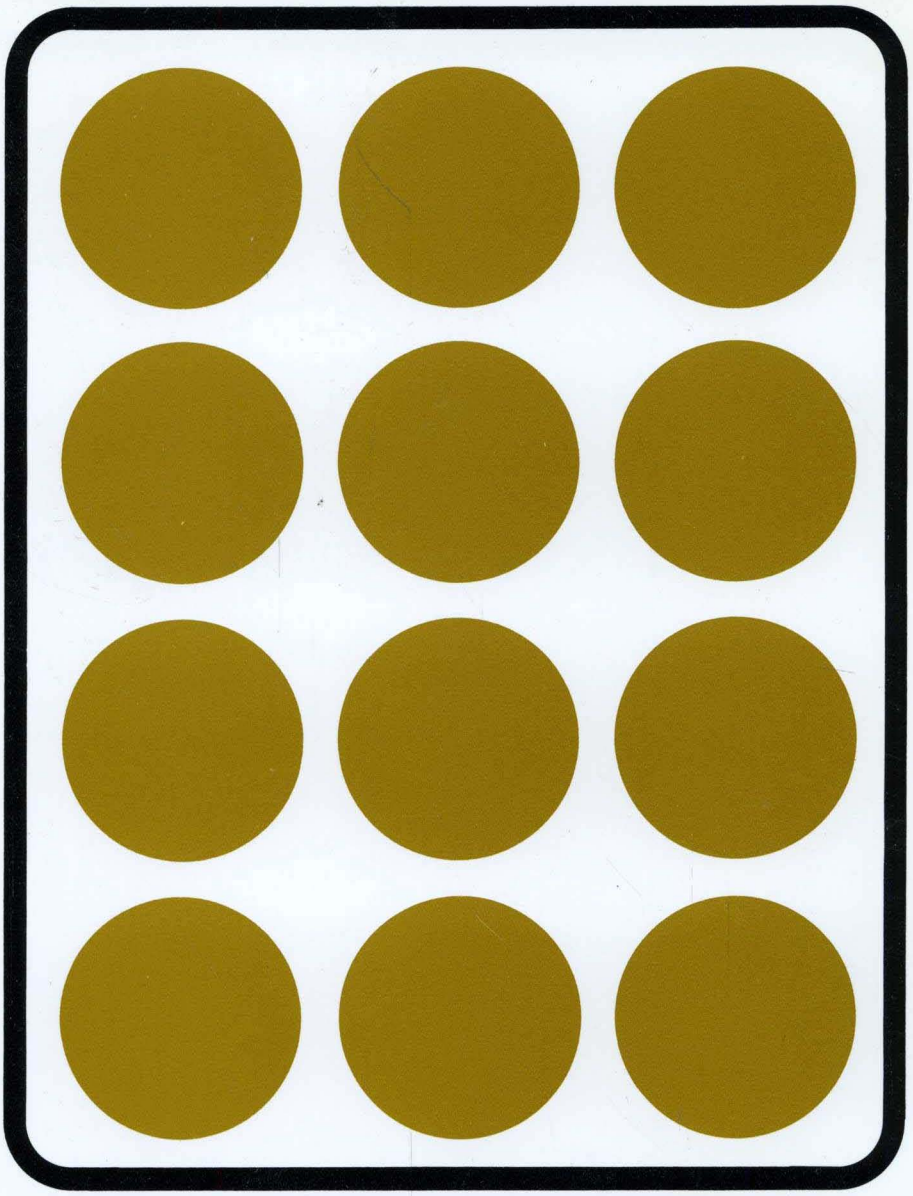
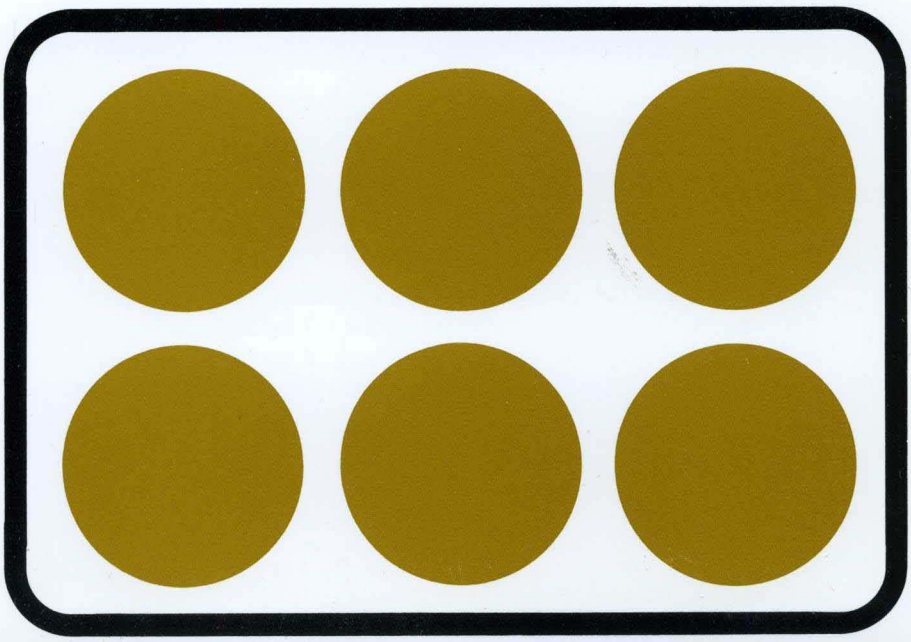


1997 DISK/TREND® REPORT



OPTICAL DISK DRIVES

1997 DISK/TREND® REPORT

OPTICAL DISK DRIVES

August, 1997

DISK/TREND, Inc.
1925 Landings Drive
Mountain View, California 94043

Telephone: 650-961-6209
Facsimile: 650-969-2560
E-mail: dtinfo@disktrend.com
Web: http://www.disktrend.com

FOREWORD

The optical disk drive industry hasn't gotten any calmer. CD-ROM drives continue to race through product generations, leaving excess inventory and unprofitability in their wake. Falling prices for 3.5" MO drives created a major upsurge in demand, justifying the oft-made claim that the optical drive business can be fun if the price is right. The PD drive had a fairly successful launch, but appears about to be submerged in the expected wave of DVD-RAM drives, and DVD-ROM drives are finally shipping in quantity. CD-R shipments are up, and CD-RW appears ready to move in a big way. The small CD-ROM autochanger, thought to be on track for annual shipments in the millions has faltered, hampered by higher prices and slower performance than system OEMs will accept. And the 12" drive segment lost a couple of manufacturers.

5.25" optical drives and small optical libraries continue to be displaced by high capacity magnetic rigid drives. However, the MO side of the industry may be on the verge of a major rebirth as new technologies provide small drives with over 5 gigabytes of online capacity in 1998. If these initiatives are technically and commercially successful, MO drives just might make some serious inroads on other technologies for a change.

For 1997, we have initiated coverage of CD-ROM towers, a frequently used alternative to CD-ROM optical libraries, where higher performance is required to serve multiple users needing access to the same disk. Both host attached and direct network attached towers operating as servers are included.

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 in the last section 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 now in its 12th year. Reflecting industry changes, the organization of this year's report has been modified to include a new product group covering CD format disk towers. Breakdowns in CD-ROM tables have been modified to reflect the rapidly changing nature of this portion of the industry. Here are a few reminders to help in interpreting the information presented.

* This report concentrates on optical disk drives, optical libraries and CD format disk towers 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, libraries and towers 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 1996 market was too small or too concentrated for market share figures to be meaningful.

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

  * CD format read-only optical disk drives
  * CD format writable optical disk drives
  * Read/write optical disk drives less than 2 gigabytes
  * Read/write optical disk drives more than 2 gigabytes

  * CD format optical libraries
  * CD format disk towers
  * Read/write optical disk libraries, 1 - 39 cartridges
  * Read/write optical disk libraries, 40 - 69 cartridges
  * Read/write optical disk 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

Total optical disk drive revenues grew 20% in 1996 to over $5.86 billion, driven by growth in CD format and 3.5" MO drive shipments. CD format read-only drive sales alone reached over $4.6 billion, while writable CD format sales added an additional $502 million, a 79.7% jump. Sales revenues for the under 2 gigabyte product group of read/write drives rose sharply to $635 million, as lower prices accelerated sales of 3.5" MO drives. Sales of drives over 2 gigabytes slipped 25.4% to $64.1 million. Total revenues in 2000 are forecasted to exceed $10.3 billion. All product groups except drives under 2 gigabytes, impacted by the shift of 5.25" drive capacities to the over 2 gigabytes group, are expected to show revenue growth in the forecast period.

Shipments of 3.5" magneto-optic drives improved somewhat in 1995, but 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 inched up as shipments of 5.25" drives over 2 gigabytes commenced, while shipments of 12" drives dropped 34%, as the result of market exits by two manufacturers.

Almost 58.4 million optical drives were shipped in 1996, including 55.6 million CD format read-only drives, which accounted for 95.3% of shipments. 1.42 million CD format writable drives were shipped, including CD-R, CD-RW and PD drives. Shipments of read/write drives under 2 gigabytes shot up 98.8% to almost 1.4 million as shipment growth for 3.5" drives overrode the decline in 5.25" drive shipments. Unit shipments for drives over 2 gigabytes accelerated 39.1% to 8,900 units, with growth in 5.25" drives countering declines in 12" drive shipments. Total unit shipments in 2000 are projected to exceed 106.1 million units, 99.2 million of which will be CD-ROM or DVD-ROM drives. CD format writable drives will exceed 4.7 million units, so all CD format drives together are forecasted to capture 98% of unit shipments in 2000.

Shipments of optical libraries and towers shot up almost 107% to over 735,000 units, but almost 93% of the shipments were CD-ROM libraries. Of the CD-ROM libraries, over 99% were small CD-ROM autochangers. 1996 shipments were bolstered by a large order from one customer, and 1997 shipments are

expected to shrink 33%, with growth resuming in 1998. CD disk tower shipments were about 37,500 units in 1996, almost evenly divided between host attached and network attached units. Tower revenues were $146 million, the largest element in overall revenues for optical libraries and towers of $514.2 million. Tower revenues were followed by CD format libraries ($141.4 million) and 70 or more cartridge optical disk libraries ($128.2 million). 1 to 39 cartridge optical libraries are losing ground, impacted by competing technologies, and shrank 20.5% to $66.5 million, while revenues in the 40 to 69 cartridge category, bolstered by the impact of higher capacity 5.25" drives, rose 17.6% to $32.1 million. Total revenues of $628.3 million are expected in 2000. CD format disk towers are expected to capture 40.6%, followed by CD format libraries with 23.8% and libraries with 70 or more cartridges at 20.8%.

U.S. drive manufacturers again lost revenue share in 1996, dropping to 1.5% of worldwide optical disk drive revenues, and reflecting minimal participation by U.S. firms in the CD format market. U.S. companies continued to lead in library revenues, capturing 55.9% of the worldwide total, a very small decline from the previous year. The U.S. share of total drive shipments is also insignificant, the result of very large CD format drive shipments from non-U.S. firms. U.S. manufacturers' 1996 share of library unit shipments fell because of the large increase in CD-ROM library shipments by non-U.S. suppliers, but is expected to recover and stabilize as the 1996 shipment bulge in small CD libraries ends in 1997.

Sales of optical disk drives to U.S. destinations in 1996 accounted for 43.3% of worldwide revenue, a slight increase from 1995. The U.S. market accounted for 59.2% of library revenues, also an increase from 1995, reflecting strong investment in data storage automation within the U.S. The U.S. optical drive market is expected to be 45.7% of a $10.3 billion drive market in 2000, while the proportion of the library market in the U.S. will decline slightly to 63.1% of $616 million in 2000, as the result of improving CD format library and tower shipments to non-U.S. markets and anticipated improvements in non-U.S. economies.

Non-U.S. manufacturers have emerged as the major drive producers because of their strengths in optical component and semiconductor laser technology. U.S. firms have difficulty in overcoming non-U.S. firms leads in media, lasers, optical components, heads and mechanisms and, relegated to the role of drive assemblers, have been dropping out of the market.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996		Forecast							
	Revenues		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	17.9	28.0	3.0	6.0	2.9	5.8	5.6	8.4	5.4	10.8
PCM/Distributor	43.8	54.6	39.5	50.3	36.7	49.1	35.7	51.9	49.8	78.6
OEM/Integrator	11.0	16.9	19.8	27.8	14.9	20.5	19.6	34.1	36.5	64.9
TOTAL U.S. REVENUES	72.7	99.5	62.3	84.1	54.5	75.4	60.9	94.4	91.7	154.3
Non-U.S. Manufacturers										
Captive	241.0	677.2	289.3	797.3	325.9	875.5	388.6	1,036.2	488.5	1,209.5
PCM/Distributor	539.9	1,504.5	618.4	1,715.5	761.3	2,049.9	904.2	2,399.0	1,191.7	2,828.5
OEM/Integrator	1,683.8	3,580.7	2,030.3	4,652.2	2,408.8	5,353.3	2,728.9	5,797.4	2,948.5	6,139.0
TOTAL NON-U.S. REVENUES	2,464.7	5,762.4	2,938.0	7,165.0	3,496.0	8,278.7	4,021.7	9,232.6	4,628.7	10,177.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,537.4	5,861.9	3,000.3	7,249.1	3,550.5	8,354.1	4,082.6	9,327.0	4,720.4	10,331.3

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK LIBRARIES AND TOWERS

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	37.2	54.0	27.1	46.0	25.2	42.0	23.6	39.3	22.1	37.3
PCM/Distributor	127.3	158.3	158.6	198.9	170.1	213.0	186.4	232.3	200.5	248.5
OEM/Integrator	55.6	75.6	60.0	80.3	59.6	83.3	62.8	87.7	64.4	90.4
TOTAL U.S. REVENUES	220.1	287.9	245.7	325.2	254.9	338.3	272.8	359.3	287.0	376.2
Non-U.S. Manufacturers										
Captive	--	7.6	--	7.4	--	4.2	--	4.5	--	4.7
PCM/Distributor	39.8	92.4	36.2	88.2	40.5	102.5	43.2	110.6	45.8	117.7
OEM/Integrator	44.3	126.3	50.4	103.8	57.6	113.0	60.9	122.1	64.1	129.7
TOTAL NON-U.S. REVENUES	84.1	226.3	86.6	199.4	98.1	219.7	104.1	237.2	109.9	252.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	304.2	514.2	332.3	524.6	353.0	558.0	376.9	596.5	396.9	628.3

Figure 1

CHANGING PRODUCT MIX

Worldwide Optical Disk Drive Revenue

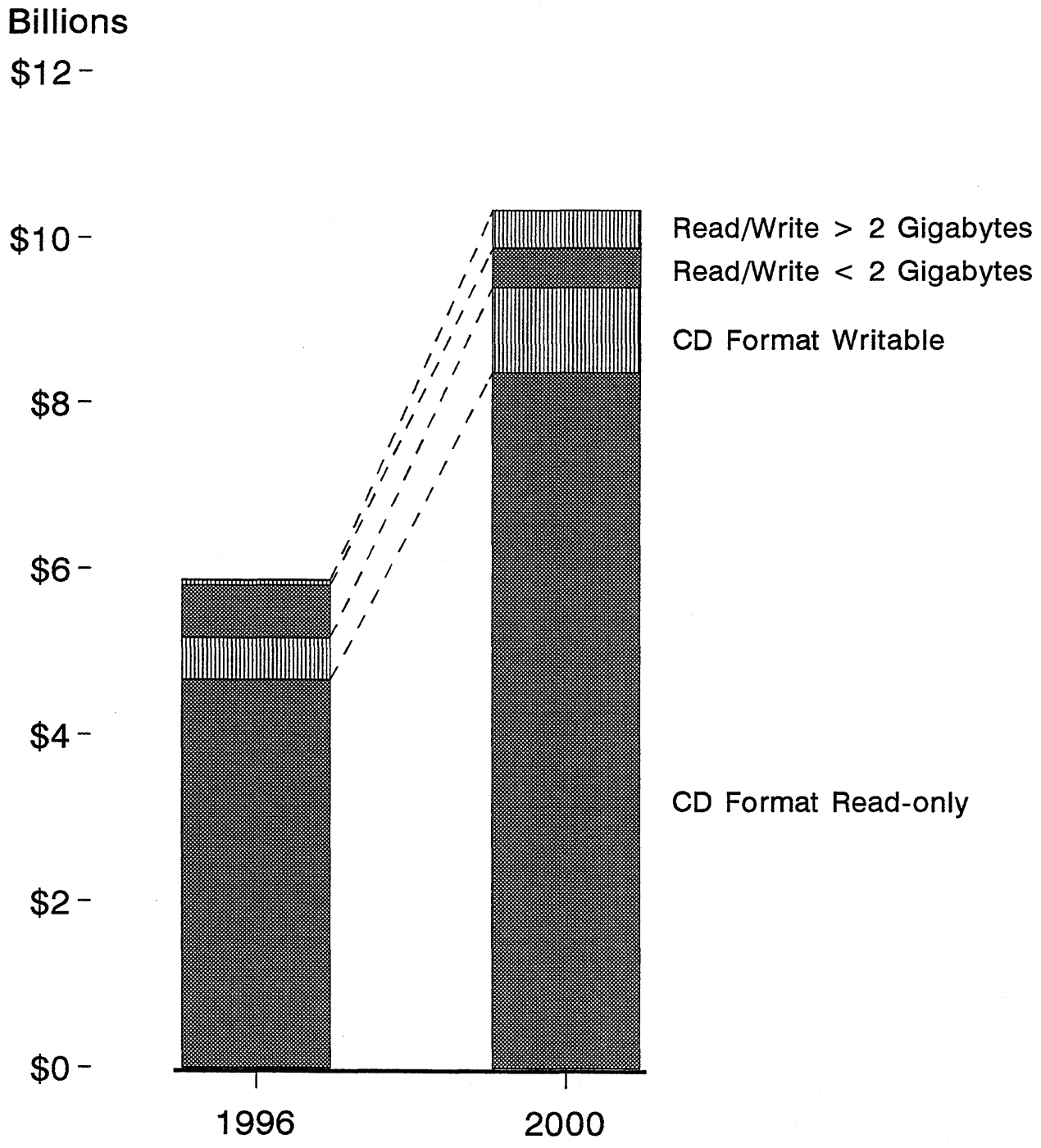
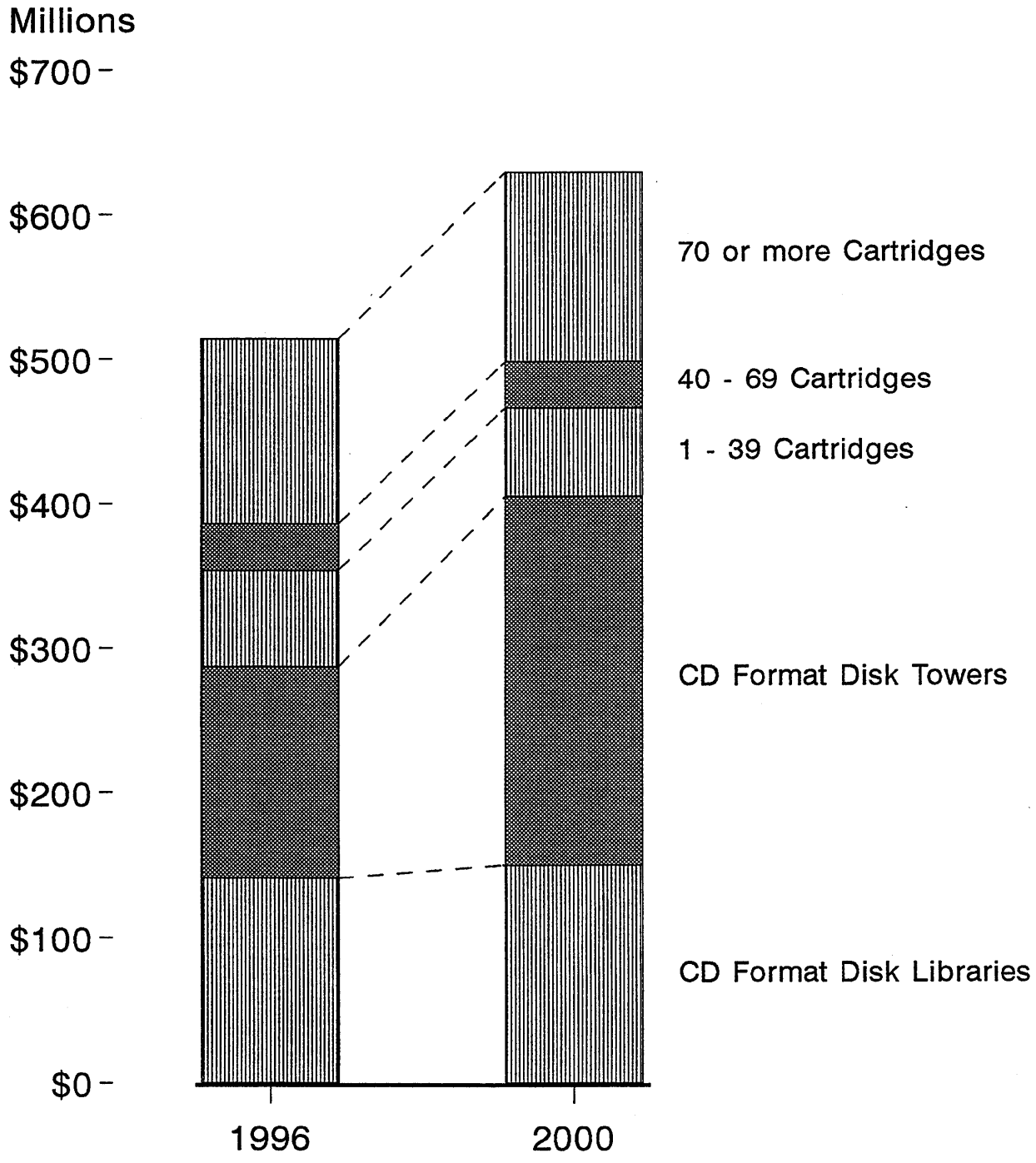


Figure 2

CHANGING PRODUCT MIX

Worldwide Optical Library Revenue



Marketing channels

Marketing channels used by optical drive and library manufacturers are defined in this report as Captive, PCM/Distributor, and OEM/Integrator. Captive drives, libraries and towers are sold as part of systems that are manufactured by the same company. The PCM/Distributor channel includes drives, libraries and towers 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/Distributor 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, libraries and towers sold to system manufacturers and system integrators to be used as part of computer systems.

OEM/Integrator optical disk drive revenues rose 20.3% in 1996 to almost $3.6 billion, accounting for 61.4% of worldwide sales revenues of $5.86 billion. PCM/Distributor revenues grew 3.6%, and were 26.6% of total revenue, while revenues from the captive channel grew 79.4% and contributed 12% of total revenue. The growth in the captive contribution is a consequence of increasing numbers of CD format drives sold on a captive basis, and the captive channel is expected to maintain this level of contribution throughout the forecast period. The OEM/Integrator and PCM/Distributor channel contributions are also expected to remain relatively close to existing levels, fluctuating only a few percentage points during the forecast period.

