Kahoku-gun, Ishikawa 929-11

Founded in 1960, PFU is currently a joint venture between Fujitsu, Matsushita Electric, Uchida Yoko and other investors. The company produces and markets computer systems and software, primarily in Japan. PFU markets 3.5" optical drive libraries based upon Fujitsu library mechanisms and drives, packaging, and private labeling for other firms, as well as under its own name.

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

1994 total net sales: $4,988,806,000 Net income: $64,237,000

Pioneer, founded in 1947, is a major manufacturer of consumer electronic equipment. 96% 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. Pioneer's media was the first commercial version of dye-based media to be brought to market. In 1990, Pioneer introduced a multifunction drive using dye or MO media interchangeably. The drive uses sampled servo format.

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. Pioneer became the leading producer of small CD-ROM libraries, but is now being challenged by Nakamichi and Sanyo. At the 1994 AIIM show, Pioneer displayed a 500 disk CD-ROM library based upon a karaoke system also produced by Pioneer.

PLEXTOR (SHINANO KENSHI)
1078 Kami-maruko
Maruko-machi, Chiisagata-gun
Nagano-ken

Shinano Kenshi was founded in 1918 as a silk spinning company. 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 markets CD-ROM drives under the Plextor name. Plextor was one of the first companies to announce and produce a 6X CD-ROM drive, which began its production run in mid-1995.

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

1994 total net sales: $9,474,736,000 Net income: $93,151,000

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 1994 revenues. Ricoh and Pioneer developed an 8" write-once optical drive which Ricoh used in a document storage system. 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 became the exclusive marketing agent for Ricoh OEM 5.25" write-once optical disk drives in the United States. Ricoh marketed subsystems containing optical drives in the U.S., an activity permitted under the terms of the Ricoh-Maxtor agreement. In the years following 1987, Ricoh supplied more write-once drives than any other manufacturer, largely as a result of its collaboration with Maxtor. However, in mid-1994, Ricoh announced it would cease production of write-once drives and concentrate upon MO and CD-R 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. A 230 megabyte version began production in early 1995.

Ricoh began manufacturing CD-R recorders in 1993, and is among the more aggressive marketers for this type of drive. A cost reduced double speed drive went into production in early 1995.

SAMSUNG ELECTRONICS
7 Soonwha-Dong
Seoul
Korea

1993 total net sales: $10,106,000,000 Net income: $192,000,000

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 was joined by a 4X drive in mid-1995.

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

1994 total net sales: $16,571,448,000 (FY ending 11/30/94) Net income: 110,812,000

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 continues to show interest in that market. The firm currently produces double speed and 4X CD-ROM drives. In 1995, Sanyo entered the CD-ROM autochanger market with a 3 disk model capable of fitting into a standard 5.25" half height form factor.

It incorporates a 4X drive with IDE/ATAPI interface. Most of Sanyo's 1995 production is already committed to OEM customers, notably Gateway Computer.

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

1994 total net sales: $4,075,734,000 Net income: $109,736,000

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" optical disk drives rather than produce them internally.

SHARP CORPORATION
22-22 Nagaike-cho
Abeno-ku, Osaka 545

1994 total net sales: $14,854,090,000 Net income: $311,076,000

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 20% 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 is expected to produce a computer peripheral version of the MiniDisc after the audio version is launched.

SONY CORPORATION
6-7-35, Kitashinagawa
Shinagawa-ku, Tokyo 141

1994 total net sales: $36,533,474,000 Net income: $149,687,000

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 72% of revenues. Sony also holds a significant 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 has consistently ranked among the three largest CD-ROM drive producers for the past several years.

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.

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 7.5 gigabyte per side capacity, while the rewritable drives are 5.25" and 3.5" MO models. The 5.25" rewritable drive product line is being further developed, although Sony skipped the 230 megabyte 3.5" drive 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.

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. The Sony PlayStation, a game system, appears to have brighter prospects, with introduction in the U.S. planned for September following its earlier introduction in Japan.

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 1994, Sony has been the largest supplier of 5.25" 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 with a 650 megabyte drive. The new design is not compatible with any other product and has received only lukewarm industry support, although Hitachi has indicated it may produce a similar product and 3M has indicated an intention to produce media. As of mid-1995, Sony was providing samples to interested parties.

Sony announced 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 1991. 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. Modest shipments began in 1994. 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

1994 total net sales: $1,118,843,000 Net income: $72,049,000

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 4X drives introduced in 1994. 6X drives are scheduled for shipment in the third quarter of 1995. TEAC has introduced 17 millimeter and 19 millimeter high drives for use in notebook computers.

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

1994 total net sales: $45,312,202,000 Net income: $118,787,000

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 50% of 1994 revenues were related to data communications or computer products. Optical and rigid disk 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 much 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.

Toshiba introduced 4X drives in 1994, and has rapidly ramped production. DISK/TREND expects Toshiba to announce 6X drives before the end of 1995.

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.

UMAX DATA SYSTEMS
68 Nanking East Road, Section 3
Taipei
Taiwan

Umax offers double and quad speed CD-ROM drives. The drives are based upon Sony mechanisms. Production of the drives began in 1994.

WEARNES PERIPHERALS INTERNATIONAL (PTE) LTD.
Joint venture of WBL Corporation, Winbond Electronics and Walsin Lihwa
801, Lorong 7, #07-00
Toa Payoh, Singapore 1231

Wearnes Technology, a subsidiary of WBL Corporation, (formerly Wearnes Brothers) and itself a multinational corporation with development and manufacturing operations in Asia, Europe and in the U.S., manufactures computers, tape drives, displays, many kinds of components and, beginning in 1993, CD-ROM drives. The company selected Philips mechanisms as the base for its products.

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

Wearnes Peripherals International (WPI) was established in early 1995 as a joint venture between WBL, Winbond Electronics (a Taiwan semiconductor producer) and Walsin Lihwa (a Taiwan conglomerate), and all of Wearnes Technology CD-ROM related activities were transferred to WPI. WPI has facilities in Singapore, Malaysia and China, and is concentrating upon CD-ROM drives with IDE/ATAPI interfaces. Double speed and 4X drives are in production, with 6X drive production scheduled for the third quarter of 1995.

YAMAHA CORPORATION
10-1 Nakazawa-machi
Hamamatsu, Shizuoka

1994 total net sales: $4,360,147,000 Net income: ($38,992,000)

Yamaha is the world's largest manufacturer of musical instruments, which account for 53% 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 4X recorder that went into production in 1994. The CD-R systems are remarketed by companies specializing in CD-ROM authoring tools and systems.

YUNG FU ELECTRICAL APPLIANCES CORP., LTD.
59 Ming Tsu Road, Section 2
Tainan, Taiwan

Marketing through Lxycon Enterprise Corp, Yung Fu produces double speed and 4X CD-ROM drives using purchased mechanisms. Production of the double speed unit began in late 1994, with the 4X drive production expected in late 1995.

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, and subsequently announced models hold up to 124 disks. The design of the autochanger is unusual in that 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.

ASM
An Der Muhle 1-5
D-26655 Westerstede
Germany

ASM was founded in 1993 to produce optical disk libraries. The current product line includes CD-ROM/CD-R libraries storing from 40 to over 1500 disks contained in individual caddies. While the smaller libraries in the product line support only one or two disks, larger systems can support up to 42 drives.

ATG SA/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 1993, ATG Gigadisc purchased Cygnet Systems, and the two firms were reorganized as ATG Cygnet. A further reorganization in 1995 divided the organization into ATG Cygnet, Inc., and ATG SA, which produces drives and media, and also markets ATG Cygnet libraries in Europe.

ATG SA products now include 12" write-once drives up to 5.1 gigabytes per side capacity, plus a library storage unit containing a drive and six 12" disks.

ATG Cygnet produces the line of larger 12" library units. The Cygnature, a 5.25" disk library capable of mixing several types of media, will begin shipping in 1995.

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, CD-ROM/CD-R drives or 5.25" drives are produced. Drives from most manufacturers are supported in the library systems. DSM announced capabilities include optical libraries with up to 2,380 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, although the firm is also marketing in the U.S. 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. The company introduced a 1600 disk CD-ROM library in 1994.

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

Logical Engineering manufactured a 300 disk CD-ROM library. 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 was founded in the early 1950s as a manufacturer of music boxes. The company transitioned to computer based systems, introducing a computer controlled music jukebox in 1974. A 100 disk audio CD library was introduced in 1989, and the growing library business led NSM to establish a separate division, NSM Jukebox GmbH, in early 1994. As of early 1995, the firm claims over 50,000 CD audio and CD-ROM libraries shipped. The products are manufactured in Germany.

NSM introduced an optical library for CD-ROM drives in 1991. The initial NSM design handled up to 100 disks, insertable into magazines holding up to 50 disks for convenient loading and unloading. The Mercury, an attractively styled 150 disk library was introduced in the second quarter of 1994. The new library is offered with CD-R drives as well as CD-ROM drives.

NSM markets primarily in Europe, but has started a more visible marketing effort in the U.S., and is capturing significant OEM business as well as serving the independent system integration market.