1996 optical disk library and tower revenues of $514.2 million from the sales channels split 39.2% from OEM/Integrators, 48.8% from the PCM/Distributor channel, and 12.0% from the captive channel. Towers, added this year, are heavily biased to the PCM/Distributor channel. Anticipated revenues of $628.3 in 2000 will be shared among OEM/Integrators with 35%, PCM/Distributor sales with 58.3% and captive sales with 6.7%. Because of the complex system integration and support requirements of libraries, only the simplest types are offered by many resellers, but towers, especially the net attached type, are easily resold, requiring minimal technical support, and favor the PCM/Distributor channel. Consequently, the PCM/Distributor share of revenues is forecasted to increase at a faster rate than OEM/Integrator 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/Distributor or

OEM/Integrator levels. Drive prices are based on disk drives alone, without separate controllers or other accessories. Library prices are for the library only and do not include the disk drives or external controllers unless the library is sold only with drives bundled in.

Industry participation

Industry participants are classified as U.S., Asian or European, depending upon the geographical composition of their majority ownership. Six U.S. companies, 44 Asian firms and three European manufacturers currently compete in the optical disk drive market. Over the years, Asian producers have steadily increased their presence, mostly with CD-ROM drives. Most of the new CD-ROM manufacturers are in Southeast Asia and Taiwan. Both U.S. and Asian firms are having drives made on a contract basis by other Asian producers, with an increasing number being made in China.

As of mid-1997, 38 companies produce CD-ROM drives, 36 are non-U.S. firms and 14 are Japanese organizations. 15 manufacturers make read/write drives less than 2 gigabytes: all of these make rewritable drives. Six companies make, or have announced, optical disk drives of more than 2 gigabytes capacity. 14 companies make 5.25" drives, and three provide 3.5" drives. But one firm supplies 12" rewritable drives, and the remaining six firms produce only 12" write-once drives.

36 U.S. firms, 18 Asian manufacturers and 10 European suppliers offer optical libraries or towers. Of the 64 companies, 23 make CD format libraries: 8 of these do not participate in other product groups. Elms Systems is a new U.S. manufacturer in this product segment. 29 firms make CD format towers. Of these, 11 produce only net attached towers, two produce only host attached towers and the remainder make both types.

Of the 24 read/write library producers, 14 firms make only 5.25" libraries, while six make larger diameter libraries. Only two companies make a 3.5" library. Two firms make read/write library models in two or more disk drive diameters. Two firms, Borett Automation and EMASS, have designed libraries that can handle multiple types of drives and media simultaneously; others are expected to offer this capability.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1996 Revenues $M	1996 Revenues %	Forecast 1997 $M	Forecast 1997 %	Forecast 1998 $M	Forecast 1998 %	Forecast 1999 $M	Forecast 1999 %	Forecast 2000 $M	Forecast 2000 %
U.S. Manufacturers										
Captive	28.0 -71.5%	.4%	6.0 -78.6%	--	5.8 -3.3%	--	8.4 +44.8%	--	10.8 +28.6%	.1%
PCM/Distributor	54.6 -40.4%	.9%	50.3 -7.9%	.6%	49.1 -2.4%	.5%	51.9 +5.7%	.5%	78.6 +51.4%	.7%
OEM/Integrator	16.9 -50.6%	.2%	27.8 +64.5%	.3%	20.5 -26.3%	.2%	34.1 +66.3%	.3%	64.9 +90.3%	.6%
Total U.S. Manufacturers	99.5 -55.6%	1.5%	84.1 -15.5%	.9%	75.4 -10.3%	.7%	94.4 +25.2%	.8%	154.3 +63.5%	1.4%
Non-U.S. Manufacturers										
Captive	677.2 +129.9%	11.5%	797.3 +17.7%	10.9%	875.5 +9.8%	10.4%	1,036.2 +18.4%	11.1%	1,209.5 +16.7%	11.7%
PCM/Distributor	1,504.5 +6.5%	25.6%	1,715.5 +14.0%	23.6%	2,049.9 +19.5%	24.5%	2,399.0 +17.0%	25.7%	2,828.5 +17.9%	27.3%
OEM/Integrator	3,580.7 +21.2%	61.4%	4,652.2 +29.9%	64.6%	5,353.3 +15.1%	64.4%	5,797.4 +8.3%	62.4%	6,139.0 +5.9%	59.6%
Total Non-U.S. Manufacturers	5,762.4 +23.6%	98.5%	7,165.0 +24.3%	99.1%	8,278.7 +15.5%	99.3%	9,232.6 +11.5%	99.2%	10,177.0 +10.2%	98.6%
Worldwide Recap										
Captive	705.2 +79.4%	12.0%	803.3 +13.9%	11.1%	881.3 +9.7%	10.5%	1,044.6 +18.5%	11.2%	1,220.3 +16.8%	11.8%
PCM/Distributor	1,559.1 +3.6%	26.6%	1,765.8 +13.3%	24.4%	2,099.0 +18.9%	25.1%	2,450.9 +16.8%	26.3%	2,907.1 +18.6%	28.1%
OEM/Integrator	3,597.6 +20.3%	61.4%	4,680.0 +30.1%	64.5%	5,373.8 +14.8%	64.4%	5,831.5 +8.5%	62.5%	6,203.9 +6.4%	60.1%
Total All Manufacturers	5,861.9 +20.0%	100.0%	7,249.1 +23.7%	100.0%	8,354.1 +15.2%	100.0%	9,327.0 +11.6%	100.0%	10,331.3 +10.8%	100.0%

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

TABLE 4

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK LIBRARIES AND TOWERS
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1996 Revenues $M	1996 Revenues %	1997 Forecast $M	1997 Forecast %	1998 Forecast $M	1998 Forecast %	1999 Forecast $M	1999 Forecast %	2000 Forecast $M	2000 Forecast %
U.S. Manufacturers										
Captive	54.0 +29.5%	10.5%	46.0 -14.8%	8.7%	42.0 -8.7%	7.5%	39.3 -6.4%	6.5%	37.3 -5.1%	5.9%
PCM/Distributor	158.3 +294.8%	30.7%	198.9 +25.6%	37.9%	213.0 +7.1%	38.1%	232.3 +9.1%	38.9%	248.5 +7.0%	39.5%
OEM/Integrator	75.6 +10.0%	14.7%	80.3 +6.2%	15.3%	83.3 +3.7%	14.9%	87.7 +5.3%	14.7%	90.4 +3.1%	14.3%
Total U.S. Manufacturers	287.9 +91.3%	55.9%	325.2 +13.0%	61.9%	338.3 +4.0%	60.5%	359.3 +6.2%	60.1%	376.2 +4.7%	59.7%
Non-U.S. Manufacturers										
Captive	7.6 -50.6%	1.4%	7.4 -2.6%	1.4%	4.2 -43.2%	.7%	4.5 +7.1%	.7%	4.7 +4.4%	.7%
PCM/Distributor	92.4 +40.6%	17.9%	88.2 -4.5%	16.8%	102.5 +16.2%	18.3%	110.6 +7.9%	18.5%	117.7 +6.4%	18.7%
OEM/Integrator	126.3 +9.4%	24.8%	103.8 -17.8%	19.9%	113.0 +8.9%	20.5%	122.1 +8.1%	20.7%	129.7 +6.2%	20.9%
Total Non-U.S. Manufacturers	226.3 +15.1%	44.1%	199.4 -11.9%	38.1%	219.7 +10.2%	39.5%	237.2 +8.0%	39.9%	252.1 +6.3%	40.3%
Worldwide Recap										
Captive	61.6 +7.9%	12.0%	53.4 -13.3%	10.2%	46.2 -13.5%	8.3%	43.8 -5.2%	7.3%	42.0 -4.1%	6.7%
PCM/Distributor	250.7 +137.0%	48.8%	287.1 +14.5%	54.7%	315.5 +9.9%	56.5%	342.9 +8.7%	57.5%	366.2 +6.8%	58.3%
OEM/Integrator	201.9 +9.6%	39.2%	184.1 -8.8%	35.1%	196.3 +6.6%	35.2%	209.8 +6.9%	35.2%	220.1 +4.9%	35.0%
Total All Manufacturers	514.2 +48.1%	100.0%	524.6 +2.0%	100.0%	558.0 +6.4%	100.0%	596.5 +6.9%	100.0%	628.3 +5.3%	100.0%

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

Product mix

Optical disk drive shipments rose 36.1% to nearly 58.4 million units in 1996, with CD format read-only drives again contributing most of the unit growth, accounting for nearly 55.6 million units (95.3%) of the 1996 worldwide shipment total. However, the overall share for read-only CD format drives is forecasted to decrease to 93.6% in 2000 as shipments of writable CD format drives climb from 2.4% of 1996 unit shipments to 4.4% of unit shipments in 2000. CD format drive shipments include shipments associated with both computers and freestanding consumer equipment such as games, but not audio or video players. The share of read/write drives under 2 gigabytes grew to 2.3% of worldwide unit shipments in 1996 as the result of stronger 3.5" MO disk drive shipments. The share of read/write drives over 2 gigabytes was under .1%, but is expected to climb to at least .3% as higher capacity drives enter the market starting in 1998. If 5.25" drives over 5 gigabytes in on-line capacity (expected to appear in 1998) are successful, this product segment has potential for explosive future growth.

Within the less than 2 gigabytes group, 5.25" drive shipments shrank slightly due to competition from rigid magnetic drives, but this weak showing was offset by shipment growth of aggressively priced 3.5" drives. Shipments of MO drives in this group will be increasingly impacted by competition from high capacity 3.5" rigid and flexible removable magnetic disk drives, plus CD-RW drives and DVD-RAM drives in the future. CD format writable drive (CD-R, CD-RW and PD) shipments jumped 176% to over 1.4 million units as a result of lower prices for CD-R and improved software and system support for CD-R. Rewritable drives captured virtually all of the less than 2 gigabytes product group shipments in 1996. Write-once drives in this group have all but vanished.

5.25" drive shipments in the more than 2 gigabytes product group exceeded 12" to 14" unit shipments in 1996 and will rapidly increase their lead in future periods. DVD-RAM rewritable drives are expected to compete with drives in this group in 1998 and after, in applications where drive performance is subordinate to drive price and CD format compatibility.

Sales revenues for 1996 came predominantly from shipments in the CD format read-only drive product group, which contributed 79.6% of optical drive sales revenues. CD format writable drives increased their share to 8.6%, while read/write drives less than 2 gigabytes contributed 10.8% of revenues, followed

by read/write drives more than 2 gigabytes, with 1.0%. The revenue share for CD format read-only drives is expected to remain in the same range throughout the forecast period. Writable CD format drive revenues will improve their share, as DVD drives ramp up towards the end of the forecast period, capturing 10.1% revenue share in 2000. Drives under 2 gigabytes will see their revenue share steadily decline as they are displaced by higher capacity drives. Correspondingly, the share for read/write drives over 2 gigabytes is expected to grow yearly starting in 1998, pushed by increasing 5.25" drive shipments.

The performance requirements of multimedia capable systems and the demands of system manufacturers seeking product differentiation have continued to rapidly shift demand toward higher performance drives. The industry has shifted from 8X drives, through 12X drives and 16X drives, to 20X and 24X drives and is poised to move to 32X by year end. Focus is then expected to shift to DVD-ROM, which will exceed CD-ROM shipments in 2000.

CD format optical disk libraries, particularly small autochangers with under 10 disk capacity, again led optical disk library and tower shipments in 1996, attaining a 92.8% share. The next largest segment was the CD format tower, with a 5.1% unit share, followed by the 1 to 39 disk cartridge library, which captured a 1.4% share. Share for the 40 to 69 cartridge library group declined to .2%, while the share of libraries with 70 or more cartridges declined to .5%. The largest year-to-year growth rate was exhibited by CD-ROM format libraries (over 102%).

Within the tower segment, there is a gradual shift to towers with larger numbers of drives anticipated, but it is constrained by the arrival of higher capacity DVD-ROM drives, which reduces the number of drives needed in some applications. A more rapid shift from host attached to network attached towers is occurring, driven by a desire for simple installation and minimal support and the availability of increasingly competent, yet inexpensive network server/controllers.

Optical library sales revenues of $514.2 million in 1996 were split by CD format towers (28.4%), CD format libraries (27.5%), the 70 or more cartridge group (24.9%), followed distantly by the 1 to 39 cartridge group (12.9%), and the 40 to 69 cartridge group with 6.2%. Towers are expected to continue to hold the leading revenue share because of their higher prices relative to the average CD format library and their higher shipment levels relative to other types of libraries.

TABLE 5

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1996		Forecast							
ALL MANUFACTURERS	Revenues		1997		1998		1999		2000	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT READ-ONLY	4,660.9	79.6%	5,883.8	81.3%	6,812.0	81.6%	7,572.8	81.3%	8,360.6	81.0%
	+16.3%		+26.2%		+15.8%		+11.2%		+10.4%	
CD FORMAT WRITABLE	501.9	8.6%	613.8	8.5%	756.5	9.1%	898.5	9.6%	1,039.6	10.1%
	+79.7%		+22.3%		+23.2%		+18.8%		+15.7%	
READ/WRITE	635.0	10.8%	682.1	9.4%	665.8	8.0%	612.5	6.6%	477.5	4.6%
LESS THAN 2 GIGABYTES	+23.3%		+7.4%		-2.4%		-8.0%		-22.0%	
READ/WRITE	64.1	1.0%	69.4	.8%	119.8	1.3%	243.2	2.5%	453.6	4.3%
MORE THAN 2 GIGABYTES	-25.4%		+8.3%		+72.6%		+103.0%		+86.5%	
Total Worldwide Revenue	5,861.9	100.0%	7,249.1	100.0%	8,354.1	100.0%	9,327.0	100.0%	10,331.3	100.0%
	+20.0%		+23.7%		+15.2%		+11.6%		+10.8%	

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

TABLE 6

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK LIBRARIES AND TOWERS
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1996		Forecast							
ALL MANUFACTURERS	Revenues		1997		1998		1999		2000	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT OPTICAL LIBRARIES	141.4	27.5%	116.0	22.1%	128.8	23.1%	139.5	23.4%	149.5	23.8%
	+57.1%		-18.0%		+11.0%		+8.3%		+7.2%	
CD FORMAT TOWERS	146.0	28.4%	188.4	35.9%	208.8	37.4%	234.4	39.3%	255.3	40.6%
	--		+29.0%		+10.8%		+12.3%		+8.9%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	66.5	12.9%	64.7	12.3%	63.7	11.4%	61.9	10.4%	61.2	9.7%
	-20.5%		-2.7%		-1.5%		-2.8%		-1.1%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	32.1	6.2%	30.8	5.9%	31.7	5.7%	32.0	5.4%	31.5	5.0%
	+17.6%		-4.0%		+2.9%		+.9%		-1.6%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	128.2	24.9%	124.7	23.8%	125.0	22.4%	128.7	21.5%	130.8	20.8%
	-12.3%		-2.7%		+.2%		+3.0%		+1.6%	
Total Worldwide Revenue	514.2	100.0%	524.6	100.0%	558.0	100.0%	596.5	100.0%	628.3	100.0%
	+48.1%		+2.0%		+6.4%		+6.9%		+5.3%	

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

TABLE 7

CONSOLIDATED WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS	1996		Forecast							
IN THOUSANDS	Shipments		1997		1998		1999		2000	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD FORMAT READ-ONLY	55,570.4	95.3%	66,752.9	94.4%	78,179.0	93.8%	88,455.0	93.6%	99,181.0	93.6%
	+33.3%		+20.1%		+17.1%		+13.1%		+12.1%	
CD FORMAT WRITABLE	1,418.5	2.4%	2,239.8	3.2%	3,116.2	3.7%	3,901.0	4.1%	4,702.0	4.4%
	+176.0%		+57.9%		+39.1%		+25.2%		+20.5%	
READ/WRITE	1,398.0	2.3%	1,783.4	2.4%	2,049.3	2.5%	2,099.5	2.2%	1,813.0	1.7%
LESS THAN 2 GIGABYTES	+98.8%		+27.6%		+14.9%		+2.4%		-13.6%	
READ/WRITE	8.9	--	23.9	--	67.6	--	195.8	.1%	432.2	.3%
MORE THAN 2 GIGABYTES	+39.1%		+168.5%		+182.8%		+189.6%		+120.7%	
Total Worldwide Shipments	58,395.8	100.0%	70,800.0	100.0%	83,412.1	100.0%	94,651.3	100.0%	106,128.2	100.0%
	+36.1%		+21.2%		+17.8%		+13.5%		+12.1%	
% U.S. Manufacturers	.1%		.1%		.1%		.1%		.1%	

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

TABLE 8

CONSOLIDATED WORLDWIDE SHIPMENTS
OPTICAL DISK LIBRARIES AND TOWERS
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1996 Shipments Units	1996 Shipments %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %	2000 Forecast Units	2000 Forecast %
CD FORMAT OPTICAL LIBRARIES	681,337	92.8%	456,328	87.8%	504,087	87.3%	542,920	86.9%	571,135	86.4%
	+102.2%		-33.0%		+10.5%		+7.7%		+5.2%	
CD FORMAT TOWERS	37,523	5.1%	47,260	9.1%	56,297	9.7%	64,282	10.3%	71,605	10.8%
	--		+25.9%		+19.1%		+14.2%		+11.4%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	10,477	1.4%	10,343	2.0%	10,313	1.8%	10,366	1.7%	10,502	1.6%
	-18.1%		-1.3%		-.3%		+.5%		+1.3%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	1,639	.2%	1,812	.3%	1,954	.3%	2,092	.3%	2,197	.3%
	+.4%		+10.6%		+7.8%		+7.1%		+5.0%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	4,190	.5%	4,666	.8%	5,141	.9%	5,608	.8%	6,005	.9%
	+3.0%		+11.4%		+10.2%		+9.1%		+7.1%	
Total Worldwide Shipments	735,166	100.0%	520,409	100.0%	577,792	100.0%	625,268	100.0%	661,444	100.0%
	+106.8%		-29.2%		+11.0%		+8.2%		+5.8%	
% U.S. Manufacturers	7.7%		11.3%		10.8%		10.8%		11.0%	

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

Figure 3

WORLDWIDE SHIPMENT SUMMARY

Total Optical Disk Drives

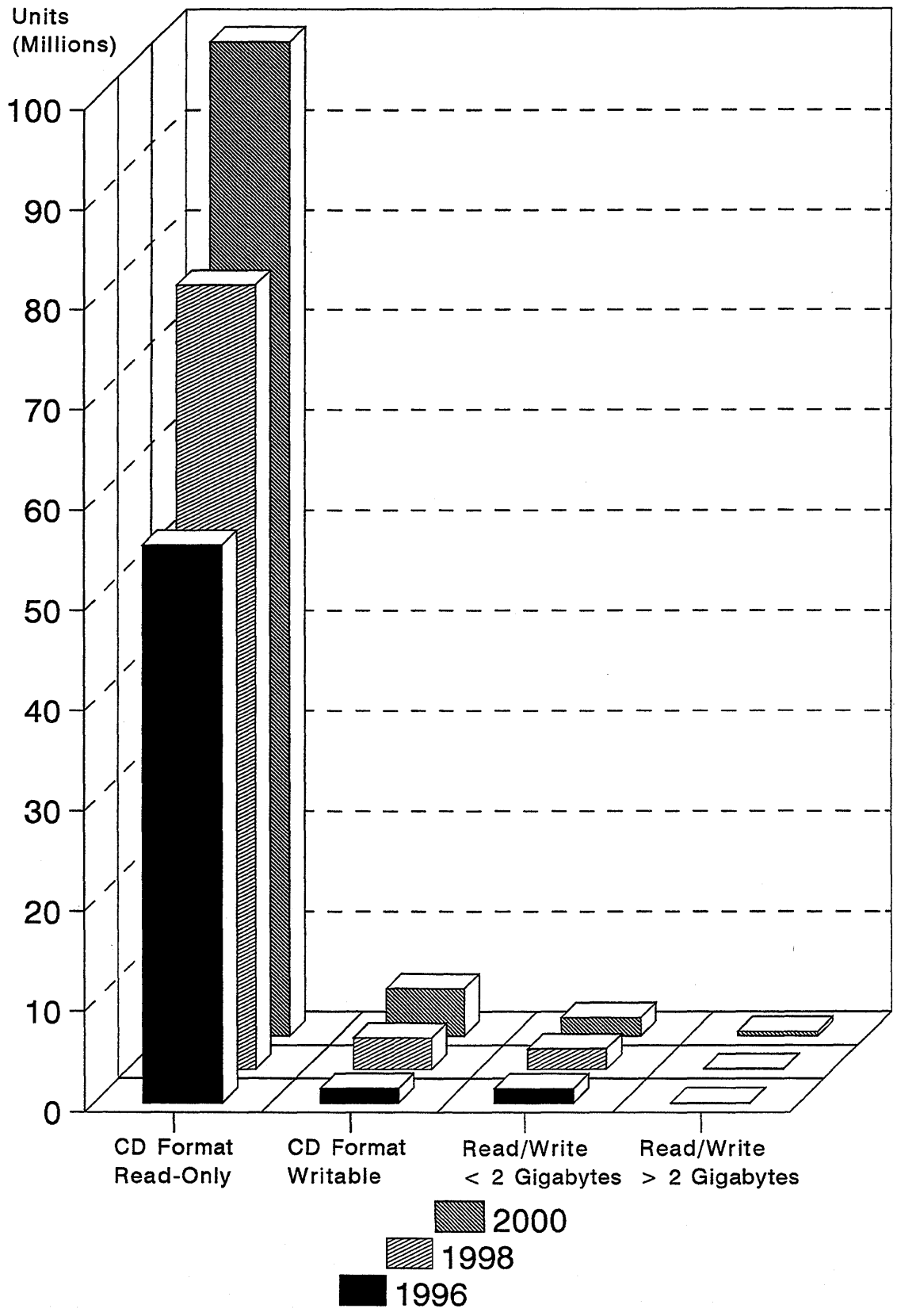
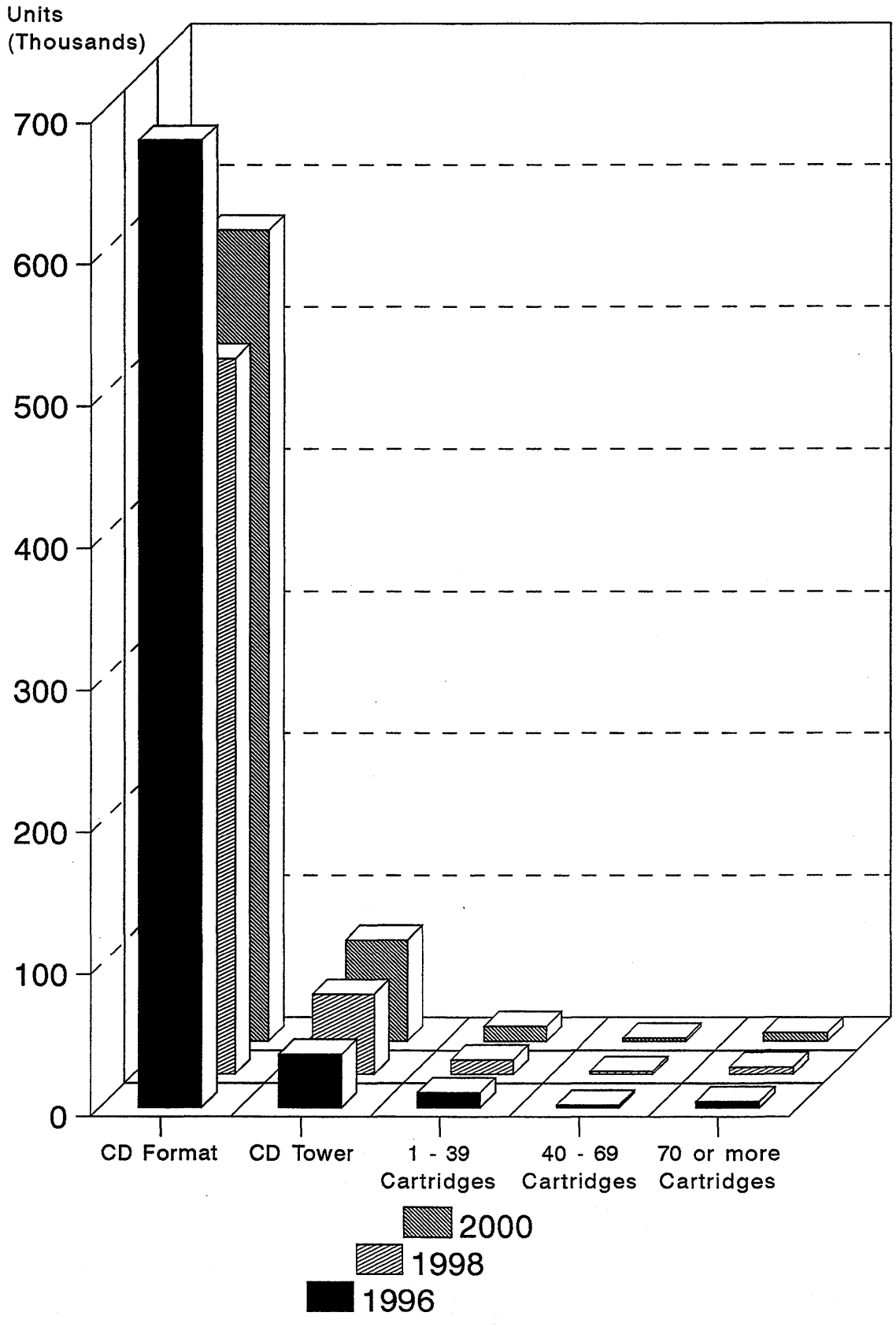


Figure 4

WORLDWIDE SHIPMENT SUMMARY

Total Optical Libraries



Noncaptive market

System manufacturers continued to gobble up CD-ROM disk drives in 1996, increasing the CD format read-only portion of the noncaptive optical disk drive total (OEM/Integrator and PCM/Distributor distribution channels) to 95% of the 53.6 million noncaptive units shipped in 1996. Shipments of CD format writable drives accounted for 2.6%, while the share of read/write drives less than 2 gigabytes rose to 2.4% of noncaptive optical disk drive total unit shipments. The share for read/write drives over 2 gigabytes was again less than .1%.

Strong demand from PC and game manufacturers is expected to drive growth in CD format drive shipments, but the CD format read-only noncaptive shipment market share will decline slightly toward the end of the forecast period as shipments of rewritable CD format drives increase.

CD format drives captured 78.9% of 1996 noncaptive revenues, while CD format writable drives collected 9.1% of the noncaptive revenues. The revenue share for read/write drives less than 2 gigabytes rose to 11%, while read/write drives more than 2 gigabytes saw their share decline again to 1%. Noncaptive revenues of over $9.1 billion in 2000 will again largely go to CD format read-only drives, which are expected to capture 80.2% of the total, followed by CD format writable drives with 10.6% and read/write drives less than 2 gigabytes with 4.9%. Drives more than 2 gigabytes will increase in noncaptive revenue share to 4.3%, as the result of increasing shipments of higher capacity 5.25" drives.

The leading OEM/Integrator drive revenue producers in 1996 were Matsushita Electric, Mitsumi Electric, Sony, Toshiba and Hitachi, in that order. The top five companies accounted for 67.1% of total OEM/Integrator sales of nearly $3.6 billion, again down slightly from the previous year. Matsushita Electric led with 26.8% of the OEM/Integrator total. The reduced share held by the top five OEM channel manufacturers reflects a market increasingly under assault by second tier drive suppliers in Korea, Taiwan and Southeast Asia. Fujitsu has taken the lead in PCM/Distributor sales as a result of its success in boosting 3.5" MO drive sales. Other major participants were LG Electronics, NEC, Hitachi, and Sony. The top five together hold a 45.6% (down from 56.5%) share of the $1.5 billion sales in this channel. U.S. producers captured only .5% of total 1996 OEM/Integrator revenues, a decline from 1995, and also saw their share of PCM/Distributor revenues decline to 3.5%.

Despite the very strong growth of the OEM oriented CD-ROM and DVD-ROM drive market, captive revenues are expected to pretty much keep pace with noncaptive revenues throughout the forecast period, due to generally higher captive price levels and new products from system makers incorporating drives of their own manufacture. Manufacturers contributing to this anticipated trend include Toshiba, Sony, NEC, Matsushita Electric, Hitachi, and others.

1996 CD format library shipments claimed 93% of over 733,000 noncaptive optical libraries and towers shipped, followed by CD format towers (5.2%), and 1-39 cartridge libraries (1.2% share). The other product groups had less than 1% share. The CD format library is expected to retain its dominance through 2000, holding 86.7% share at that time. CD format towers will expand share to 10.9%, and the 1-39 cartridge libraries will grow slightly to 1.4%. Noncaptive shipments of the other library groups are expected to grow slightly during the period.

Noncaptive library revenues grew to $452.6 million in 1996 and are anticipated to exceed $586 million in 2000. Because of their higher prices, revenue shares for towers and larger libraries exceeded their unit shipment shares. The CD tower product group led with 32.3%, followed by CD format libraries with 31.3%, the more than 70 cartridge segment with 20.2%, and the 1-39 cartridge segment with 12.2% share. The 40-69 disk product group had 4% share. The optical disk library groups lost ground relative to other groups as a result of the inclusion of CD format towers in the report for the first time strong, competition from high capacity 5.25" magnetic disk drives and the strong growth of the CD format libraries. The CD format towers are expected to capture over 43% of noncaptive revenues in 2000, followed by the CD format libraries (25.6%) and the more than 70 cartridge group with 18.5%. Moderate share declines are forecasted for the other two groups as well.

U.S. library and tower manufacturers captured 37.4% of the OEM/Integrator channel revenues and 63.1% of the PCM/Distributor channel revenues in 1996. Nakamichi, Hewlett-Packard, and Eastman Kodak were the leading OEM/Integrator suppliers, accounting for 51.3% of $201.9 million channel revenues between them. In the PCM/Distributor channel, Hewlett-Packard, Procom, Meridian Data, Nakamichi and Microtest were the leaders, together capturing 54.3% of over $250 million sales in the channel.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1996		Forecast							
ALL MANUFACTURERS	Revenues		1997		1998		1999		2000	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT READ-ONLY	4,066.0	78.9%	5,163.8	80.2%	6,034.8	80.9%	6,647.6	80.4%	7,298.6	80.2%
	+7.8%		+27.0%		+16.9%		+10.2%		+9.8%	
CD FORMAT WRITABLE	468.9	9.1%	586.0	9.1%	710.7	9.5%	847.5	10.2%	968.1	10.6%
	+79.2%		+25.0%		+21.3%		+19.2%		+14.2%	
READ/WRITE	566.5	11.0%	634.4	9.8%	628.6	8.4%	580.1	7.0%	445.5	4.9%
LESS THAN 2 GIGABYTES	+46.2%		+12.0%		-.9%		-7.7%		-23.2%	
READ/WRITE	55.3	1.0%	61.6	.9%	98.7	1.2%	207.2	2.4%	398.8	4.3%
MORE THAN 2 GIGABYTES	-25.5%		+11.4%		+60.2%		+109.9%		+92.5%	
Total Worldwide Revenues	5,156.7	100.0%	6,445.8	100.0%	7,472.8	100.0%	8,282.4	100.0%	9,111.0	100.0%
	+14.8%		+25.0%		+15.9%		+10.8%		+10.0%	

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

TABLE 10

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK LIBRARIES AND TOWERS
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1996		Forecast							
ALL MANUFACTURERS	Revenues		1997		1998		1999		2000	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT OPTICAL LIBRARIES	141.4	31.3%	116.0	24.7%	128.8	25.3%	139.5	25.3%	149.5	25.6%
	+57.1%		-18.0%		+11.0%		+8.3%		+7.2%	
CD FORMAT TOWERS	146.0	32.3%	188.4	40.0%	208.8	40.8%	234.4	42.4%	255.3	43.5%
	--		+29.0%		+10.8%		+12.3%		+8.9%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	55.1	12.2%	54.3	11.5%	53.8	10.5%	52.5	9.5%	51.8	8.9%
	-19.9%		-1.5%		-.9%		-2.4%		-1.3%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	18.0	4.0%	18.4	3.9%	19.4	3.8%	20.0	3.7%	20.4	3.5%
	-1.1%		+2.2%		+5.4%		+3.1%		+2.0%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	92.1	20.2%	94.1	19.9%	101.0	19.6%	106.3	19.1%	109.3	18.5%
	-18.5%		+2.2%		+7.3%		+5.2%		+2.8%	
Total Worldwide Revenues	452.6	100.0%	471.2	100.0%	511.8	100.0%	552.7	100.0%	586.3	100.0%
	+56.1%		+4.1%		+8.6%		+8.0%		+6.1%	

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

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1996 Shipments Units	1996 Shipments %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %	2000 Forecast Units	2000 Forecast %
CD FORMAT READ-ONLY	50,863.4	95.0%	61,390.8	94.1%	72,149.0	93.5%	81,925.0	93.2%	91,311.0	93.2%
	+25.9%		+20.7%		+17.5%		+13.5%		+11.5%	
CD FORMAT WRITABLE	1,363.5	2.6%	2,189.8	3.3%	3,062.2	4.0%	3,841.0	4.4%	4,592.0	4.7%
	+180.0%		+60.6%		+39.8%		+25.4%		+19.6%	
READ/WRITE LESS THAN 2 GIGABYTES	1,340.4	2.4%	1,725.3	2.6%	1,983.3	2.5%	2,027.5	2.3%	1,733.0	1.8%
	+116.3%		+28.7%		+15.0%		+2.2%		-14.5%	
READ/WRITE MORE THAN 2 GIGABYTES	8.5	--	23.6	--	61.3	--	183.5	.1%	409.8	.3%
	+44.1%		+177.6%		+159.7%		+199.3%		+123.3%	
Total Worldwide Shipments	53,575.8	100.0%	65,329.5	100.0%	77,255.8	100.0%	87,977.0	100.0%	98,045.8	100.0%
	+29.1%		+21.9%		+18.3%		+13.9%		+11.4%	
% U.S. Manufacturers	.1%		.1%		.1%		.1%		.2%	

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

TABLE 12

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL DISK LIBRARIES AND TOWERS
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1996 Shipments Units	1996 Shipments %	1997 Units	1997 %	1998 Units	1998 %	Forecast 1999 Units	Forecast 1999 %	Forecast 2000 Units	Forecast 2000 %
CD FORMAT OPTICAL LIBRARIES	681,337	93.0%	456,328	88.1%	504,087	87.7%	542,920	87.2%	571,135	86.7%
	+102.2%		-33.0%		+10.5%		+7.7%		+5.2%	
CD FORMAT TOWERS	37,523	5.2%	47,260	9.2%	56,297	9.7%	64,282	10.3%	71,605	10.9%
	--		+25.9%		+19.1%		+14.2%		+11.4%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	9,136	1.2%	9,090	1.7%	9,098	1.6%	9,175	1.5%	9,296	1.4%
	-19.2%		-.5%		--		+.8%		+1.3%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	1,360	.2%	1,507	.3%	1,615	.3%	1,725	.3%	1,817	.3%
	-2.2%		+10.8%		+7.2%		+6.8%		+5.3%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	3,705	.4%	4,176	.7%	4,666	.7%	5,124	.7%	5,512	.7%
	+2.2%		+12.7%		+11.7%		+9.8%		+7.6%	
Total Worldwide Shipments	733,061	100.0%	518,361	100.0%	575,763	100.0%	623,226	100.0%	659,365	100.0%
	+107.5%		-29.3%		+11.1%		+8.2%		+5.8%	
% U.S. Manufacturers	7.5%		11.0%		10.5%		10.6%		10.8%	

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

Figure 5

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Disk Drives

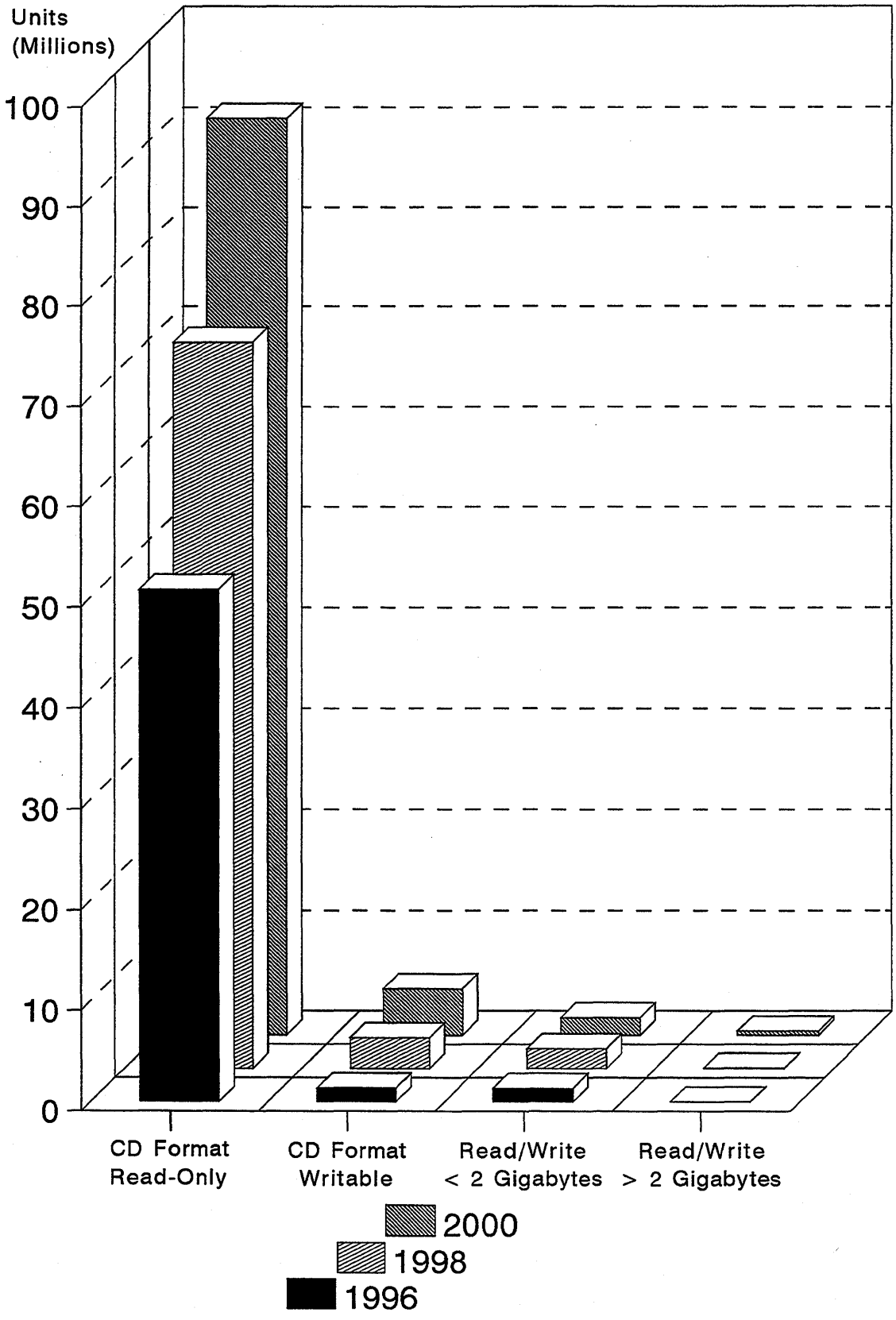


Figure 6

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Libraries

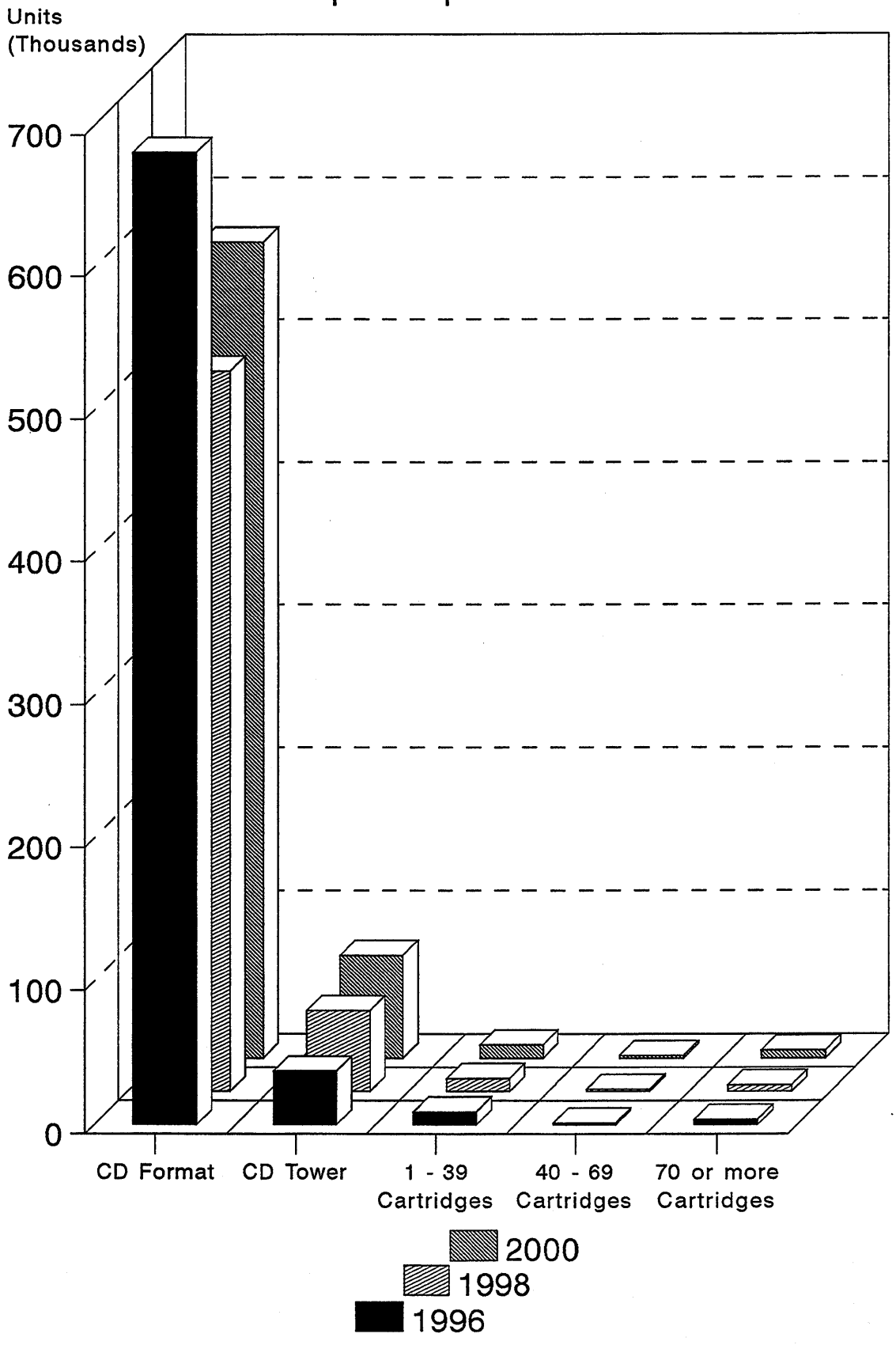
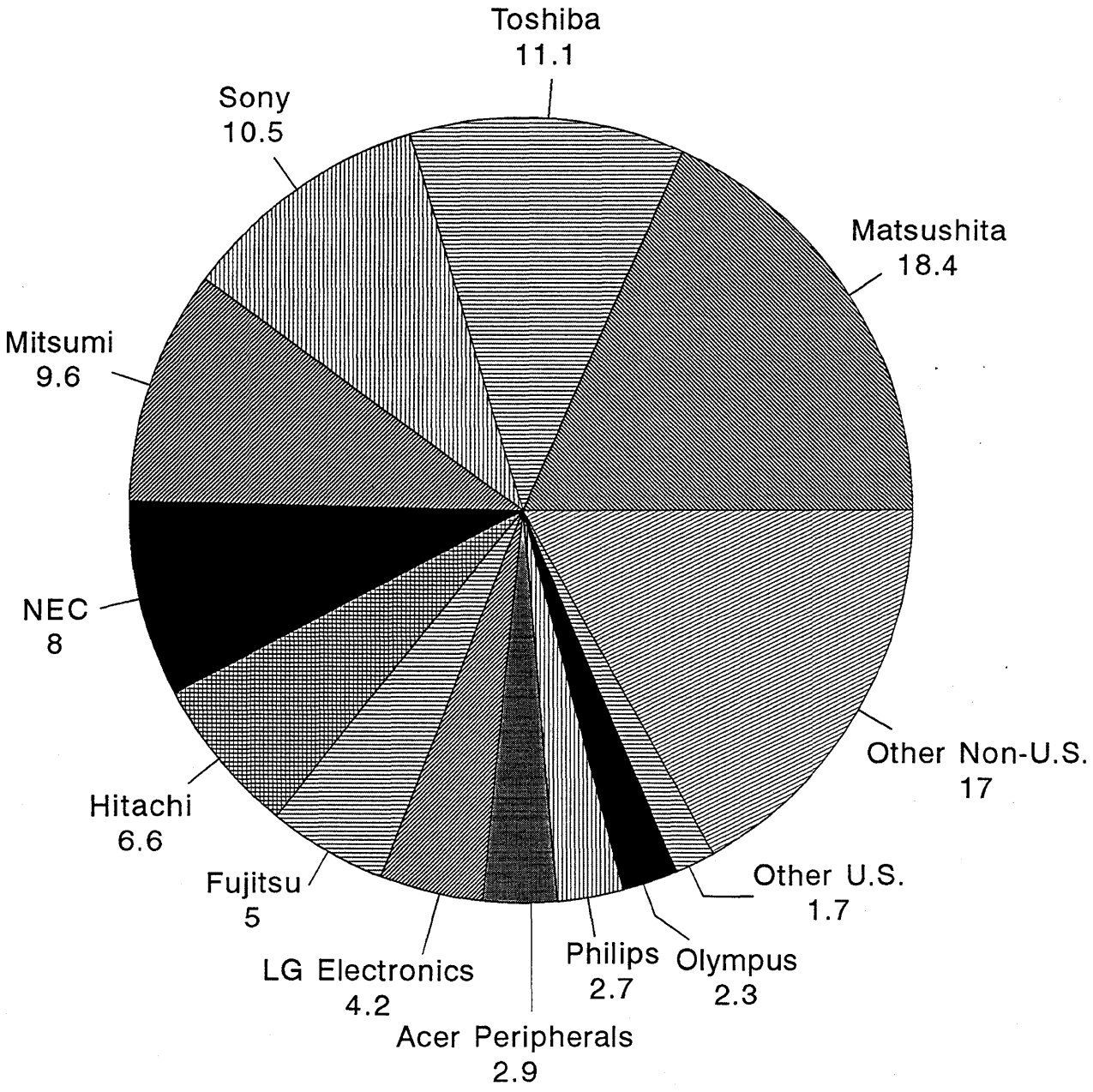