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

1994 total net sales: $33,688,950,000 Net income: $1,174,033,000

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. Philips currently supplies 3.5" MO mechanisms for other manufacturers.

Manufacturing of CD-ROM drives, CD-R drives and MO drives (and mechanisms) is the responsibility of Philips Key Modules Group, which sells large quan-

tities of mechanisms to CD-ROM drive producers, some of which manufacture complete drives for resale under the Philips label.

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 while 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 began volume shipments of CD-I players in mid-1992, marketing under the Magnavox brand name. The firm has also sold freestanding CD-ROM drive subsystems bundled with software since 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 Modules 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 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. Philips LMS produced CD-ROM drives for a few years, but CD-ROM activity has now been transferred to Philips Key Modules Group.

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.

PLASMON DATA SYSTEMS, INC. (Formerly International Data Engineering)
Division of Plasmon PLC
1654 Centre Pointe Drive
Milpitas, CA 95035

1994 total net sales: $36,544,000 (FY ending 3/31/95) Net profit: $1,757,000

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.

The firm was purchased by Plasmon Data Systems in 1994, but continued for a while to operate under its original name in the OEM market it serves. Plasmon Data Systems is one of the leading suppliers of small 5.25" optical libraries, but has broadened its product line with increasingly larger library systems over the past few years, with the largest library capable of storing 300 disk cartridges.

SOCIETE D'APPLICATIONS GENERALES D'ELECTRICITE ET DE MECANIQUE (SAGEM)
6, Avenue d'lena
75783 Paris CEDEX 16
France

SAGEM is a French high technology company specializing in electronic products. About 25% of revenues are obtained from military and avionic systems, 31% from industrial telecommunications products and 44% from data processing and related telecommunications products. The firm makes small quantities of militarized rigid disk drives for use in harsh environments.

SAGEM was 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 had drive development responsibilities, and media was to be developed by Hoechst. The long-term target was a 5 gigabyte 5.25" magneto-optic drive, but the consortium was disbanded, effectively putting SAGEM's development effort in abeyance.

1995 DISK/TREND REPORT

DISK/TREND ON DISK

Introduction

DISK/TREND ON DISK is a licensed set of floppy disks available for separate purchase that contain the statistical tables and specification tables from the annual DISK/TREND Reports. The disk files have been prepared in a format usable on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. A system with a hard disk is highly recommended, but a system with two floppy disks can be used if necessary. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended.

Two types of diskette files are supplied for each DISK/TREND disk drive report. The first type contains the statistical tables in ASCII format. File names are keyed to the table numbers in the report for easy identification. The second type contains the specification section in a Lotus 1-2-3 data base format. Multiple disks of each type are provided where the files are too numerous or too large to fit on a single floppy disk. The color of the label of the floppy disk is similar to the color used on the cover of the corresponding report for ease in identification.

Because the statistical tables are provided in ASCII format, they can be used with any spreadsheet program that can import ASCII text files. However, the specification tables have been prepared specifically in Lotus 1-2-3 format to allow them to be searchable using Lotus 1-2-3 data base commands. If you are using a spreadsheet program other than Lotus 1-2-3 that can translate Lotus WK1 formatted files to its own format, it may be able to import the specification tables without difficulty.

A file translation program, AutoImport, is available from DISK/TREND to assist in converting the data supplied to the formats of several popular spreadsheet programs. One copy of AutoImport is provided automatically at no extra charge to DISK/TREND subscribers who have purchased an original copy of DISK/TREND ON DISK but is provided only in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any

time. If you have not purchased DISK/TREND ON DISK, but would find AutoImport useful with other file translation tasks, it may be purchased independently from DISK/TREND or White Crane Systems, Inc.

IMPORTANT NOTE: Effective July, 1994, White Crane began shipping 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 1995 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1995 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.

1995 DISK/TREND REPORT

Getting started

The first thing you should do is to make working copies of the original DISK/TREND diskettes. Place the originals in a safe location and use only the working copies for day-to-day operations. This procedure will help to protect your data from inadvertent destruction or loss due to a malfunction of the computer or its operator. We also recommend that you place a write protect tab on the working copies (after you create them) for the same reason. Use the hard disk or another floppy disk copy for day-to-day manipulations of the files.

The statistical tables are provided in ASCII text format. This allows you to use any word processor to edit the file prior to importing it into Lotus 1-2-3. Appropriate editing removes any material you don't wish to work with and allows you to add figures or text to the data tables. You may also embed the data in internal documents or reports you are preparing for use within your company.