Figure 7

1996 ESTIMATED MARKET SHARES

Worldwide Revenue Percentages of all Optical Disk Drives



1996 Revenues: $5,861,900,000

TABLE 13

1996 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK DRIVES
(Value of non-U.S. currencies estimated at average 1996 rates)

	CAPTIVE		PCM/DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
U.S. Total	28.0	4.0	54.6	3.5	16.9	.5	99.5	1.7
NON-U.S. MANUFACTURERS								
Acer Peripherals	--	--	54.1	3.5	116.7	3.2	170.8	2.9
Fujitsu	16.2	2.3	264.6	17.0	9.5	.3	290.3	5.0
Hitachi	38.7	5.5	97.1	6.2	252.0	7.0	387.8	6.6
LG Electronics	15.2	2.2	155.1	9.9	75.7	2.1	246.0	4.2
Matsushita Electric Industrial	49.9	7.1	66.1	4.2	963.9	26.8	1,079.9	18.4
Mitsumi Electric	--	--	70.8	4.5	490.1	13.6	560.9	9.6
NEC	121.8	17.3	110.8	7.1	236.3	6.6	468.9	8.0
Olympus	--	--	49.2	3.2	84.7	2.4	133.9	2.3
Philips	--	--	78.9	5.0	80.7	2.3	159.6	2.7
Sony	145.2	20.6	84.5	5.4	386.4	10.7	616.1	10.5
Toshiba	267.6	37.9	60.5	3.9	323.9	9.0	652.0	11.1
Other Non-U.S.	22.6	3.2	412.8	26.5	560.8	15.5	996.2	17.0
Non-U.S. Total	677.2	96.0	1,504.5	96.5	3,580.7	99.5	5,762.4	98.3
WORLDWIDE TOTAL	705.2	100.0	1,559.1	100.0	3,597.6	100.0	5,861.9	100.0

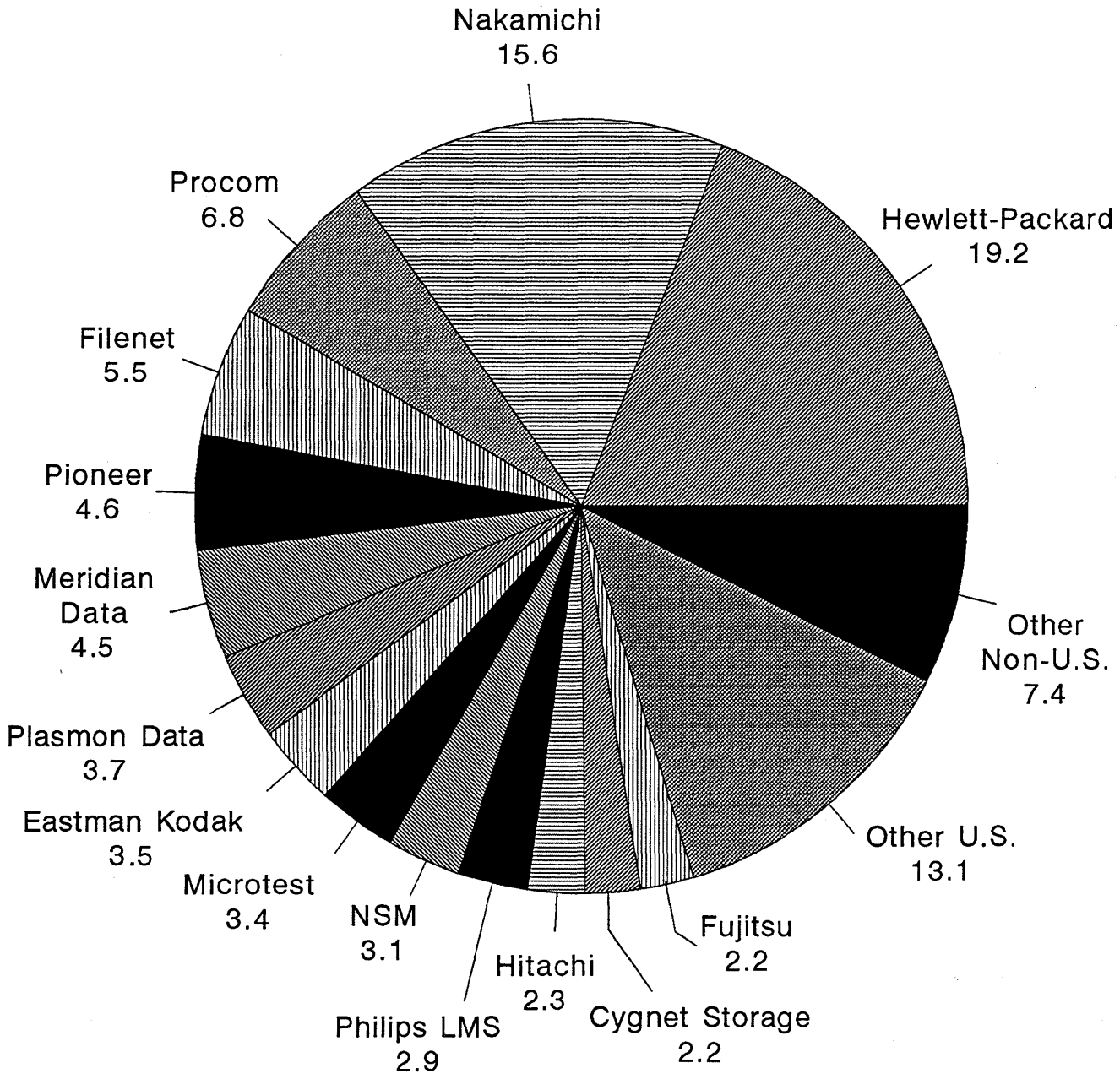
Note: 1. Drives sold in the PCM/Distributor market by other than the original manufacturer are valued at PCM/Distributor prices above, to avoid distortion of total market value.

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.

Figure 8

1996 ESTIMATED MARKET SHARES

Worldwide Revenue Percentages of all Optical Disk Libraries and Towers



1996 Revenues: $514,200,000

TABLE 14

1996 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK LIBRARIES AND TOWERS
(Value of non-U.S. currencies estimated at average 1996 rates)

	CAPTIVE		PCM/DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Eastman Kodak	7.2	11.7	--	--	10.6	5.3	17.8	3.5
Filenet	26.4	42.9	--	--	1.8	.9	28.2	5.5
Hewlett-Packard	20.4	33.1	48.0	19.1	30.4	15.1	98.8	19.2
Meridian Data	--	--	23.1	9.2	--	--	23.1	4.5
Microtest	--	--	15.8	6.3	1.9	.9	17.7	3.4
Procom	--	--	31.4	12.5	3.4	1.7	34.8	6.8
Other U.S.	--	--	40.0	16.0	27.5	13.6	67.5	13.1
U.S. Total	54.0	87.7	158.3	63.1	75.6	37.4	287.9	56.0
NON-U.S. MANUFACTURERS								
Cygnet Storage Solutions	--	--	1.1	.4	10.3	5.1	11.4	2.2
Fujitsu	--	--	10.8	4.3	.6	.3	11.4	2.2
Hitachi	6.1	9.9	.6	.2	4.9	2.4	11.6	2.3
Nakamichi	--	--	18.0	7.2	62.4	30.9	80.4	15.6
NSM	--	--	12.5	5.0	3.2	1.6	15.7	3.1
Philips LMS	--	--	6.5	2.6	8.4	4.2	14.9	2.9
Pioneer	--	--	13.6	5.4	10.1	5.0	23.7	4.6
Plasmon Data	--	--	11.9	4.7	7.3	3.6	19.2	3.7
Other Non-U.S.	1.5	2.4	17.4	6.9	19.1	9.5	38.0	7.4
Non-U.S. Total	7.6	12.3	92.4	36.9	126.3	62.6	226.3	44.0
WORLDWIDE TOTAL	61.6	100.0	250.7	100.0	201.9	100.0	514.2	100.0

Note: 1. Libraries and towers sold in the PCM/Distributor market by other than the original manufacturer are valued at PCM/Distributor 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.

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

TABLE 15

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL DISK DRIVES

DISK/TREND PRODUCT GROUP:		20	21	22	23
U.S. Manufacturers (6)	Type	CD Format Read-Only Drives	CD Format Writable Drives	Read/Write Optical Drives <2 GB	Read/Write Optical Drives >2 GB
CD-ROM, Inc.	P	12 cm			
Eastman Kodak	C,O,P		12 cm		14
Hewlett-Packard	C,O,P		12 cm	5.25E	
MOST	O,P			5.25E	
Mountain Optech	O	12 cm		3.5E, 5.25E	
Pinnacle Micro	P		12 cm	5.25E	5.25E
Asian Manufacturers (44)					
Acer Peripherals	O,P	12 cm			
ADI	P	12 cm			
Advanced Information (AOpen)	C,O,P	12 cm	12 cm		
Aztech Systems	O,P	12 cm			
Behavior Tech Computer	O,P	12 cm	12 cm		
CyberDrive	O,P	12 cm			
Delta Electronics	O,P	12 cm	12 cm		
Elitegroup Computer Systems	O,P	12 cm			
Fujitsu	O,P			3.5E	
Funai Electric	O	12 cm			
Hitachi	C,O,P	12 cm	12 cm	5.25E	
Hopax Industries	O,P	12 cm			
IMES	O,P	12 cm			
JVC	O		12 cm		
Kubota	O			5.25E	
LG Electronics	O,P	12 cm			
Lion Optics	O,P	12 cm			
Lite-On Technology	O,P	12 cm			
Matsushita Electric Ind.	C,O,P	12 cm	12 cm		
Maxoptix	O,P			5.25E	
Mitsubishi Electric	O	12 cm			
Mitsumi Electric	O,P	12 cm	12 cm		
NEC	C,O,P	12 cm	12 cm	5.25E	12
Nikon	O,P			5.25E	12E
Ocean Office Automation	P	12 cm			
Olympus Optical	O,P		12 cm	3.5E, 5.25E	
Optics Storage	O,P	12 cm			
Pioneer Electronic	O,P	12 cm	12 cm	5.25E	
Plextor (Shinano Kenshi)	O,P	12 cm	12 cm		
Ricoh	C,O,P		12 cm	5.25E	
Samsung Electronics	O,P	12 cm			
Sanyo Electric	O,P	12 cm	12 cm		
Sharp	O,P			2.5E, 5.25E	
Sony	C,O,P	8 cm,12 cm	12 cm	2.5E,3.5E,5.25E	
Tae Il Media	O	12 cm			
Takaya	O	12 cm			
Tatung	O,P	12 cm			
TEAC	O,P	12 cm	12 cm		
Toshiba	O,P	12 cm			
Unitron	O,P	12 cm			
USDrives	O,P	12 cm			
Wearnes Peripherals	O,P	12 cm	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 AND CD-ROM TOWERS

Codes: C = Captive
O = OEM/Integrator
P = PCM/Distributor
H = Host attached
N = Net attached

DISK/TREND PRODUCT GROUP:		50	51	52	53	54
U.S. Manufacturers (36)	Type	CD Format Optical Libraries	CD Format Towers	Read/Write Optical Libraries 1-39 Disks	Read/Write Optical Libraries 40-69 Disks	Read/Write Optical Libraries 70+ Disks
Advanced Media Services	O,P		H,N			
Adaptive Information Systems	O,P				5.25	5.25
Atronics	O,P		N			
Axonix	O,P		N			
Boffin	P		H,N			
CD International	P		H,N			
Cherub	P	12 cm				
CMS Peripherals	P		N			
Cutting Edge	P		H,N			
DISC	O	12 cm			5.25	5.25
Dynatek Automation (Canada)	P		N			
Eastman Kodak	C,O,P	12 cm				14
Elms Systems	P	12 cm				
EMASS	O,P					5.25
Excel Computer	O,P		H,N			
FileNet	C,O				12	12
Hewlett-Packard	C,O,P			5.25	5.25	5.25
IBM	C,O,P			5.25	5.25	5.25
Kintronics	P		H,N			
Kubik Enterprises	O	12 cm				5.25
Legacy Storage Systems	O,P		H,N			
Meridian Data	O,P		H,N			
Micro Design International	O,P		H,N			
Microtest	O,P		N			
Network Storage Solutions	P		N			
Optical Access International	O,P		H,N			
Plextec (Canada)	O,P		H,N			
Procom Technology	O,P		H,N			
Regal Electronics	O,P	12 cm				
Smart and Friendly	P		H			
SMS Data Products	O,P		H,N			
TAC Systems	O,P		H,N			
Ten X Technology	O,P		N			
TiltRac	O,P	12 cm				
Todd Enterprises	O,P	12 cm	H,N			
Vision Computers	P		H,N			

TABLE 16 (Continued)

DISK/TREND PRODUCT GROUP:	50	51	52	53	54
	Type	CD Format Optical Libraries	CD Format Towers	Read/Write Optical Libraries 1-39 Disks	Read/Write Optical Libraries 40-69 Disks	Read/Write Optical Libraries 70+ Disks
Asian Manufacturers (18)						
Allion Computer	O,P		N			
Fujitsu	C,O			3.5, 5.25		5.25
Hitachi	C,O,P			5.25	5.25	5.25
JVC	O,P	12 cm				
Kubota	O			5.25	5.25	
Matsushita Electric Ind.	O,P	12 cm				
Maxoptix	O,P			5.25	5.25	
Nakamichi	O,P	12 cm				
NEC	C	12 cm		5.25	5.25	5.25
Nippon Columbia (Denon)	O,P	12 cm				
Nistec	P	12 cm				
PFU	O,P			3.5		
Pioneer	O,P	12 cm				
Plextor (Shinano Kenshi)	O,P		H,N			
Rexas	P		H			
Sony	O,P	12 cm		5.25	5.25	5.25
TEAC	O,P	12 cm				
Tekram	O,P		N			
European Manufacturers (10)						
ASM	O,P	12 cm		5.25	5.25	5.25
ATG Cygnet	O			12		
Cygnet Storage Solutions	O	12 cm		12		12
DSM	O,P	12 cm		12	5.25, 12	5.25, 12
DTS Computer	P		N			
Grundig (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	12 cm		5.25	5.25	5.25
SciNet	P		N			

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

TECHNICAL REVIEW

The optical disk drive industry is going through a period of wrenching changes. The rate of change in CD-ROM drives remains rapid and is making it difficult for the industry to achieve adequate profitability. For writable drives, much higher capacities are coming next year and are welcome. Although the rate of change still lags that of the magnetic drive industry, new technologies promise accelerated capacity improvements and areal density in excess of rigid drive technology. Signs of a merger between the technologies used to construct rigid magnetic drives and optical drives are evident.

Some of the key areas where improvements are occurring are:

* Flying optical heads, operating close to media surfaces and eliminating the need for bulky focus mechanisms, and improving areal density.

* Higher power, higher frequency lasers, for higher areal density.

* Improved ASICs to do specialized coding, compression, or other signal processing functions.

* Denser recording formats, for higher areal density.

* Tighter control of mechanical tolerances for improved performance at higher areal density.

* Reduced susceptibility to hostile environments, especially dust.

* Higher data transfer rates, to support large files and full motion video.

* Direct overwrite for some magneto-optic drives and media.

* Thinner and lower power drives, for use with portable equipment.

Improvements in optical drive technology have not yet countered threats from other technologies. Multigigabyte rigid disk drives continue to decimate the low end of the 5.25" optical drive and library markets, and the new generation of removable magnetic drives with capacities of one gigabyte or more per cartridge is creating heated competition 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, as it has only shown at best an average 40% improvement rate in areal density. Beginning in 1998, new families of magneto-optic drives are expected to begin offering stronger competition, with the prospect of invading markets currently held by tape drives and low performance, multigigabyte magnetic disk drives.

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 (including DVD-ROM), write-once disk drives (including CD-R, and DVD-R), and rewritable disk drives (including MO drives, phase change drives, CD-RW and DVD-RAM).

* CD-ROM and DVD-ROM optical disks: In optical 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.

  Mass production of read-only optical disks is done by a mastering and mass replication process, rather than by recording directly on the disk, so cost per disk is 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 disks require a few additional process steps and more complex equipment to accommodate dual layer media, but single layer replication costs are not likely to be increased unduly by the new format.

  Except for CD format disk drives, (and laser videodisks, not covered in this report) optical read-only (OROM) solutions have not met with success. Read-only memory formats were proposed for 3.5" and 5.25" and 12" media, but were rejected by the industry due to high media costs inappropriate for a distribution medium.

  The read-only optical disk group is dominated by 12 centimeter diameter CD format drives (CD-ROM and DVD-ROM), which have typical on-line capacities of 550 megabytes to 8.5 gigabytes depending upon the format and media used. An 8 centimeter proprietary format CD-ROM made its appearance in 1990 in the Sony "Data Discman", a portable data retrieval system. The few manufacturers attempting to launch an 8 centimeter CD-ROM drive capable of storing 180 to 200 megabytes of data have met no great success to date, although most 12 centimeter drives read 8 centimeter disks. Most CD format drives are equipped with IDE/ATAPI interfaces

and sold to computer manufacturers, although drives are also made with SCSI interfaces for use with servers, optical libraries, CD format disk towers or computers supporting SCSI interfaces.

An increasing number of CD-ROM titles now require more than one disk to hold all of the content, and motion picture storage requires 4 to 5 gigabytes to store a typical movie. Movie video requires a data transfer rate in excess of 3 megabytes per second. This need is addressed by the DVD-ROM, which offers 4.7 gigabytes per surface and is starting to become widely available.

Two contending groups of manufacturers proposed feasible, but incompatible, specifications for DVD drives and reached general agreement in late 1995. The Multi Media CD (MMCD) format, proposed by Sony and Philips, and the Super Density (SD) format, sponsored by Toshiba and Matsushita were blended to reach a joint specification, avoiding a format war, although issues of backward compatibility with CD-R and forward compatibility with DVD-RAM drives have plagued early DVD-ROM models.

DVD drives use shorter wavelength lasers (630 to 650 nanometer), rather than the 780 nanometer lasers used for CD-ROMs, providing smaller spot size and higher areal density and data transfer rates. First generation DVD drives provide approximately 9 times (9X) the data rate of the first CD-ROM drives, but do not offer low average access times. The DVD data transfer rate, about 1.35 megabytes/second, is inferior to CD-ROM rates for 12X drives and faster. 2X DVD-ROM drives have been announced, and most companies are talking about 8X performance within a few years.

Disagreement between major suppliers and between suppliers and content providers on specifications, standards and copy protection has delayed availability of DVD-ROM, DVD-R and DVD-RAM, although it appears that general agreement on copy protection and related restrictions desired by the entertainment and software industries has been reached as of mid-1997.

The high production volumes achieved by CD-ROM drive manufacturers have made possible steep cost reductions, while the demands of computer manufacturers for faster drives have stimulated performance improvements. During the last year, CD-ROM drives from the majority of drive manufacturers went from 8X to 24X in data transfer rate in order to improve output, but the industry is well past the point of diminishing utility to the user. At 8X sustained data rates, data will saturate a typical local area network, while 12X rates can saturate many processors. Most applications don't require even 6X or 8X performance, but computer manufacturers eager to improve system specifications have created early demand for higher performance CD-ROM drives. Average seek times have dipped below 100 milliseconds for some models.

Most CD format 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 a preferred medium for distributing system documentation and software as well as sizable application packages. CD-ROM acceptance benefits from industry agreement on the CD and CD-ROM standards developed jointly by Sony and Philips and also from 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. Variable packet writing software now permits CD-R and CD-RW drives to appear to computing systems as a standard disk drive.

* 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.

  Write-once recording usually 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, has become the dominant 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, disk 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 optical disk drives using CCW media can provide some improvement in write-once performance.

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 less expensive and 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 trade off write sensitivity for the improved longevity obtained, requiring more powerful lasers.

The largest applications for write-once recording technology, including CD-R, are distribution of data and the archival storage of documents and data. A document is often stored as a document image, rather than as character data, most often using 12" or 5.25" disks. CD-R is also used for preparing master disks for subsequent replication. Increasing integration of CD-R electronics into fewer chips has reduced the price of CD-R drives to well below the $500 level and the low cost of CD-R media makes them popular devices for data distribution. CD-R drives are acquiring the role of an archiving device where very long storage life is not required.

While the market for write-once optical storage is limited to niche markets that can tolerate nonreversibility, the ability of write-once storage to maintain an audit trail or indicate whether or not stored data has been modified is a benefit in some applications.

* Rewritable optical disks: Magneto-optic (MO) recording, whose roots go back over 30 years, is the most commonly used rewritable technology, but rewritable phase change is also in use for CD-RW, PD drives and DVD-RAM. 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.

  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 improves latency and data transfer rate. A few production magneto-optical disks employ light intensity modulation (LIM-DOW) to provide direct overwrite in place, avoiding the requirement that a complete sector must be erased before the sector can be rewritten.

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 is used for DVD-RW and DVD-RAM writable drives, although MO has also been suggested as an alternative to DVD-RAM with performance characteristics more suited to computer requirements.

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.

The first 12" rewritable drive, with 2 gigabytes per side, was announced by Nikon in late 1991, but most manufacturers, including Sony, Fujitsu, IBM, NEC, Hitachi, Maxoptix, Hewlett-Packard and others, concentrated on 5.25" and 3.5" drives. Drives and media with 1.3 gigabytes per side became available in late 1995 and early 1996, with MOST being the first company to formally announce such a drive. 2.6 gigabyte per side drives are expected to be announced in late 1997 and early 1998, with 1998 availability. 1998 is also expected to see the first availability of new families of magneto-optic drives offering projected capacities of 6 to 20 gigabytes per side. These may offer limited only compatibility with earlier drives, and some may not use removable media.

Sony makes 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 announced a computer peripheral version as the MD-DATA, with about 140 megabyte capacity, and 150 kilobyte per second data transfer rate, but has not emphasized the product, although the firm has alluded to higher planned capacities for the form factor.