To convert the statistical tables to a spreadsheet you may use the AutoImport utility software, which is probably quicker and easier than the typical text file import and conversion procedure provided with spreadsheet programs. One copy of AutoImport is provided automatically at no extra charge to each DISK/TREND subscriber who has purchased an original copy of DISK/TREND ON DISK and is provided in the first year DISK/TREND ON DISK is purchased. Updates to AutoImport may be provided in following years at DISK/TREND's discretion. Extra copies of AutoImport may be purchased at any time.

DISK/TREND ON DISK is normally shipped on 1.44 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.

   Installing AutoImport V3.xx: 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

   R (Rigid disk drive data)
   O (Optical disk drive data)
   A (Disk drive array data)
   V (Removable data storage data)

   YY= Table number, as shown in the appropriate report volume

   Examples:
   File RT10.WK1 is Rigid Disk Drive Report Table 10
   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 Data Storage 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 for flexible disk drives in the Removable Data Storage 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	Removable 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 to 6, 11,12,24,25	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			Table 21
MASKE	N/A	N/A	Write-Once/ Erasable Analysis	N/A
MASKH	Tables 7,8	Table 31	N/A	N/A
MASKI	<----- Product Group -----> Price/Megabyte		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	1994 Rigid Report	1994 Removable Report	1995 Optical Report	1995 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	MASKC
6	MASKC	MASKC	MASKC	MASKC
7	MASKH	--	MASKC	MASKC
8	MASKH	--	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKA	MASKC	MASKA
11	MASKC	MASKC	MASKC	MASKA
12	--	MASKC	MASKC	--
13	--	--	--	--
14	MASKA	MASKI	--	--
15	MASKA	--	--	--
16	--	MASKI	--	MASKA
17	--	--	MASKA	MASKA
18	MASKD	MASKI	MASKA	--
19	MASKI	--	--	--
20	--	MASKI	--	--
21	MASKA	--	MASKD	MASKD
22	MASKA	MASKA	--	--
23	--	MASKA	MASKA	MASKA
24	--	MASKC	MASKA	MASKA
25	MASKD	MASKC	--	--
26	MASKI	MASKA	--	--
27	--	MASKA	--	--
28	MASKA	MASKA	--	--
29	MASKA	MASKA	MASKE	MASKA
30	--	MASKA	MASKD	MASKA
31	--	MASKH	--	--
32	MASKD	MASKD	MASKA	--
33	MASKI	--	MASKA	--
34	--	MASKA	--	--
35	MASKA	MASKA	--	
36	MASKA	--	MASKE	
37	--	--	MASKD	
38	--	MASKI	--	
39	MASKD	MASKD	MASKA	
40	MASKI	--	MASKA	
41	--	MASKA	--	
42	MASKA	MASKA	--	
43	MASKA	--	MASKA	
44	--	--	MASKA	
45	--	MASKD	--	
46	MASKD	--	--	
47	MASKI	MASKA	MASKE	

Cross-reference (continued)

Table Number	1994 Rigid Report	1994 Removable Report	1995 Optical Report	1995 Array Report
48	--	MASKA	MASKA	
49	MASKA	--	MASKA	
50	MASKA	--	--	
51	--	MASKD	--	
52	--	--	MASKE	
53	MASKD		MASKA	
54	MASKI		MASKA	
55	--		--	
56	MASKA		--	
57	MASKA		MASKE	
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: RT4.95R VT12.95V OT14.95O AT19.95A

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, 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 VT12 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, V, O, or A), nn is the table number and yy is the report year.

   Example: OT10.95O

   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= O (Optical disk drive data)
   R (Rigid disk drive data)
   A (Disk drive array data)
   V (Removable data storage 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: OS195 Optical disk drive specification table.
LS195 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 which type of storage device is involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND Report. Each column represents a specific specification parameter, and is equivalent to one row of the DISK/TREND Report.

The data base has been set up for data extraction using Lotus 1-2-3 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

Expanding the input or output ranges: The predefined output range is of a nominal size, and a search with broad parameters may result in overflowing the output range. In such a case, merely extend the output range (add more rows) using the Lotus 1-2-3 /DQEO command. Similarly, it is possible to extend the input range to add more products, but be sure you move the output range so that there is no overlap.

Memory overflow: If you should receive a memory overflow message while manipulating the specification data, it is usually because:

- There are other "pop-up" programs resident in the memory of your computer. These should be removed.
- You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.
- If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You probably will have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 640K memory, you will probably get this message.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups you are interested in into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

Make sure that when you save a worksheet using the FILE SAVE command that you save it in a new file name. If you save it in the file name from which it was loaded, the original copy will be overwritten. If a file is overwritten unintentionally, it can take a long time to recreate.

If you are interested only in a subset of specific 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 optical disk 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.