A consortium of drive and media manufacturers is investigating the possibility of producing MO disk drives in a 12 centimeter form factor, with the drive able to make use of CD format drive components to reduce cost. Capacity on a single surface is expected to be 6 gigabytes, achieved by using PRML encoding and super-resolution optical recording technology, which involves writing with a flying magnetic head while the laser illuminates the recording layer. The drive would also be able to read CD-ROM and DVD disks. The project is considered difficult, with no product available before 1998. Drive and media specifications were produced in mid-1997 by companies supporting the development effort, including Fujitsu, Sanyo, Olympus, Hitachi, Sharp, Sony and several media manufacturers.

* 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 3 to over 1000 disk units in 12", 5.25", 4.72" 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 available and attracting increasing interest because of their ease of integration. Random access disk libraries available for CD players have migrated to the computer world as an accessory for the CD-ROM. CD-ROM libraries with capacities ranging from 4 to 20,000 disks are available, and CD-ROM autochangers fitting into a standard half height slot and holding from 4 to 6 disks are shipping in significant volume.

  Disk 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 and library 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 3390-2 may eventually influence the industry to provide stronger mainframe support.

* CD format towers: CD towers incorporate CD format drives, an enclosure and interface hardware connecting the tower as a unit to a SCSI port or a network, being considered host attached or network attached, respectively. Early towers were simply a collection of CD-ROM drives in a rack with a common SCSI port, but more recent host attached designs have incorporated SCSI concentrators, permitting groups of drives to appear as one SCSI address to the host system. Network attached controllers appeared several years ago from firms such as Microtest, Compact Devices and Axis Communications, permitting easy attachment of a tower to a network without the expense of an entire computer system as a server. More recent and capable versions of these controllers incorporate more of the components and functionality of a complete computer and can be employed as a Web server capable of attaching a variety of peripheral devices and storage subsystems to the network.

  End users of towers have incorporated them into their day-to-day activities to the extent that they are increasingly perceived as mission critical, and tower manufacturers are increasingly asked to provide data availability features such as hot swap drives, redundant power supplies, and network oriented remote management and performance monitoring tools.

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. Some, such as the incorporation of aspects of rigid magnetic disk drive technology into optical drive designs, impact multiple areas. As a result, the merging of rigid and optical drive technologies is likely to be the most influential technical trend in the next few years. Key enhancements to optical storage performance are likely in the following areas.

* Areal Density: 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 writable optical 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, now at over 2.5 gigabits per square inch, has for the moment surpassed optical drive areal density for both rewritable and write-once optical drives. DVD-ROM, at 3.2 gigabits per square inch, retains a momentary advantage over rigid magnetic drives.

  The rate of improvement of optical drive areal density has lagged the average 60% per year rate shown in recent years by magnetic disk drives, but though some projected advances, including denser coding methods such as pulse width recording, shorter wavelength lasers, elimination of grooved media in favor of sector servo recording, lower flying heights and nonconventional optics that reduce spot size can improve areal density.

  Several companies have combined elements of magnetic drive and optical drive technologies and are developing drives using heads that fly within a few microinches of the media surface, reducing the need for focus mechanisms and simplifying both mechanical and electrical elements. One of these firms, TeraStor, has suggested that its drive design will achieve an areal density of 10-20 gigabits per square inch in 1998, 5 to 10 times the areal density of 1997 magnetic drives, by use of a solid immersion lens embedded in the slider. Using more conventional optical technology, Sony has reported reaching 9.5 gigabits per square inch in the laboratory using a 515 nanometer laser, thin media and improved optics, permitting 12 gigabytes to be stored on a 12 centimeter disk. Sanyo and Hitachi Maxell are targeting 1999 for a jointly developed drive and media providing 14 gigabytes on a 12 centimeter disk. However, seek time and average latency is expected to be inferior to most magnetic drives for these approaches.

  High areal densities can also 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. Callimetrics is proposing a pit depth modulation technique to provide multibit cells and increase areal density by a factor of 4 or 8.

  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 2.6 gigabytes per side (the Pinnacle Micro Apex drive has 2.3 gigabytes per side), the current 3.5" generation has 640/650 megabytes per side, with a move to 1.3 gigabytes per side proposed as the next step. DVD-ROM drives will offer up to 8.5 gigabytes per side, assuming double layer media is used. The ASMO (Advanced Storage Magneto Optic) group has speci-

fied 6 gigabytes/surface on a CD sized disk, while start-ups Quinta and TeraStor are aiming at 10-20 gigabytes of on-line capacity per disk.

* Backward compatibility: As new generations of drives and media are developed, the need to remain backward compatible with previous versions is becoming a critical issue for end users who have developed large libraries of media and do not want to have to invest in new media or conversion efforts as the result of moving to new drive technology. The need for 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.

  A few issues are specific to CD-ROM formatted drives. Early DVD drives were unable to read media written on CD-R drives because the media have insufficient reflectivity at the shorter laser wavelengths used in DVD drives. Later designs incorporate two heads in order to read both CD-ROM and CD-R media.

  CD-RW drives, available starting in late 1996, use media not readable on any CD-ROM drive in production before mid-1996 because of low reflectivity. Since compatibility can be achieved by adding an inexpensive automatic gain control circuit to the CD-ROM drive, later CD-ROM drives are able to read CD-RW 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 eventually 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. Advanced component integration techniques explored have the potential to result in a monolithic assembly in which laser and lens are fabricated as a single unit.

Heads can be designed 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.

Both Quinta and TeraStor use heads incorporating sliders and suspensions similar to those used in rigid disk drives, permitting the head to fly within a few microinches of the disk and permitting the use of electronics, actuators, and other components developed for magnetic drives. The low mass of the head enables the optical drive to achieve nearly the seek time of rigid magnetic drives, and the use of readily available components and technology is expected to keep manufacturing costs lower than those of conventional magneto-optic 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 optical disk drives have exceeded 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.

  Spot size, hence bit size, 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. Green and blue semiconductor lasers are likely to enter use in the post 1998 period: The blue laser should quadruple areal densities (compares to those available with infrared lasers), but may require the abandonment of grooved media in favor of a sampled servo tracking system. Laser lifetime and power for these short wavelength lasers is not yet adequate to meet drive manufacturers requirements in the short term.

  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 tempera-

ture, 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.

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.

* Recording disks: Media has been an area of challenge, especially for magneto-optic media, which requires many manufacturing steps. Most read/write optical disks use complex multilayer designs and sputtering techniques to deposit the various layers. But manufacturing techniques have evolved to the point that disk media is able to withstand the range of temperatures and humidities most likely to be experienced without undue degradation. The use of multiple recording layers per side of a disk is supported by drives (such as DVD drives) that incorporate heads able to focus at multiple depths, permitting a substantial increase in disk capacity.

  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 surfaces 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. A 2 layer stack is supported by DVD drives at present.

  A group of drive and media manufacturers have succeeded in using laser intensity modulation to provide direct overwrite capability for MO drives. The technique (LIM-DOW) is supported by Hitachi, MOST, Fujitsu, Sony and Maxoptix in current 5.25" drives. Hitachi Maxell and M.N. Optical supply the 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.

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 little field experience of actual lifetimes of this duration.

* 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 DVD-ROM systems. Multilayer recording presents more problems, resulting in lower writable capacity than readback capacity and create yield problems for media manufacturers and replicators.

  DVD-ROM provides 4.7 gigabytes per surface on a single layer surface or 8.5 gigabytes on a 2 layer multisurface disk. On a two sided disk, per-disk capacities could be doubled. DVD-R capacity is currently 3.9 gigabytes per surface and DVD-RAM drives will offer 2.6 gigabytes per surface.

* 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. Hybrid magnetic/optical approaches are expected to use a conventional rotary actuator, but may also incorporate some type of secondary positioning capability for fine position tracking.

* 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 for notebook computers will be the first 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, but appropriately designed CD-ROM drives should be able to operate at that voltage level.

* Packaging: Most early small optical drives were packaged to fit into a standard 5.25" form factor for easy mounting in personal computers produced in the late 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 optical disk drives fit into a 41.3 millimeter high space. Fujitsu announced a one inch high 3.5" drive in 1992 and this form factor is currently available from multiple manufacturers.

  Because small diameter optical 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 systems requiring small form factors. Sony, Matsushita, TEAC, Toshiba and others are producing drives in heights ranging from 17 to 12.7 millimeters.

  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 when not used in libraries.

* Power: The power requirements of many optical drives make them 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, and a growing number of notebook computers also incorporate internal thin profile CD-ROM drives. Because the CD-ROM is often used in conjunction with presentations that are given where AC power is available, the power requirement is not always a serious disadvantage, but is, nevertheless, an issue for notebook system manufacturers.

* Interface: The most common interface encountered on writable optical drives is SCSI, covering the range from low-end 3.5" drives to larger drives intended for use with multiuser or document storage systems. Interfaces compatible with the IDE/ATAPI standard used with most personal computers are most common on CD-ROM drives because of the large number installed by computer OEMs. Drives used in certain document filing systems and with sound cards have frequently used proprietary interfaces, but these have faded away as a result of the installation of CD-ROMs by almost all personal computer manufacturers. Current SCSI drives usually embed the SCSI controller 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 integration into personal computer systems. ATAPI has become the dominant form of interface for CD-ROM drives, displacing both SCSI and proprietary interfaces and has prospects for adoption in the next generation of high capacity 3.5" drives. P1394 is also being designed into future personal computers by makers of systems and mother boards. The SDX interface proposed by Western Digital provides a dedicated bus between a CD-ROM drive and a hard disk drive, permitting the caching of CD-ROM contents on the hard drive to improve response time of the storage subsystem. SDX has had a mixed reception, endorsed by a few drive producers but ignored by others that prefer to perform the same function using host or controller based software.

  Early optical libraries used RS-232 channels to control the library mechanism, but later generations have preferred 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, and is included with most operating systems for personal computers.

  Some firms have incorporated sophisticated firmware in their drives to avoid degradation of throughput caused by error correction, write verifica-

tion, bad sector rewrites and other delay factors. While these techniques do 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.

  For the DVD generation of CD-ROM drives, initially, there were two major physical standards, SD and MMCD. In late 1995, the competing camps arrived at a single compromise standard. The ad hoc Technical Working Group (TWG), consisting of Apple, Compaq, IBM, Hewlett-Packard and Microsoft set forth a list of requirements that any future CD-ROM standard would have to meet, and this group was instrumental in helping the industry arrive at a single compromise standard that adopted features from both proposed standards.

  Aside from the DVD related conflicts, 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 and Sega. 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 is required for VHS or better quality on a single disk, requiring the use of DVD-ROM.

In early 1986, Sony and Philips released the CD-I (Compact Disc-Interactive) specification which defines a freestanding appliance rather than a computer peripheral. CD-I has been aimed at consumer, education, and a few commercial applications, such as point-of-sale displays. CD-ROM XA, announced in 1988, 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.

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). 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 was 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) and the 3.5" standards (ISO 10090, ISO 15041) are based on CCS. The outlook is for approval and 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.

At present, there is little standardization of 12" media. There were so many 12" drive designs sold 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, if for

no other reason that suppliers are dropping out and the survivor(s) may create a de facto standard.

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. For instance, ECMA approved in June, 1996, ECMA-240, a standard for the PD drive, which will now be considered by ISO as an international standard.

* 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 typical 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 disk 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 (although this status must be reevaluated as very high capacity MO drives begin to enter the market). More pertinent, rigid disk drives offer serious competition to optical drives in some situations.

  SyQuest's 3.5" 230 megabyte EZ-Flyer removable drive competes strongly with 3.5" 230 and 128 megabyte optical drives. The 1 gigabyte Iomega

Jaz drive and 1.5 gigabyte SyQuest SyJet compete with 640 megabyte 3.5" MO drives and 5.25" optical drives. And the SyJet 4.7 gigabyte Rocket, which might appear as early as 1998, could turn out to be a competitor to DVD-RAM and lower capacity 5.25" MO drives. 5.25" drives, such as the 23 gigabyte Elite 23, challenge the 5.25" optical drives by offering equivalent or greater capacity at a lower price. The Elite series has also shown itself a formidable competitor against small optical libraries. The new generation of gigabyte capacity removable rigid disk cartridge drives from SyQuest and Iomega will place increasing pressure upon optical disk drives. While 3.5" rigid magnetic disk cartridge drives are expected to offer capacities exceeding 5 gigabytes per cartridge before the year 2000, it is yet unclear that removable optical storage will meet that challenge.

While optical drives have improved performance to the point where they can offer 30-40 millisecond average seek time on a 1.3 gigabyte 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 read/write optical disk drives have exceeded 3,600 RPM rotation rates, while magnetic drives are moving past 5,400 RPM and 7,200 RPM to 10,000 RPM at the high end of the performance range. Even the new high capacity, high performance optical drives are not expected to match rigid magnetic drive performance.

The highest areal densities of current magnetic drives, currently in excess of 2,500 megabits per square inch, now compete against the areal density of optical drives and are expected to be in the range of 10 gigabits per square inch by the end of the decade. Rigid drives with areal densities approaching 3 gigabits per square inch are expected to be shipping by the end of 1997. Although advanced optical drives with similar or greater areal density may begin shipments in 1998, it is unlikely that the magnetic drive will be seriously threatened by optical disk drives in its role as a high performance system disk, although lower performance drives such as the Quantum Bigfoot may be subject to displacement by very high capacity optical drives in the future.

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 has a chance to 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 100 megabyte Iomega Zip drive and the 120

megabyte LS120 (derived from the floptical disk drive) have extended floppy drive capacities to a new level. 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. Future generations of high capacity floppy drives are expected to exceed 200 megabytes, with availability depending more upon market conditions than technical or manufacturing issues.

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. Over 25 companies have purchased licenses permitting them to make optical card drives using Drexler patents.

  The write-once format and low capacity of the optical 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, although similar products using phase change

media are being developed by other firms. CREO Products, a Canadian firm, teamed 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. The product rights were subsequently acquired by EMASS. A number of companies continue to develop cartridge based optical tape drives, and it is possible that some may become available before the end of the decade.

* 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 ambient light. In its current form, the design requires multiple lasers at different wavelengths. Optex is addressing the video systems market rather than the computer peripherals market.

* Holographic storage: Holographic storage is a type of storage in which an array of bits is stored in an optically sensitive medium as a pattern scattered throughout the volume of the medium. A scanned laser generated writing (object) beam and reference beam create an interference pattern in the storage element, which in turn modifies the index of refraction throughout the storage medium in a similar pattern. Many bit pattern images can be stored in a single piece of storage media, limited largely by the need to maintain an adequate signal to noise ratio. As images are added, there is some tendency for interference between them. The location of the image is determined by the angle at which the reference beam impinges upon the storage medium. When the medium is illuminated by the reference beam only, the data can be projected upon a detector.

  Storage media can be fixed or removable, and both write-once and rewritable forms are possible. Current media designs employ crystals fabricated from iron doped lithium niobate, barium titanate, strontium barium niobate and organic polymer materials. In general, the materials are not interchangeable. While some of these materials permit degradation of stored data due to the effect of read operations, temperature cycling can make the data permanent while still permitting further writing operations. Acousto-optical modulators are used to scan the laser beams. The deflected object beam used for writing is directed through a spatial light modulator (SLM) to create the bit stream to be stored. The SLM is typically a liquid crystal array with the bit pattern imaged upon it. A CCD sensor array is used as an output detector for data readback.

  Because holographic storage systems have no moving mechanical parts, they have applications in military, industrial, and other applications where

ruggedized storage is essential. If practical, holographic storage can virtually eliminate the current limitations on throughput caused by mechanical drives, and must be considered as having the potential to compete with magnetic and optical rotating disk drives in selected applications after the turn of the century.

Early attempts to develop holographic storage for use in computer memories were unsuccessful due to technical difficulties (many due to a lack of suitable components), such as a tendency of read operations to degrade the stored data, and inability to meet cost and performance constraints. But the very high storage densities and fast access times theoretically achievable have encouraged continuing research and development efforts by many organizations worldwide, and many of the early problems have been reduced or eliminated.

One of the more ambitious holographic storage programs was conducted by MCC (Microelectronics and Computing Corporation), a research consortium sponsored by major U.S. technology firms. Supporters of the MCC effort included DEC, NCR, Eastman Kodak, General Dynamics and E-Systems. MCC demonstrated working prototypes of holographic memories in a 5.25" form factor in 1992 and established a subsidiary corporation, Tamarack Storage Devices, to commercialize the technology. MCC's write-once devices had targeted capacities in the range of 200 megabytes to 10 gigabytes, average access times in the 1 to 10 microsecond range and data transfer rates in the gigabyte per second range.

While Tamarack's efforts did not result in a salable product, other companies and universities are working as a consortium on the HDSS (Holographic Data Storage System) to develop prototype holographic storage equipment or required components by the year 2000. Much of this effort is funded by a $32 million program jointly funded by NSIC (National Storage Industry Consortium) and DARPA (Defense Advanced Research Project Agency). The goal of HDSS is a capacity of at least a trillion bits and at least a 1 gigabit per second data transfer rate. A second consortium started in 1994, designated PRISM (Photo Refractive Information Storage Materials) is concentrating upon development of suitable holographic media. Both write-once and rewritable media are anticipated. The consortium is focusing upon creating a storage device with a terabyte of memory (using several media units), 1 gigabit per second data transfer rate and an access time of less than 1 millisecond within a single medium unit. A mechanical transport mechanism will switch storage crystals, with a typical transport time of 30 milliseconds anticipated. Packaging of the device within a standard 5.25" form factor is expected. Current cubic storage density is under 50 megabytes/cubic centimeter, but the target is storage media with 10 gigabytes/cubic centimeter capability.

Among the organizations participating in the HDSS consortium are IBM, Optitek, GTE, Eastman Kodak, Rochester Photonics, SDL and several

universities, including Stanford, Carnegie Mellon, the University of Arizona and the University of Dayton. PRISM members include IBM, Optitek, GTE, Hughes, Rockwell, SRI and Stanford University. Nonconsortium organizations are also developing holographic memories, including Holoplex, Templex and NTT. Consortium members do not expect to have salable products available until at least 1999, although a few evaluation prototypes may be completed sooner. Rockwell and Holoplex have created operating prototypes with limited storage capabilities for evaluating the technology. Templex is developing a form of holography based upon frequency modulation of the laser beam, permitting storage of multiple bits at one physical site. Special materials are required for the crystal.

Research related to nonholographic three-dimensional optical storage continues, but many of the same temperature and material problems must be overcome. For instance, the University of California at Irvine disclosed an experimental device capable of storing 6.5 trillion bits in an organically doped plastic module the size of a sugar cube. Two different lasers are needed to write and read data, and the device must be operated at cryogenic temperatures to avoid data loss.

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 other firms have adopted that physical format. 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 serpentine recording format originated by Digital Equipment Corporation and now a major product area at Quantum, has made major inroads in this segment of the tape drive market. The forthcoming very high capacity rewritable optical disk drives expected in 1998 have the potential to displace a significant portion of the magnetic tape drives used for save/restore applications as optical disk drive and media prices decline, but 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. A variety of tape based libraries and autoloaders are available from other companies as well. If CD format libraries and towers are excluded, tape libraries appear to have outstripped sales of optical disk libraries, and must be considered a significant threat in applications where relatively short access times are less important than price per megabyte.

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 50 gigabytes) and a low cost per bit stored, but suffer from relatively long access times, as do all tape storage systems. For half inch drives, data transfer rates lie in the 2 to 12 megabyte per second range. For 8 millimeter and DAT types, data transfer rates under a megabyte per second are more typical, although some DAT drives reach 1.2 megabyte/second and a few 8 millimeter drives operate at 3 megabytes per second. 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.

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: Small cartridge tape drives have been increasing in capacity and performance since their introduction in the 1970s. Tape widths in use are: .15", .25", .315" and .5". Tape capacities range from 40 megabytes to 13 gigabytes in the .25" and smaller tape formats. Travan technology tape cartridge drives with .315" tape now extend to 4 gigabytes in native capacity. The .5" parallel track tape cartridge drives offer 200 to 400 megabytes in a 5.25" form factor. Drives operating in a serpentine mode can store up to 2.6 gigabytes. Some manufacturers adopted the physical format of the IBM 3480 cartridge in their drives but not the recording format; such products are less expensive than the 3480 but don't offer media interchangeability with IBM systems.

These products are threatened to some degree by PD drive, CD-R write-once technology and CD-RW rewritable technology, and will definitely be impacted by small form factor 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 improving state of optical disk technology, displacement effects may become visible within the next few 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.

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/Distributor 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/Distributor or OEM/Integrator market classes are classified accordingly.

Examples:

* CD-ROM drives sold by Toshiba with its notebook computers 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/Distributor 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/Distributor: Disk drives, libraries and CD towers sold in the "aftermarket" -- shipments by drive and library manufacturers to subsystem producers, value-added resellers, distributors, retail chains, mail-order firms and individual dealers. Also includes 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. Includes products to be connected to systems of all types, including personal computers, minicomputers and mainframes, or sold as add-on devices by distributors and dealers.

OEM/Integrator: Drives, libraries and CD towers sold by the original producer to system manufacturers which resell them as part of complete computer systems. Also includes sales to system integrators which combine finished system components and software to provide complete systems for specific applications. Sales by a disk drive, library or tower manufacturer to a second drive, library or

tower manufacturer for resale are included only in shipment totals for the originating manufacturer, except when the products are produced on a contract manufacturing basis with a design supplied by the disk drive, library or CD tower 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 drive 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, libraries or CD towers 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 and tower 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/Distributor or OEM/Integrator levels. All prices are in 1997 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 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/midrange computers: Drives, libraries or CD towers attached to general purpose processors 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.

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 FORMAT READ-ONLY OPTICAL DISK DRIVES

1997 DISK/TREND REPORT

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter (4.72") disk diameter

Advanced Information (AOpen)	CD-924E, CD-932E
Acer Peripherals	CD-620, CD-624
ADI	CP-2412
Aztech Systems	CDA 1668, CDA 1868
Behavior Tech Computer	BCD-20X, BCD-24X
CD-ROM, Inc.	CRI 1600, CRI 1800
Cyberdrive	CY200D, CY240D
Delta Electronics	OJC-F101
Elitegroup Computer Systems	SMART 100X
Funai Electric	E2850, E2950
Hitachi	CDR-8330, CDR-S200, GD-2000
Hopax Industries	HO-820, HO-824
IMES	ICD-3600AT
LG Electronics	DRD-810B, GCD-8080B, GCD-8240B
Lion Optics	XC-800
Lite-On Technology	LTN-262, LTN-264
Matsushita Electric Industrial	CR-508, SR8582B, UJDCD8730
Mitsubishi Electric	MDV-D10
Mitsumi Electric	CRMC-FX140, CRMC-FX240
Mountain Optech	SC-680
NEC	CDR-1600, CDR-1700, CDR-1800
Ocean Automation	CDR 820, CDR 824
Optics Storage	8831, 8841
Philips	PCA 16SC
Pioneer	DR-511, DVD-A01
Plextor (Shinano Kenshi)	PX 12TS, PX 20TS
Samsung Electronics	SCR-2037
Sanyo	CRD-820P
Sony	CDU-611, DDU-100E, PRD-650WN
Tae Il Media	CDD-7120, CDD-7200
Tatung	CD-650E, CD652E
Takaya	CD-812, CD-1016
Tatung	CD-1620E, CD-1624E
TEAC	CD-220E, CD-516S, CD-524E
Toshiba	SD-M1002, XM-1602B, XM-6102
Unitron	UCD20S, UCD24S
USDrives	16DT, 20DS, 24DT, 24ST
Wearnes Peripherals	CDD-1820, CDD-2420
Yung Fu (Lxycon)	CDX-1200, CDX-1600

8 centimeter (3.15") disk diameter

Sony	Data Discman

A standard CD-ROM or DVD-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 or DVD-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, CD-RW, DVD-R, DVD-RAM) are covered in section DT-21 of this report, which follows this product group. 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. While DVD consumer video players are not covered in this report, it is useful to note that the high cost of TV and audio equipment needed to make full use of improved DVD player video and audio capabilities, lack of recording capability, and competition from VCRs will probably keep DVD video player sales low relative to DVD-ROM sales for several years.

CD-ROM/DVD-ROM drives and media are a form of electronic publishing. A mass replication process analogous to the printing of a book or the stamping of a phonograph record is widely used to place data on disks. 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 usage is simplified.

Market status

1996 was another strong growth year for CD-ROM drive shipments, although short product life cycles reduced profitability for most industry participants. The rapid evolution from 8X drives in 1996, through 12X drives, to 24X drives this year continues to cause inventory and component procurement problems for many

manufacturers that adversely affected profitability. In particular, there were continuing effects from last year's overproduction of 4X drives, resulting in sales below cost in order to clear inventory. Prices for faster models were negatively impacted as a result, and inventory problems continued to plague the industry in 1997, though not to the same degree. Personal computer manufacturers remain the greatest demand source for CD-ROM drives as a result of the increasing number of multimedia software products being shipped. The industry has begun its transition to DVD-ROM drives. Though DVD shipments are small in 1997, a major ramp is expected next year. With the introduction of CD-RW rewritable drives in 1996, the first CD-ROM drives capable of reading CD-RW media finally began production in late 1996.

Unit shipments rose 33.3% in 1996 to nearly 55.6 million units, while worldwide sales revenues increased 16.3% to exceed $4.6 billion. Sales revenue growth was again limited by declining prices resulting from manufacturing economies, lower cost designs and competitive pressures, but the sell off of excess inventories at distress prices also impacted revenue growth. The rapidly growing market continues to attract new entrants, notably in Asia, and encourages the growth of contract manufacturing of CD-ROM drives in Southeast Asia, China and other locations. However, some smaller manufacturers, unable to keep up with declining prices, have ceased assembling CD-ROM drives. Most newcomers purchase the optical and mechanical mechanisms, and complete the drive by adding their own electronics and packaging. With the exception of Philips, 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, and one Asian firm has established manufacturing facilities in the U.S.

Nearly all CD-ROM drives can use either 12 centimeter or 8 centimeter diameter media. Sony introduced an 8 centimeter (3.15") CD-ROM in the Data Discman in 1990, but the 8 centimeter format has not been very successful due to its low capacity (about 180 megabytes) and lack of published titles.

Mitsumi, Toshiba and the Matsushita companies were the leading noncaptive CD-ROM drive producers in 1996, followed by Sony, NEC and Hitachi. Toshiba and Sony are the leading captive producers on the strength of sales of their notebook computer and game products, respectively.

Thin CD-ROM drives, now available from multiple manufacturers for use with notebook computers, have entered the market and accounted for nearly 5 million units of the 1996 total shipments.

Marketing trends

CD-ROM drive shipment growth is expected to continue, with 32X drives starting to ship in late 1997. However, 32X is expected to be the last major transition for CD-ROM, as shipments of DVD-ROM are beginning to replace CD-ROM. DVD-ROM drives are forecasted to account for over 13% of shipments in 1998, growing to 51.6% in 2000. Shipments of drives with 20X or greater speeds are expected to peak in 1999. Worldwide unit shipments of CD-ROM/DVD-ROM drives are expected to exceed 99 million in 2000, while revenues are expected to exceed $8.3 billion. Average OEM prices (which increased slightly in 1997 as pressures from inventory sell offs declined) are expected to drop below eighty dollars due to increasing competition from companies producing in Korea, China, Taiwan and Southeast Asia. DVD-ROM drives are forecasted to produce over 61% of sales revenues in 2000, reflecting the anticipated higher price points for DVD drives throughout the forecast period. DVD-ROM OEM prices are expected to be in the $150 range by late 1997 and in the $120 range in 1998, declining gradually to under $100 in 2000.

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 and Optics Storage are among the firms that have begun production in Southeast Asia in the last few years, while several Japanese firms have arranged to manufacture their drives in China. Korean manufacturers LG Electronics, Samsung Electronics and Tae Il Media are also in production. In Taiwan, Acer, Acer Peripherals, Lite-On, Cyberdrive and others are in production using purchased mechanisms, with significant quantities produced by units of the Acer Group.

OEM shipments in 2000 are projected at about 72% of the total, down slightly from 73% in 1996 as a result of anticipated increases in captive shipments from

Asian producers of both drives and systems. Reseller shipments, 21.3% of 1996 shipments, are expected to decline to 20% in 2000. Captive shipments are expected to decline slightly from 8.4% in 1996 to 7.9% in 2000 as a result of the broadening of the base of suppliers and strong anticipated growth for personal computers. Despite the percentage decline, captive shipments are expected to increase to over 7.8 million units in 2000.

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 but useful for karaoke. 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 displace them 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, computer games and consumer appliances based upon microcomputers. It is unclear what effect the introduction of network computers will have on CD-ROM shipments. While the NC philosophy is to minimize the peripheral content of the NC, it may be necessary for some NC units to have a CD-ROM in order to minimize the demands on network bandwidth. The current expectation is that the effect will be neutral in terms of shipments. Consumer applications, including home computing, 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 accept-

ance of video on CD awaits the DVD drives that permit a single disk to contain two hours of video.

In 1996, 75.8% of the CD-ROM drives shipped were attached to personal computers, including notebook computers. Consumer computer and other applications, notably games such as Sony's Playstation, increased to 15.7% because of the strong growth in PC usage. CD-ROM drive use with network servers declined slightly to 3.6% in 1996, largely due to the substitution of CD-ROM minichangers for CD-ROM drives in CD-ROM towers attached to file servers or directly attached to the network. Many of these servers are used to supply business data across a corporate "Intranet", a local area network supporting Internet addressing conventions. Single user personal computers are forecasted to remain the largest application for CD-ROM drives in 1999, capturing 70.6% of the drive shipments. Consumer applications, led by entertainment, home computing and education uses, are expected to be the second largest application area, with 22.4% of the units sold. Network servers will use 2.8% of the drives shipped, while workstations will account for 3%.

In the consumer area, games, education, music and arts, and numerous special interest subjects are developing as significant 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 Internet attached inexpensive multimedia players that incorporate CD-ROM disk drives and computer based systems which incorporate a CD-ROM or DVD-ROM player in a relatively inexpensive home computer.

Many software producers now preferentially distribute their software and documentation on CD-ROM because the cost of replication and packaging is substantially less than when floppy disks are used. Installation is also (usually) easier and faster for the end user. 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 on-line manuals that can be installed from the CD-ROM demo disk. The software author provides an unlock code after customer payment so that installation is enabled.

Business use of CD-ROM is oriented towards reference and training uses. Reference materials may include purchased 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. And numerous firms provide data-bases of phone numbers, maps and other reference materials.

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 li-braries 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.

CD-ROM and DVD-ROM titles that operate with software allowing access to the Internet (or Intranets) are expected to be increasingly common, with the disk containing Internet links to websites that support or interact with the content of the disk.

Technical trends

The basic technology utilized in this product group was derived from the consumer CD player, with significant product differentiation based primarily on performance and embedded features. DVD-ROM drives have expanded upon CD-ROM technology as a result of pressures to increase the ability of the disk to

contain increased video and audio content. Because of incompatibility issues concerning CD-R and DVD-RAM media, DVD-ROM drives are evolving rapidly in 1997 to resolve the issues. Most manufacturers are expected to be in position for a major rampup by late 1997.

Compatibility: Early users of DVD-ROM drives are likely to receive an unpleasant surprise when they discover that their drives are incapable of reading CD-R media. This problem occurs because CD-R media has low reflectivity at the shorter laser wavelengths used in DVD drives. While some drives may employ dual lasers in the pickup to provide a solution, a more elegant and less costly approach is to modify the media to broaden the high reflectance portion of the reflectivity spectrum, but this has proven to be more difficult than originally anticipated. The industry has done a poor job of informing users of the problem, creating the possibility of a reputation for unreliability for DVD drives, CD-R drives or both.

Multimedia support: CD-ROM drives and DVD-ROM drives routinely incorporate the necessary support for audio and video content, but the capabilities of the DVD-ROM drives are inherently greater, as they were designed specifically to support audio and video content.

Capacity: Data bases, games, system software and documentation may span several CD-ROM disks, and content providers are eager for the new audio and video features the increased capacity of DVD-ROM will make possible. IBM has developed a stacked disk approach in which several recording layers are bonded together, with the desired surface addressed by varying the focal point of the pickup lens. This approach has been adopted in the DVD drive specification, which defines disks that have 1 or 2 recorded surfaces on each side of the disks. The DVD drives employ shorter wavelength red lasers (635-650 nanometers), higher track densities (over 30,000 TPI) and higher bit densities. However, the multisurface disks are harder for replicators to produce, and it is expected that 4.7 gigabyte disks will be the mainstream DVD-ROM standard for years to come.

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 motor vehicles or to be mounted in a vertical position within a system enclosure.

Because of cost pressures, most 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 and high performance CD-ROM libraries.

Jukebox designers may find caddies easier for high speed picker mechanisms to handle than unprotected disks, although lower performance, lower cost libraries seem to handle unenclosed disks satisfactorily.

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 latter 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. As of 1996, all manufacturers offered drives capable of dealing with XA and multisession Photo CD formats.

Standards for motion video compression being worked out by MPEG (Motion Picture Experts Group) were 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 videotape, 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.

DVD-ROM working standards generated by the potential producers of the drives are basically complete, although issues relating to copy protection were not completely resolved to everyone's satisfaction. The ISO 13346 compliant UDF (Universal Disk Format) standard developed by OSTA for 3.5" and 5.25" drives has been adopted for DVD drives, a major step towards insuring compatibility among future drives.

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 20 times the original 150 KB/second data transfer rate, with the improvement in performance achieved by increasing the rotation rate. As spin rates increased above 6000 RPM, drive designers discovered that mechanical instabilities limited further RPM increases. As a result, drives adopted constant angular velocity designs or hybrid CAV/CLV designs as they moved above 12X speeds in order to limit the spin rates required. The consequence is that instead of exhibiting a constant linear velocity and a nearly constant internal data transfer rate, drives now exhibit a range of rates, with the slowest on the inner tracks, increasing as the head approaches the outer tracks. The drive requires more sophisticated electronics to handle the situation, but suitable chip sets are available.

The presence of a large buffer is becoming increasingly important for adequate multimedia performance. 128 kilobyte buffers are a minimum requirement, but drives with 256 kilobyte or larger 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. Additional software is needed to support the new generation of high capacity DVD drives as they enter the marketplace. Newer operating systems, such as Windows 95, can support CD-ROM and DVD-ROM drives without the addition of third party software.

Interface: Initially, CD-ROM drives were typically 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. The more recent SDX interface proposal by Western Digital, to facilitate connection of CD-ROM drives to personal computers through attachment to a new interface to be made available on rigid disk drives, has not developed general support by PC and disk drive manufacturers.

Future generations of desktop computers will employ serial bus structures for the connection of peripheral devices. Drives with P1394 compliant interfaces are expected to appear in 1998.

Cost reduction: Cost reduction programs are continuing and accelerating. Plastic molded lenses, for instance, have replaced polished glass lenses. In some low performance CD-ROM 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 CD-ROM drive shipment 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 25.4, 17, 15 and 12.7 millimeter high models have appeared, with the latter capable of fitting under the keyboard of a notebook computer. 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 6 disk capacities have become 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) and variable packet writing encouraged products that include all software and hardware tools needed, and improved production tools for use with CD-R drives began appearing in 1994. CD-R drives are more fully discussed in chapter DT-21.

Networks, libraries and CD-ROM towers: 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 many server designers to adopt multiple drive configurations, or CD-ROM towers. The CD-ROM tower typically holds from 4 to 28 drives, although 7 drives is the most common size. Early towers typically had a SCSI interface to a server, although some controllers used with towers, such as those offered by Compact Devices, Axis Communications and Microtest could attach directly to a local area network and be configured to operate with one of several available network protocols. Buyer interest is shifting towards these network attached towers because of their flexibility, Internet compatibility, and ease of installation.

A number of firms have announced autochangers for CD-ROM: The number of manufacturers is increasing, with libraries ranging in storage capacity from four 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. DVD-ROM drives are currently being incorporated into CD format libraries and towers.

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. Other reliability problems seem to be connected to drives operating at 8X and higher speeds, which require tighter tolerances on media and media production processes. Reliability problems above 6,000 RPM have required a shift from CLV to CAV spin control, as described earlier.

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 problems with both CD-ROM and CD-R 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, but the arrival of multilayer DVD disks and higher spin rates have exacerbated the situation.

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-RW (CD-rewritable) drives proposed by Philips were

introduced in late 1996. See the section on read/write drives under a gigabyte for a full discussion.

Potential competition: At the present time, CD-ROM/DVD-ROM is relatively unchallenged as an inexpensive publishing and data distribution technology. While small applications may be distributed on floppy disks, CD-ROM has superior economics for most software producers and is approaching ubiquity at sites where personal computers are installed.

3.5" magneto-optic drives also have read-only capability and could be used in many of the same applications as CD-ROM drives. However, their much higher prices make strong competition with CD-ROM drives unlikely.

High capacity floppy drives, currently offering 100-130 megabytes, do not have the capacity required for many applications, and the media is also more expensive. They are not considered significant competition.

The rapidly declining costs and improving performance of CD-ROM and DVD-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-RW drives, CD-R drives and their DVD equivalents, which might capture from 1% to 5% of the available drive slots in 2000.

Forecasting assumptions

1. CD-ROM drive production capability will substantially meet demand, although short-term component shortages may recur after 1997 as the industry infrastructure retools to support DVD.
2. 32X will be the last significant CD-ROM generation, but DVD-ROM drive producers will undertake the same speed race that occurred in CD-ROM drives.
3. Non-U.S. suppliers will continue to dominate the CD-ROM hardware market, with most production outside the U.S.
4. There will be little impact on CD-ROM or DVD-ROM shipments from competing technologies throughout the forecast period.
5. Most consumers will prefer to use CD-ROM based games and educational materials with personal computers rather than with freestanding players.
6. 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 20X and higher operating rates. Replication capability for DVD drives will be adequate.
7. Cost reduction will continue and result in a long-term decline in average drive prices.

TABLE 17

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996		Forecast							
	Revenues		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	14.4	14.4	14.4	14.4	14.7	14.7	15.0	15.0	15.3	15.3
TOTAL U.S. REVENUES	14.4	14.4	14.4	14.4	14.7	14.7	15.0	15.0	15.3	15.3
Non-U.S. Manufacturers										
Captive	239.2	594.9	289.3	720.0	316.1	777.2	371.5	925.2	457.0	1,062.0
PCM/Distributor	375.8	914.5	446.7	1,042.9	542.9	1,264.1	645.5	1,564.1	855.0	1,865.5
OEM/Integrator	1,430.8	3,137.1	1,750.0	4,106.5	2,127.9	4,756.0	2,403.1	5,068.5	2,603.4	5,417.8
TOTAL NON-U.S. REVENUES	2,045.8	4,646.5	2,486.0	5,869.4	2,986.9	6,797.3	3,420.1	7,557.8	3,915.4	8,345.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,060.2	4,660.9	2,500.4	5,883.8	3,001.6	6,812.0	3,435.1	7,572.8	3,930.7	8,360.6
OEM Average Price ($000)		.080		.083		.082		.078		.076

TABLE 18

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	47.0	47.0	48.0	48.0	49.0	49.0	50.0	50.0	51.0	51.0
TOTAL U.S. SHIPMENTS	47.0	47.0	48.0	48.0	49.0	49.0	50.0	50.0	51.0	51.0
Non-U.S. Manufacturers										
Captive	1,920.0	4,707.0	2,182.9	5,362.1	2,460.0	6,030.0	2,670.0	6,530.0	3,370.0	7,870.0
PCM/Distributor	4,815.2	11,846.4	5,179.9	12,212.5	6,125.0	14,200.0	7,090.0	16,905.0	9,220.0	19,955.0
OEM/Integrator	17,975.9	38,970.0	20,788.6	49,130.3	25,735.0	57,900.0	30,830.0	64,970.0	34,375.0	71,305.0
TOTAL NON-U.S. SHIPMENTS	24,711.1	55,523.4	28,151.4	66,704.9	34,320.0	78,130.0	40,590.0	88,405.0	46,965.0	99,130.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	24,758.1	55,570.4	28,199.4	66,752.9	34,369.0	78,179.0	40,640.0	88,455.0	47,016.0	99,181.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	64.9	138.0	93.1	204.7	127.5	282.9	168.1	371.3	215.1	470.5

TABLE.19

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DATA TRANSFER RATE

	1996 Revenues				Forecast																
					1997					1998					1999				2000		
	<=8X	10X-12X	13X-18X	DVD	<=8X	10X-12X	13X-18X	>=20X	DVD	<=8X	10X-12X	13X-18X	>=20X	DVD	10X-12X	13X-18X	>=20X	DVD	13X-18X	>=20X	DVD
U.S. MANUFACTURERS																					
PCM/Distributor	14.4	--	--	--	14.4	--	--	--	--	14.7	--	--	--	--	15.0	--	--	--	15.3	--	--
TOTAL U.S. REVENUES	14.4	--	--	--	14.4	--	--	--	--	14.7	--	--	--	--	15.0	--	--	--	15.3	--	--
NON-U.S. MANUFACTURERS																					
Captive	513.7	67.7	13.5	--	161.1	101.4	57.3	384.7	15.5	48.5	67.2	103.2	478.3	80.0	24.2	90.2	430.8	380.0	--	237.0	825.0
PCM/Distributor	733.4	150.2	30.9	--	100.4	340.0	171.0	399.0	32.5	17.5	54.0	78.0	716.8	397.8	4.5	30.0	626.5	903.1	--	260.0	1,605.5
OEM/Integrator	2,679.1	381.6	76.2	.2	685.6	902.2	690.5	1,769.2	59.0	60.5	120.4	185.3	3,543.2	846.6	40.3	122.0	3,000.2	1,906.0	38.5	2,697.3	2,682.0
TOTAL NON-U.S. REVENUES	3,926.2	599.5	120.6	.2	947.1	1,343.6	918.8	2,552.9	107.0	126.5	241.6	366.5	4,738.3	1,324.4	69.0	242.2	4,057.5	3,189.1	38.5	3,194.3	5,112.5
WORLDWIDE RECAP																					
Captive	513.7	67.7	13.5	--	161.1	101.4	57.3	384.7	15.5	48.5	67.2	103.2	478.3	80.0	24.2	90.2	430.8	380.0	--	237.0	825.0
	+117.8%	--	--	--	-68.6%	+49.8%	+324.4%	--	--	-69.9%	-33.7%	+80.1%	+24.3%	+416.1%	-64.0%	-12.6%	-9.9%	+375.0%	--	-45.0%	+117.1%
PCM/Distributor	747.8	150.2	30.9	--	114.8	340.0	171.0	399.0	32.5	32.2	54.0	78.0	716.8	397.8	19.5	30.0	626.5	903.1	15.3	260.0	1,605.5
	-33.6%	--	--	--	-84.6%	+126.4%	+453.4%	--	--	-72.0%	-84.1%	-54.4%	+79.6%	--	-63.9%	-61.5%	-12.6%	+127.0%	-49.0%	-58.5%	+77.8%
OEM/Integrator	2,679.1	381.6	76.2	.2	685.6	902.2	690.5	1,769.2	59.0	60.5	120.4	185.3	3,543.2	846.6	40.3	122.0	3,000.2	1,906.0	38.5	2,697.3	2,682.0
	+1.3%	--	--	--	-74.4%	+136.4%	+806.2%	--	--	-91.2%	-86.7%	-73.2%	+100.3%	--	-66.5%	-34.2%	-15.3%	+125.1%	-68.4%	-10.1%	+40.7%
Total Revenues	3,940.6	599.5	120.6	.2	961.5	1,343.6	918.8	2,552.9	107.0	141.2	241.6	368.5	4,738.3	1,324.4	84.0	242.2	4,057.5	3,189.1	53.8	3,194.3	5,112.5
	-1.6%	--	--	--	-75.6%	+124.1%	+661.9%	--	--	-85.3%	-82.0%	-60.1%	+85.6%	--	-65.2%	-33.9%	-14.4%	+140.8%	-77.8%	-21.3%	+60.3%
ANNUAL SHARE, BY DIAMETER	84.6%	12.9%	2.5%	--	16.3%	22.9%	15.6%	43.4%	1.8%	2.1%	3.5%	5.4%	69.7%	19.3%	1.1%	3.2%	53.7%	42.0%	.6%	38.3%	61.1%

Note: <= means "less than or equal to".
>= means "more than or equal to".

TABLE 20

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DATA TRANSFER RATE

	1996 Shipments				Forecast																
					1997					1998					1999				2000		
	<=8X	10X-12X	13X-18X	DVD	<=8X	10X-12X	13X-18X	>=20X	DVD	<=8X	10X-12X	13X-18X	>=20X	DVD	10X-12X	13X-18X	>=20X	DVD	13X-18X	>=20X	DVD
U.S. MANUFACTURERS																					
PCW/Distributor	47.0	--	--	--	48.0	--	--	--	--	49.0	--	--	--	--	50.0	--	--	--	51.0	--	--
TOTAL U.S. SHIPMENTS	47.0	--	--	--	48.0	--	--	--	--	49.0	--	--	--	--	50.0	--	--	--	51.0	--	--
NON-U.S. MANUFACTURERS																					
Captive	4,115.0	519.0	73.0	--	1,411.9	791.2	400.8	2,705.8	52.4	510.0	560.0	860.0	3,780.0	320.0	220.0	820.0	3,590.0	1,900.0	--	2,370.0	5,500.0
PCW/Distributor	9,951.1	1,575.9	319.4	--	1,385.3	4,112.2	2,004.5	4,545.7	164.8	350.0	900.0	1,200.0	8,690.0	3,060.0	90.0	500.0	8,105.0	8,210.0	--	3,900.0	16,055.0
OEM/Integrator	33,762.6	4,358.8	850.1	.5	8,582.0	10,502.7	8,417.3	21,288.5	339.8	930.0	1,720.0	2,725.0	45,470.0	7,055.0	630.0	2,000.0	43,280.0	19,060.0	700.0	40,805.0	29,800.0
TOTAL NON-U.S. SHIPMENTS	47,828.7	6,451.7	1,242.5	.5	11,379.2	15,406.1	10,822.6	28,540.0	557.0	1,790.0	3,180.0	4,785.0	57,940.0	10,435.0	940.0	3,320.0	54,975.0	29,170.0	700.0	47,075.0	51,355.0
WORLDWIDE RECAP																					
Captive	4,115.0	519.0	73.0	--	1,411.9	791.2	400.8	2,705.8	52.4	510.0	560.0	860.0	3,780.0	320.0	220.0	820.0	3,590.0	1,900.0	--	2,370.0	5,500.0
	+215.8%	--	--	--	-65.7%	+52.4%	+449.0%	--	--	-63.9%	-29.2%	+114.6%	+39.7%	+510.7%	-60.7%	-4.7%	-5.0%	+493.8%	--	-34.0%	+189.5%
PCW/Distributor	9,998.1	1,575.9	319.4	--	1,433.3	4,112.2	2,004.5	4,545.7	164.8	399.0	900.0	1,200.0	8,690.0	3,060.0	140.0	500.0	8,105.0	8,210.0	51.0	3,900.0	16,055.0
	+17.6%	--	--	--	-85.7%	+160.9%	+527.6%	--	--	-72.2%	-78.1%	-40.1%	+91.2%	--	-84.4%	-58.3%	-6.7%	+168.3%	-89.8%	-51.9%	+95.6%
OEM/Integrator	33,762.6	4,358.8	850.1	.5	8,582.0	10,502.7	8,417.3	21,288.5	339.8	930.0	1,720.0	2,725.0	45,470.0	7,055.0	630.0	2,000.0	43,280.0	19,060.0	700.0	40,805.0	29,800.0
	+5.9%	--	--	--	-74.6%	+141.1%	+890.2%	--	--	-89.2%	-83.6%	-67.6%	+113.6%	--	-63.4%	-26.6%	-4.8%	+170.2%	-65.0%	-5.7%	+56.3%
Total Shipments	47,875.7	6,451.7	1,242.5	.5	11,427.2	15,406.1	10,822.6	28,540.0	557.0	1,839.0	3,180.0	4,785.0	57,940.0	10,435.0	990.0	3,320.0	54,975.0	29,170.0	751.0	47,075.0	51,355.0
	+14.8%	--	--	--	-76.1%	+138.8%	+771.0%	--	--	-83.9%	-79.4%	-55.8%	+103.0%	--	-68.9%	-30.6%	-5.1%	+179.5%	-77.4%	-14.4%	+76.1%
ANNUAL SHARE, BY DIAMETER	86.3%	11.6%	2.1%	--	17.1%	23.2%	16.2%	42.8%	.7%	2.4%	4.1%	6.1%	74.2%	13.2%	1.1%	3.8%	62.3%	32.8%	.8%	47.6%	51.6%

Note: <= means "less than or equal to".
>= means "more than or equal to".

TABLE 21

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	2,000.7	3.6	2,769.5	2.8
PERSONAL COMPUTERS Business and professional, single user	42,127.9	75.8	69,831.2	70.6
WORKSTATIONS Engineering and office, single user	1,889.5	3.4	2,967.3	3.0
CONSUMER, GAME AND HOBBY COMPUTERS	8,734.3	15.7	22,156.1	22.4
OTHER APPLICATIONS	822.5	1.5	1,186.9	1.2
Total	55,574.9	100.0	98,911.0	100.0

TABLE 22

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	<=8X	10X-12X	13X-18X	DVD	Total		<=8X	10X-12X	13X-18X	DVD	Total	
Matsushita Electric	3084.0	864.0	--	--	3948.0	17.3	8270.0	2160.0	--	.5	10430.5	20.5
Mitsumi Electric	3448.0	460.0	--	--	3908.0	17.1	6224.0	920.0	--	--	7144.0	14.0
Toshiba	1737.0	143.0	2.0	--	1882.0	8.2	4567.0	390.0	7.0	--	4964.0	9.8
Sony	2516.2	13.4	336.8	--	2866.4	12.6	4193.0	45.0	561.2	--	4799.2	9.4
NEC	2145.6	--	200.8	--	2346.4	10.3	3953.6	--	365.0	--	4318.6	8.5
Hitachi	2147.0	--	48.6	--	2195.6	9.6	4048.5	--	91.5	--	4140.0	8.1
LG Electronics	850.7	39.6	--	--	890.3	3.9	2891.8	82.8	--	--	2974.6	5.8
Acer Peripherals	949.2	96.0	55.2	--	1100.4	4.8	2050.8	240.0	116.0	--	2406.8	4.7
Other U.S.	47.0	--	--	--	47.0	.2	47.0	--	--	--	47.0	.1
Other Non-U.S.	2598.0	1041.6	14.4	--	3654.0	16.0	7515.0	2094.9	28.8	--	9638.7	19.1
TOTAL	19522.7	2657.6	657.8	--	22838.1	100.0	43760.7	5932.7	1169.5	.5	50863.4	100.0

Note: <= means less than or equal.
>= means more than or equal.

CD FORMAT WRITABLE OPTICAL DISK DRIVES

1997 DISK/TREND REPORT

CD FORMAT WRITABLE OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter disk diameter

Advanced Information (AOpen)	CD-1420C, CRW-622 (E)
ADI	2040E
Behavior Tech Computer	BCE 621RW (E), BCR 6SR
Delta Electronics	ODR-6121
Eastman Kodak	PCD Writer 600
Hewlett-Packard	4325A, 6020
Hitachi	GF-1000 (E), GF-1050 (E)
JVC	XR-S230, XR-W2022
Matsushita Electric Industrial	CW-7502B, LF-1000AB, LF-1004AB (E)
Mitsumi Electric	CR2600TE
NEC	ODX654 (E), ODX656 (E)
Olympus	CD-R2X6
Philips	CDD2600, CDD3600 (E)
Pinnacle Micro	RCDW 226
Pioneer	DW-S114X, DVD-R
Plextor	PX R24CS
Ricoh	MP6200 (E), MP6211S (E)
Sanyo Electric	CRD-R24S
Sony	CDU-924S, CDU-926S, CDU-928E
TEAC	CD-R55S, PD-518E
Wearnes Technology	CDR-622
Yamaha	CDR-200, CDR-400, CDR-4001 (E)

(E) indicates rewritable.

Drives included in this group use CD-ROM or DVD-ROM formats, and have the ability to record in either write-once or rewritable mode. This includes CD-R (write-once), CD-RW (rewritable), plus DVD-R (write-once) and DVD-RAM (rewritable) drives when they appear. PD drives are also included: Although their writing format is not CD compatible, PD drives do have CD-ROM read capabilities and are included here for convenience. The drives discussed in this section are typically used with small and midrange computer systems of the mini and micro class, with intelligent workstations, and with network servers.

Market status

1996 shipments again turned in a strong performance, rising 176% to over 1.4 million units, despite a shortfall in expected PD drive production. CD-R ship-

ments grew 323.2%, to 922,500 units, while shipments of PD drives, produced for the first time in 1995, reached 496,000 units, but fell far short of expectations due to lack of acceptance by OEMs.

NEC began significant production of its own PD drive in 1997, and TEAC is also expected to begin production this year. A standard for PD drive media was approved in mid-1996 as ECMA-240. CD-RW drive shipments began in 1997 and are expected to account for over 24% of the unit shipments in the product group in 1997. Sample quantities of DVD-RAM drives are also expected to be shipped this year, with Hitachi the first company to announce and ship.

1996 shipments of CD-R drives were again strengthened by declining prices and improvements in software that made them easier to integrate and use in personal computer systems. Another positive factor is the increasing number of companies publishing CD-ROMs. The CD-R drives can be used to transmit finished content to testers and CD-ROM replicators. Despite shortages of CD-R media that occurred in 1996, sales of drives were unaffected by media shortages, and CD-R media suppliers now have significant overcapacity.

1996 sales revenues for the group rose 79.7% from $279.3 million to 501.9 million. About 56% of sales were made to the U.S., the same as in the previous year. Worldwide OEM activity represented 57% of unit shipments and 44.5% of revenues. 39.1% of shipments were to distributors, which provided 48.6% of revenues, a proportional increase from the previous year. The balance was derived from captive sales.

Philips, Yamaha and JVC were the leading CD-R drive producers in 1996, accounting for over 50% of overall unit shipments between them. Matsushita Electric was the only manufacturer to supply PD drives in quantity.

Marketing trends

This product group is expected to continue its growth through 2000, more than tripling unit shipments and doubling revenues, but the product mix within the group will alter radically as production of CD-RW drives ramps up, PD drives are displaced by DVD-RAM drives in the years after 1998 and DVD-RAM becomes the dominant product, accounting for over 62% of unit shipments in 2000.

CD-RW drives will continue to displace CD-R drives as prices of drives approach equality. CD-RW drives can write on either write-once or rewritable media at the users' discretion. DVD-RAM drive production is expected to be nominal in 1998, but should rapidly increase thereafter as designs and manufacturing processes mature.

Shipments for the group are expected to exceed 4.7 million units in 2000, while revenues are forecasted to exceed $1.03 billion. CD-R unit shipments, 72% of the group in 1996, are expected to decline to 7.8% of the group in 1999 and vanish thereafter, as the result of displacement by CD-RW and DVD writable technology. The DVD technologies are expected to capture about a fifth of group shipments in 1999, although DVD-R shipments are expected to be only a small fraction of DVD-RAM shipments due to the preference of users for rewritability over write-once technologies.

Applications

CD-R drives are mostly used for short run disk duplication and distribution where volume does not warrant the cost of the replication process, but archiving of files is also a significant application. They are also frequently installed in CD-ROM libraries to automate disk handling when multiple disks must be produced, to reduce manual handling of disks and reduce labor costs. CD-R drives are expected to be displaced by CD-RW drives beginning in 1997.

Users of CD-RW drives will be able to use either CD-R media or rewritable CD-RW media and can obtain the same storage utility functions currently provided by floppy disk drives or inexpensive tape drives, albeit at a higher price. CD-RW will also be preferred over CD-R for routine save/restore uses since the media can be recycled. While CD-RW media is substantially more expensive than CD-R media, this is not expected to be a factor in 1997 and media prices are expected to decline in future periods.

PD drives have been positioned by Matsushita as backup, archival and save/restore drives that can also read CD-ROM media. They have been adopted for use in some of Compaq's high end desktop computers. They also have applications in small servers, where their combined capability for archiving, backup and installing CD-ROM based software across a network makes them

attractive. PD drives compete against CD-RW drives, and PD manufacturers, which will benefit from a lead in entering production, are expected to compete aggressively against CD-RW to protect their position.

DVD-RAM and DVD-R are suitable for the same applications as CD-RW and CD-R, respectively, except that their limited capacities relative to the 4.7 gigabyte capacity of DVD-ROM limits their utility to content providers as a vehicle for testing and transmitting developed DVD-ROM content. It may be several years before this limitation can be corrected due to technical issues and pressures from content providers worried about piracy and copy protection.

Attachments to personal computers accounted for 78.1% of the units shipped in 1996, but this percentage will decrease to 51.6% in 2000 as usage in servers and workstations increases. Workstations used to prepare CD-ROMs and Web pages are expected to be major users of drives in this group, with their 5.8% share in 1996 expanding to 26% in 2000. An increasing number will also be used in duplicators, both standalone and host or network attached.

Technical trends

The major events for this product group include the shipment of CD-RW drives in late 1997, shipment of the first DVD-R drives in late 1997 or early 1998, and quantity shipment of DVD-RAM drives in 1998. PD drives are expected to be displaced by DVD-RAM as it enters its ramp-up phase in 1999. Some of the key aspects of this product progression are reviewed below:

Capacity: The capacity of CD-RW drives will be the same as CD-R and CD-ROM. However, due to technical limitations, the capacity of DVD-R is limited to 3.9 gigabytes in its initial form, while DVD-RAM drives will be limited to 2.6 gigabytes per side in their initial releases. Eventual capacity increases for DVD will be due to a combination of factors, including improved optics and shorter laser wavelength, permitting smaller spots and higher BPI and TPI. Pressure to provide capacity compatibility with DVD-ROM has resulted in a reevaluation of DVD-R designs, and some manufacturers believe they can introduce a 4.7 gigabyte capacity DVD-R unit sometime in 1998.

Write-once recording: The technology used for CD-R recording is dye-based, while the technology used for DVD-R will be phase change. In either method, the writing laser causes a change in media reflectivity which can be sensed during the readback process. Unfortunately, the CD-R

media currently used today will not be readable by first generation DVD-ROM or other DVD types because the CD-R media, written with a 780 nanometer laser, is essentially transparent at the shorter 650 nanometer wavelengths used by DVD drives. The industry has not done a good job of briefing the user community, and the resulting confusion and anger when DVD-ROM user "surprises" appear has the potential to significantly harm DVD sales.

Rewritability: Phase change technology will be used for CD-RW drives and for DVD-RAM as well, although there is a consortium of disk drive manufacturers working on a magneto-optic drive that will also be able to read CD-ROM and DVD-ROM media. PD media uses phase change technology and is expected to continue doing so. Like MO technology, phase change technology permits the interchange of write-once and erasable media on a single drive. It also provides direct overwrite capability with simpler drive designs than for MO drives. However, phase change media has a limitation on the number of write/erase cycles, much lower than MO media.

The CD-RW media cannot be read by most pre-1997 CD-ROM drives because of differences in media reflectivity, but addition of an inexpensive automatic gain control circuit to many new CD-ROM drive models resolved this incompatibility.

Recording format: The recording format and related error correction schemes used in CD-ROM compatible CD-R and CD-RW are optimized for sequential writing in a CLV mode. To make writing to CD-R and CD-RW 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 methods, known as packet writing, have been adopted as a standard by Sony, Philips, Hewlett-Packard and Adaptec, and formalized in OSTA's (Optical Storage Technology Association) adoption of the UDF packet writing file format in mid-1996.

Average access times: Average access times (seek plus latency) for products in this group are not particularly fast, with 300 to 400 milliseconds being typical and some drives offering average access times as slow as 1,000 milliseconds. PD drives are about twice as fast, but still in excess of 100 milliseconds. This slow performance is one of the motivating factors encouraging the development of the MO version of the DVD-RAM, since the typical performance of an MO drive would offer average access times well under 50 milliseconds, a more suitable value for a computer peripheral.

Data transfer rate: Typical CD-R and CD-RW performance is 2X write and 6X or 8X read, although 4X write drives are becoming available from more producers. A few 6X write drives are being made, notably by Eastman Kodak. PD drives have a maximum data transfer rate of 1.41 megabytes per second. Data transfer rates are expected to gradually increase, with

read rates going to 8X or faster, but write rates continue to lag, due to laser power and media sensitivity limits.

Packaging: Most of the drives in this group are packaged in a half height 5.25" form factor, and frequently as externally mounted drives for ease in integration. While there is no fundamental reason the drives could not be reduced in height, uncertain demand from notebook computer markets and the relatively limited production rate has made the payback for component integration efforts questionable.

Competing Products: Products in this group face competition from other optical and magnetic removable drives of equivalent or greater capacity. This competition is effective only if CD-ROM or DVD-ROM compatibility is not an issue. Despite recent price reductions, 3.5" MO drives, high capacity floppy drives and 1 gigabyte rigid drives compare well in price with drives in this group, supplying equivalent or superior capacity and performance in some cases. Where CD compatibility is an issue, there is no competition except between drives in this group.

A magneto-optic competitor for DVD-RAM is being examined by a group of companies including Fujitsu, Olympus, Philips, Hitachi, Sony, Sanyo, Sharp and Hitachi Maxell. The target drive will have a capacity of 6 gigabytes and performance substantially better than that projected for DVD-RAM using phase change media. The drives are also expected to read CD-ROM and DVD-ROM media, but probably will not read other magneto-optic media formats. The group developed a working specification for the drive and media in 1997 and some participants have projected availability of drives and media sometime in 1998.

In addition, competition is possible from advanced magneto-optic drives such as the Quinta or TeraStor products, assuming that they turn out to be price competitive when introduced and have at least some removable media incarnations.

More immediate competition comes from removable cartridge magnetic disk drives such as the Iomega Jaz drive and the SyQuest SyJet, both in the gigabyte range, price competitive and having superior performance. However, because they are not CD format compatible and use expensive media, direct competition is not expected. Rather, the existence of these competitors limits the expansion potential for the CD format products in this group.

Forecasting assumptions

1. CD-RW drives will be available from multiple sources in 1997. Prices will rapidly approach CD-R prices after introduction.

2. DVD-R drives will be announced and commence shipments in late 1997.
3. DVD-RAM drives will be introduced in 1997 and commence quantity shipments in 1998, impacting shipments of PD, CD-R and CD-RW drives thereafter.
4. Advanced magneto-optic drives will not significantly impact this product group within the forecast period.

TABLE 23

CD FORMAT WRITABLE OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	1.2	1.5	.3	.6	--	--	--	--	--	--
TOTAL U.S. REVENUES	1.2	1.5	.3	.6	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	33.0	--	27.8	9.5	45.8	10.2	51.0	19.5	71.5
PCM/Distributor	104.0	243.8	103.7	251.9	151.9	332.9	182.8	356.7	250.5	487.4
OEM/Integrator	177.8	223.6	203.7	333.5	200.8	377.8	234.4	490.8	237.6	480.7
TOTAL NON-U.S. REVENUES	281.8	500.4	307.4	613.2	362.2	756.5	427.4	898.5	507.6	1,039.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	283.0	501.9	307.7	613.8	362.2	756.5	427.4	898.5	507.6	1,039.6
OEM Average Price ($000)		.276		.244		.214		.208		.189

TABLE 24

CD FORMAT WRITABLE OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	.4	.5	.1	.2	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	.4	.5	.1	.2	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	55.0	--	50.0	10.0	54.0	12.0	60.0	30.0	110.0
PCM/Distributor	250.0	555.0	354.1	823.2	594.1	1,300.2	779.0	1,488.0	1,075.0	2,052.0
OEM/Integrator	684.0	808.0	835.2	1,366.4	942.0	1,762.0	1,162.0	2,353.0	1,260.0	2,540.0
TOTAL NON-U.S. SHIPMENTS	934.0	1,418.0	1,189.3	2,239.6	1,546.1	3,116.2	1,953.0	3,901.0	2,365.0	4,702.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	934.4	1,418.5	1,189.4	2,239.8	1,546.1	3,116.2	1,953.0	3,901.0	2,365.0	4,702.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	1.2	2.0	2.4	4.2	4.0	7.3	5.9	11.2	8.3	15.9

TABLE 25

CD FORMAT WRITABLE OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DRIVE TYPE

	1996 Revenues		Forecast															
			1997				1998					1999				2000		
	CD-R	PD	CD-R	CD-RW	PD	DVD-RAM	CD-R	CD-RW	PD	DVD-R	DVD-RAM	CD-R	CD-RW	DVD-R	DVD-RAM	CD-RW	DVD-R	DVD-RAM
U.S. MANUFACTURERS																		
PCM/Distributor	1.5	--	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. REVENUES	1.5	--	.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS																		
Captive	--	33.0	--	--	27.8	--	--	--	4.0	--	41.8	--	--	--	51.0	--	--	71.5
PCM/Distributor	208.6	35.2	169.5	49.6	32.6	.2	175.0	130.0	17.5	2.4	8.0	24.4	258.3	4.0	70.0	211.4	18.0	258.0
OEM/Integrator	150.8	72.8	163.0	106.6	63.5	.4	178.5	176.4	11.0	--	11.9	45.6	277.2	--	168.0	161.0	--	319.7
TOTAL NON-U.S. REVENUES	359.4	141.0	332.5	156.2	123.9	.6	353.5	306.4	32.5	2.4	61.7	70.0	535.5	4.0	289.0	372.4	18.0	649.2
WORLDWIDE RECAP																		
Captive	--	33.0	--	--	27.8	--	--	--	4.0	--	41.8	--	--	--	51.0	--	--	71.5
	--	+87.5%	--	--	-15.8%	--	--	--	-85.6%	--	--	--	--	--	+22.0%	--	--	+40.2%
PCM/Distributor	210.1	35.2	170.1	49.6	32.6	.2	175.0	130.0	17.5	2.4	8.0	24.4	258.3	4.0	70.0	211.4	18.0	258.0
	+176.4%	+9.0%	-19.0%	--	-7.4%	--	+2.9%	+162.1%	-46.3%	--	--	-88.1%	+98.7%	+66.7%	+775.0%	-18.2%	+350.0%	+268.6%
OEM/Integrator	150.8	72.8	163.0	106.6	63.5	.4	178.5	176.4	11.0	--	11.9	45.6	277.2	--	168.0	161.0	--	319.7
	+45.3%	+46.8%	+8.1%	--	-12.8%	--	+9.5%	+65.5%	-82.7%	--	--	-74.5%	+57.1%	--	--	-41.9%	--	+90.3%
Total Revenues	360.9	141.0	333.1	156.2	123.9	.6	353.5	306.4	32.5	2.4	61.7	70.0	535.5	4.0	289.0	372.4	18.0	649.2
	+100.7%	+41.7%	-7.7%	--	-12.1%	--	+6.1%	+96.2%	-73.8%	--	--	-80.2%	+74.8%	+66.7%	+368.4%	-30.5%	+350.0%	+124.6%
ANNUAL SHARE, BY DIAMETER	72.0%	28.0%	54.4%	25.4%	20.2%	--	46.8%	40.5%	4.3%	.3%	8.1%	7.8%	59.7%	.4%	32.1%	35.9%	1.7%	62.4%

TABLE 26

CD FORMAT WRITABLE OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DRIVE TYPE

	1996		Forecast															
	Shipments		1997				1998					1999				2000		
	CD-R	PD	CD-R	CD-RW	PD	DVD-RAM	CD-R	CD-RW	PD	DVD-R	DVD-RAM	CD-R	CD-RW	DVD-R	DVD-RAM	CD-RW	DVD-R	DVD-RAM
U.S. MANUFACTURERS																		
PCM/Distributor	.5	--	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	.5	--	.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS																		
Captive	--	55.0	--	--	50.0	--	--	--	10.0	--	44.0	--	--	--	60.0	--	--	110.0
PCM/Distributor	445.0	110.0	564.0	138.0	121.0	.2	700.0	520.0	70.0	.2	10.0	116.0	1,230.0	2.0	140.0	1,174.0	18.0	860.0
OEM/Integrator	477.0	331.0	664.0	407.0	295.0	.4	850.0	840.0	55.0	--	17.0	253.0	1,540.0	--	560.0	1,150.0	--	1,390.0
TOTAL NON-U.S. SHIPMENTS	922.0	496.0	1,228.0	545.0	466.0	.6	1,550.0	1,360.0	135.0	.2	71.0	369.0	2,770.0	2.0	760.0	2,324.0	18.0	2,360.0
WORLDWIDE RECAP																		
Captive	--	55.0	--	--	50.0	--	--	--	10.0	--	44.0	--	--	--	60.0	--	--	110.0
	--	+103.7%	--	--	-9.1%	--	--	--	-80.0%	--	--	--	--	--	+36.4%	--	--	+83.3%
PCM/Distributor	445.5	110.0	564.2	138.0	121.0	.2	700.0	520.0	70.0	.2	10.0	116.0	1,230.0	2.0	140.0	1,174.0	18.0	860.0
	+502.8%	+12.2%	+26.6%	--	+10.0%	--	+24.1%	+276.8%	-42.1%	--	--	-83.4%	+136.5%	+900.0%	--	-4.6%	+800.0%	+514.3%
OEM/Integrator	477.0	331.0	664.0	407.0	295.0	.4	850.0	840.0	55.0	--	17.0	253.0	1,540.0	--	560.0	1,150.0	--	1,390.0
	+231.0%	+93.6%	+39.2%	--	-10.9%	--	+28.0%	+106.4%	-81.4%	--	--	-70.2%	+83.3%	--	--	-25.3%	--	+148.2%
Total Shipments	922.5	496.0	1,228.2	545.0	466.0	.6	1,550.0	1,360.0	135.0	.2	71.0	369.0	2,770.0	2.0	760.0	2,324.0	18.0	2,360.0
	+323.2%	+67.6%	+33.1%	--	-6.0%	--	+26.2%	+149.5%	-71.0%	--	--	-76.2%	+103.7%	+900.0%	+970.4%	-16.1%	+800.0%	+210.5%
ANNUAL SHARE, BY DIAMETER	65.1%	34.9%	54.9%	24.3%	20.8%	--	49.8%	43.6%	4.3%	--	2.3%	9.5%	71.1%	.1%	19.3%	49.5%	.4%	50.1%

TABLE 27

CD FORMAT WRITABLE OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	96.0	6.8	752.3	16.0
PERSONAL COMPUTERS				
Business and professional, single user	1,108.3	78.1	2,426.3	51.6
WORKSTATIONS				
Engineering and office, single user	81.8	5.8	1,222.5	26.0
CONSUMER, GAME AND HOBBY COMPUTERS	45.8	3.2	188.1	4.0
OTHER APPLICATIONS	86.6	6.1	112.8	2.4
Total	1,418.5	100.0	4,702.0	100.0

TABLE 28

CD FORMAT WRITABLE OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	CD-R	PD	Total		CD-R	PD	Total	
Matsushita Electric	34.0	360.0	394.0	42.2	60.0	441.0	501.0	36.7
Philips	358.0	--	358.0	38.3	458.0	--	458.0	33.6
Yamaha	72.0	--	72.0	7.7	150.0	--	150.0	11.0
JVC	60.0	--	60.0	6.4	110.0	--	110.0	8.1
Ricoh	40.0	--	40.0	4.3	100.0	--	100.0	7.3
Other U.S.	.4	--	.4	--	.5	--	.5	--
Other Non-U.S.	10.0	--	10.0	1.1	44.0	--	44.0	3.3
TOTAL	574.4	360.0	934.4	100.0	922.5	441.0	1363.5	100.0

READ/WRITE OPTICAL DISK DRIVES LESS THAN 2 GIGABYTES

READ/WRITE OPTICAL DISK DRIVES LESS THAN 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

2.5" disk diameter

Sharp	MD-PS1
Sony	MDH-10

3.5" disk diameter

Fujitsu	M2512A, M2513A, M2541S
Matsushita Electric Industrial	LF-3200, LF-3294
Mountain Optech	CS-250 R/W
Olympus	640MO Turbo, MOS330E, MOS341E
Sony	HS-D650, RMO-S330

5.25" disk diameter

Hewlett-Packard	C1113F
Hitachi	OD172 LIM-DOW
Matsushita Electric Industrial	LF-7394
Maxoptix	T4-1300, T5-2600
MOST	Jupiter 2, RMD 626
Mountain Optech	CS-1000 M/F
NEC	N1137-57, ODD-160
Nikon	DD53B1
Olympus	MOS525E, MOS540E
Pinnacle Micro	Vertex
Pioneer	DE-SH7101
Ricoh	RO-5060E
Sharp	JY 800
Sony	RMO-S580, SMO-F541

All drives are rewritable unless otherwise indicated.

Two types of drives are included in this group: Write Once Read Many, (WORM) and Rewritable. 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 multifunction magneto-optic/ablative media drives.

The read/write drives in this section are typically used with small and mid-range computers 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 used in larger optical libraries as well.

Market status

Over the past few years, activity in this group has increasingly been dominated by 3.5" drives, and 1996 was no exception. Shipments of 5.25" drives declined (again) to 182,700 units, while shipments of 3.5" drives grew over 134% to 1.2 million drives, boosted by active price competition. 3.5" optical disk drives might have done even better if they were not competing with so many other types of data storage products.

OEM shipments of 3.5" drives remain less than demand through distribution, with integrators and resellers moving the majority of the drives shipped. The Apple Macintosh add-on market, where there is less price sensitivity, remains the healthiest 3.5" market segment. Shipments of 3.5" drives remained strongest in Japan where networks are not yet as well established as in the United States (3.5" optical disks are frequently used for data exchange), and a relatively weak SyQuest and Iomega presence in Japan also helped sustain strong demand.

Sony was the leading noncaptive producer of 5.25" drives in 1996, while Fujitsu again produced more 3.5" drives than all other 3.5" drive producers. All 3.5" drive producers are Japanese firms.

Worldwide sales revenues grew 23.3% to $635 million in 1996, with 3.5" drive revenues increasing over 60% while 5.25" drive revenues shrank 12.7% due to captive producers dropping out and purchasing drives from OEM suppliers. U.S. firms accounted for 10.5% of 1996 revenues, a decline from 1995 and a trend that is expected to continue due to the strong growth of 3.5" drives.

Marketing trends

Rewritable 5.25" drives with capacities of over two gigabytes per side are now available, and this will result in declining OEM shipments of 5.25" drives in this product group. Sales through distribution peaked in 1996, as existing stocks of older drives were liquidated. Competition from magnetic disk drives, with both

fixed and removable disks, offering low OEM and distribution pricing during future years will continue to contribute to the decline. Optical libraries have become increasingly significant in the application mix, with over 20% of the 5.25" drives in this class now going into libraries, but libraries incorporating 3.5" drives are expected to do poorly because of low drive capacity.

3.5" drives with capacities of 640 megabytes or higher are now in production at several companies. However, the 3.5" MO drive will be challenged by Sy-Quest's and Iomega's new families of 3.5" removable rigid disk cartridge gigabyte-plus drives, which offer higher capacity, very competitive prices and superior performance in the coming year. These drives are very strong competitors in the U.S. market, though less so in Japan where 3.5" MO drives are strongest. The PD drive, the CD-RW drive, and later the DVD-RAM drive, will also compete in the same capacity segment of the market, often with lower prices but also with inferior performance.

While the 2.5" drive has been a lackluster performer, it may receive a new lease on life as a result of Sharp's usage of the form factor in a forthcoming video camera due for 1997 introduction. Shipments are projected to reach the 100,000 unit level in 2000.

Shipments for the entire product group are expected to increase to over 1.8 million drives in 2000 based on anticipated growth in 3.5" optical disk drive shipments, even though shipments of 5.25" drives in this group will be very small. Sales revenues for the group are actually expected to decline, falling to $477.5 million in 2000, as a consequence of the predominance of lower priced 3.5" and 2.5" drives in the product mix.

Applications

5.25" write-once and rewritable optical drives under 2 gigabytes are used primarily to store images in office, medical, design, video editing, security 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.

Specific applications for drives in this product group include:

Save/restore operations

* Archival storage of files.

Temporary image and other file storage

* Storage of downloaded Internet files
* Image storage from security systems

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

* 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

* When installed in optical library, may contain content for video server. Files are staged to magnetic drives for distribution.
* Large files required for complex graphics, audio and video presentations.
* Editing of files with digital video or digital audio content.

The faster erasable drives, such as the Maxoptix "T" series, have found limited application as system disks in high security applications requiring vault stor-

age of recorded media when the equipment is unattended, but this usage has been impacted by the availability of high capacity rigid disk cartridge drives.

3.5" drives are used to provide project oriented storage on a single volume, and are often used to store downloaded Internet files, and 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 recent price declines have also encouraged their use as high performance backup devices for workstations and personal computers.

Personal computers were again the largest application platform for this product group in 1996, accounting for 80.3% of the units shipped. This is an increase over l995, reflecting the larger mix of 3.5" drives shipped. The share attached to networks will decline as user interest shifts to higher capacity drives in the over 2 gigabyte range, resulting in share increases for personal computer and workstation attachment rates.

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, Sony and others. Only a small percentage of 3.5" drives will be installed in optical libraries.

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 5.25" rewritable drives is expected to reach 2.6 gigabytes per side by late 1997 and may go well beyond that in 1998 if advanced MO drives go into production as projected. 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, the adoption of pulse width modulation (100% improvement), zoned recording, land and groove recording (50-100% improvement), and variable track pitch. If blue semiconductor lasers with adequate power become commercially available, small optical drives will be able to provide several gigabytes of capacity in a 3.5" form factor. With 3.5" drive producers encouraged by

the growth in 1996 shipments, 1.3 gigabyte 3.5" drives are expected to be developed and introduced by late 1998.

Write-once recording: A variety of optical recording technologies and media fabrication processes were originally used, 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) were the most commonly used methods. Write-once dye-based media is being used by Pioneer. In general, media using these separate recording methods are not interchangeable.

Because of the interchange problems, these methods have been displaced by the MO based CCW (Continuous Composite Worm) format, 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 in this product group.

Rewritability: Of the several technologies contending for acceptance, magneto-optic media is the most commonly used method capable of meeting user demands for sensitivity, erasability, and stability. Technical problems and uncertainty about adequate yields for the complex media structures delayed wide use of direct MO overwrite until 1996, when MOST, Nikon and Hitachi began offering 5.25" drives using light intensity modulation to provide direct overwrite capability.

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 standard 11560.

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.

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. MO drives are now available with sub-30 millisecond seek times, while the Maxoptix T5-2600 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 Olympus going under the 30 millisecond level. Increasing rotational speed also improves performance. The Maxoptix drive cited above rotates at over 3,800 RPM, and some 3.5" drives reach 4,000 RPM.

Long access times for optical 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. Maxoptix, Pinnacle Micro and NEC also offer drives with RPM exceeding 3,600 RPM.

Data transfer rate: Specified internal drive maximum data transfer rates are over 4 megabytes per second range for 5.25" drives and over 3 megabytes per second for 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.

Error rate: Error correcting codes are used to compensate for the high raw error rate of optical media, and are designed to deal with the higher defect density occurring at the end of media life. Although disk data capacity is reduced 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 use more sophisticated ECC circuitry capable of doing on-the-fly error correction so quickly that ECC latency will not be observed.

Packaging: Optical disk drives using read/write 5.25" disks were originally packaged to conform with the envelope of a full height 5.25" floppy disk drive, limiting use to external mounting with many personal computers. More recent drives tend to use the half-height 5.25" form factor.

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 was the first company to announce and ship a 25.4 mm high 3.5" drive, followed by a 17 millimeter drive in late 1995 which is still the thinnest available.

Drive producers are improving packaging and reducing costs 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 does 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 been approved by ECMA (ECMA standard 184) and ISO as ISO 13549. Downward compatible 1.3 gigabyte per side 5.25" media is defined by ISO 14517. 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, while 640 megabyte media is covered by ISO 15041. 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.

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:

* 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. Most optical drives have SCSI interfaces and can use readily available SCSI controllers and drivers.

Competing Products: Strong competition for the 3.5" drives is provided by a range of products, including gigabyte range rigid magnetic disk cartridge drives being delivered by Iomega and SyQuest, at prices substantially under current prices for 3.5" MO drives. Fixed magnetic drives with multigigabyte capacities are being advertised at retail prices in the $100 to $200 range as of mid-1997.

5.25" magnetic disk drives from Seagate with capacities up to 23 gigabytes have impacted 5.25" optical disk drive sales in those stand-alone applications where a removable disk is not mandatory, and 3.5" magnetic disk drives with capacities now offered up to 9 gigabytes are having a restraining effect on 3.5" MO sales as well.

Ultimately, the competing technology most impacting this product group is the higher capacity optical disk drives that will begin shipments in 1998, and which are discussed in the following section.

Forecasting assumptions

1. 5.25" optical disk drives with over 2 gigabytes of capacity per side will start to divert shipments of 5.25" drives from this product group beginning in 1997.

2. Components and media will be available in adequate production quantities throughout the forecast period.

3. 600+ megabyte 3.5" optical disk drives will remain in production from multiple major producers throughout the forecast period. 1.3 gigabyte drives are expected to be introduced in late 1998.

TABLE 29

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	14.7	24.8	--	--	--	--	--	--	--	--
PCM/Distributor	19.0	26.3	8.4	13.3	3.0	6.0	1.7	2.6	--	--
OEM/Integrator	10.1	15.6	15.3	22.4	9.5	13.3	2.6	3.5	--	--
TOTAL U.S. REVENUES	43.8	66.7	23.7	35.7	12.5	19.3	4.3	6.1	--	--
Non-U.S. Manufacturers										
Captive	--	43.7	--	47.7	--	37.2	--	32.4	--	32.0
PCM/Distributor	52.4	333.4	62.0	409.8	58.8	427.1	59.9	427.0	48.6	375.1
OEM/Integrator	55.6	191.2	61.8	188.9	57.3	182.2	38.6	147.0	12.5	70.4
TOTAL NON-U.S. REVENUES	108.0	568.3	123.8	646.4	116.1	646.5	98.5	606.4	61.1	477.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	151.8	635.0	147.5	682.1	128.6	665.8	102.8	612.5	61.1	477.5
OEM Average Price ($000)		.471		.406		.350		.276		.218

TABLE 30

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.7	11.2	--	--	--	--	--	--	--	--
PCM/Distributor	15.5	21.3	8.1	12.6	3.0	6.0	2.0	3.0	--	--
OEM/Integrator	11.0	16.8	14.9	21.6	10.0	14.0	3.0	4.0	--	--
TOTAL U.S. SHIPMENTS	33.2	49.3	23.0	34.2	13.0	20.0	5.0	7.0	--	--
Non-U.S. Manufacturers										
Captive	--	46.4	--	58.1	--	66.0	--	72.0	--	80.0
PCM/Distributor	132.9	880.6	169.7	1,193.4	184.6	1,419.3	202.0	1,480.5	180.0	1,410.0
OEM/Integrator	83.2	421.7	104.6	497.7	109.0	544.0	96.0	540.0	45.0	323.0
TOTAL NON-U.S. SHIPMENTS	216.1	1,348.7	274.3	1,749.2	293.6	2,029.3	298.0	2,092.5	225.0	1,813.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	249.3	1,398.0	297.3	1,783.4	306.6	2,049.3	303.0	2,099.5	225.0	1,813.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	1.3	4.1	1.6	5.9	1.9	7.9	2.2	10.0	2.4	11.8

TABLE 31

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast											
	1997			1998			1999			2000		
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
Captive	24.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	26.3	--	--	13.3	--	--	6.0	--	--	2.6	--	--	--	--	--
OEM/Integrator	15.6	--	--	22.4	--	--	13.3	--	--	3.5	--	--	--	--	--
TOTAL U.S. REVENUES	66.7	--	--	35.7	--	--	19.3	--	--	6.1	--	--	--	--	--
NON-U.S. MANUFACTURERS															
Captive	27.7	16.0	--	25.2	22.5	--	10.2	27.0	--	3.0	29.4	--	--	32.0	--
PCM/Distributor	24.1	309.1	.2	16.5	378.9	14.4	9.7	402.0	15.4	5.2	406.0	15.8	--	359.1	16.0
OEM/Integrator	109.9	81.3	--	96.2	88.7	4.0	81.6	96.6	4.0	44.1	98.7	4.2	8.1	58.0	4.3
TOTAL NON-U.S. REVENUES	161.7	406.4	.2	137.9	490.1	18.4	101.5	525.6	19.4	52.3	534.1	20.0	8.1	449.1	20.3
WORLDWIDE RECAP															
Captive	52.5	16.0	--	25.2	22.5	--	10.2	27.0	--	3.0	29.4	--	--	32.0	--
	-24.8%	-72.4%	--	-52.0%	+40.6%	--	-59.5%	+20.0%	--	-70.6%	+8.9%	--	--	+8.8%	--
PCM/Distributor	50.4	309.1	.2	29.8	378.9	14.4	15.7	402.0	15.4	7.8	406.0	15.8	--	359.1	16.0
	-38.8%	+83.8%	--	-40.9%	+22.6%	--	-47.3%	+6.1%	+6.9%	-50.3%	+1.0%	+2.6%	--	-11.6%	+1.3%
OEM/Integrator	125.5	81.3	--	118.6	88.7	4.0	94.9	96.6	4.0	47.6	98.7	4.2	8.1	58.0	4.3
	+14.5%	+202.2%	--	-5.5%	+9.1%	--	-20.0%	+8.9%	--	-49.8%	+2.2%	+5.0%	-83.0%	-41.2%	+2.4%
Total Revenues	228.4	406.4	.2	173.6	490.1	18.4	120.8	525.6	19.4	58.4	534.1	20.0	8.1	449.1	20.3
	-12.7%	+60.6%	-50.0%	-24.0%	+20.6%	--	-30.4%	+7.2%	+5.4%	-51.7%	+1.6%	+3.1%	-86.1%	-15.9%	+1.5%
ANNUAL SHARE, BY DIAMETER	36.1%	63.9%	--	25.5%	72.0%	2.5%	18.1%	79.0%	2.9%	9.5%	87.3%	3.2%	1.7%	94.2%	4.1%

TABLE 32

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997			1998			1999			2000		
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS															
Captive	11.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	21.3	--	--	12.6	--	--	6.0	--	--	3.0	--	--	--	--	--
OEM/Integrator	16.8	--	--	21.6	--	--	14.0	--	--	4.0	--	--	--	--	--
TOTAL U.S. SHIPMENTS	49.3	--	--	34.2	--	--	20.0	--	--	7.0	--	--	--	--	--
NON-U.S. MANUFACTURERS															
Captive	14.4	32.0	--	13.1	45.0	--	6.0	60.0	--	2.0	70.0	--	--	80.0	--
PCM/Distributor	19.6	860.5	.5	14.3	1,119.1	60.0	9.3	1,340.0	70.0	5.5	1,400.0	75.0	--	1,330.0	80.0
OEM/Integrator	99.4	322.3	--	97.6	382.1	18.0	85.0	439.0	20.0	48.0	470.0	22.0	9.0	290.0	24.0
TOTAL NON-U.S. SHIPMENTS	133.4	1,214.8	.5	125.0	1,546.2	78.0	100.3	1,839.0	90.0	55.5	1,940.0	97.0	9.0	1,700.0	104.0
WORLDWIDE RECAP															
Captive	25.6	32.0	--	13.1	45.0	--	6.0	60.0	--	2.0	70.0	--	--	80.0	--
	-19.2%	-38.5%	--	-48.8%	+40.6%	--	-54.2%	+33.3%	--	-66.7%	+16.7%	--	--	+14.3%	--
PCM/Distributor	40.9	860.5	.5	26.9	1,119.1	60.0	15.3	1,340.0	70.0	8.5	1,400.0	75.0	--	1,330.0	80.0
	-33.0%	+110.1%	--	-34.2%	+30.1%	--	-43.1%	+19.7%	+16.7%	-44.4%	+4.5%	+7.1%	--	-5.0%	+6.7%
OEM/Integrator	116.2	322.3	--	119.2	382.1	18.0	99.0	439.0	20.0	52.0	470.0	22.0	9.0	290.0	24.0
	+26.2%	+471.5%	--	+2.6%	+18.6%	--	-16.9%	+14.9%	+11.1%	-47.5%	+7.1%	+10.0%	-82.7%	-38.3%	+9.1%
Total Shipments	182.7	1,214.8	.5	159.2	1,546.2	78.0	120.3	1,839.0	90.0	62.5	1,940.0	97.0	9.0	1,700.0	104.0
	-1.1%	+134.6%	-16.7%	-12.9%	+27.3%	--	-24.4%	+18.9%	+15.4%	-48.0%	+5.5%	+7.8%	-85.6%	-12.4%	+7.2%
ANNUAL SHARE, BY DIAMETER	13.1%	86.9%	--	8.9%	86.8%	4.3%	5.9%	89.8%	4.3%	3.0%	92.5%	4.5%	.5%	93.9%	5.6%

TABLE 33

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	4.2	.3	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	87.2	6.2	3.6	.2
PERSONAL COMPUTERS				
Business and professional, single user	1,123.8	80.3	1,570.1	86.6
WORKSTATIONS				
Engineering and office, single user	157.5	11.3	213.9	11.8
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	27.0	1.9	25.4	1.4
Total	1,399.7	100.0	1,813.0	100.0

TABLE 34

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
Fujitsu	--	127.0	--	127.0	52.3	--	770.0	--	770.0	57.4
Olympus	1.0	40.0	--	41.0	16.9	16.0	410.0	--	426.0	31.8
Sony	45.0	.5	--	45.5	18.8	81.0	2.8	--	83.8	6.3
Other U.S.	26.5	--	--	26.5	10.9	38.1	--	--	38.1	2.8
Other Non-U.S.	2.6	--	--	2.6	1.1	22.0	--	.5	22.5	1.7
TOTAL	75.1	167.5	--	242.6	100.0	157.1	1182.8	.5	1340.4	100.0

READ/WRITE OPTICAL DISK DRIVES MORE THAN 2 GIGABYTES

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READ/WRITE OPTICAL DISK DRIVES MORE THAN 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Eastman Kodak	System 2000

12" disk diameter

ATG Cygnet	GD6001, GD9001/S, GD16000
NEC	N6513-23
Nikon	MO-DD121-1AJ (Rewritable)
Philips LMS	LD 4100, LD 6100

5.25" disk diameter

Pinnacle Micro	Apex (Rewritable)

All drives listed above are write-once unless otherwise indicated.

This product group includes drives with over 2 gigabytes of on-line capacity, reflecting increases in drive capacity level. High capacity optical disk drives are read/write drives, either write-once or rewritable. Currently, most drives in this capacity range are 12" write-once types, although Nikon started shipments of a 12" rewritable drive in 1992. Eastman Kodak produces high capacity 14" drives as well. 5.25" drives became participants in this product group in 1996, with the shipment of Pinnacle Micro's Apex 2.3 gigabyte per side rewritable drive late in the year. More 5.25" drives in this group are expected to be announced in late 1997, and a number of drives employing advanced magneto-optic design techniques to achieve capacities above 5 gigabytes per side are anticipated in 1998.

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 often used in libraries that provide random access mass storage subsystems with hundreds of gigabytes of storage capacity. All but two of the currently listed drives in this group use 12" media, and most 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.

Market status

Unit shipments in this group grew to 8,900 units, a 39.1% increase as a result of shipments of 4,700 5.25" drives in this group, outnumbering shipments of 12" drives, which declined 34% to 4,200 units in the same period. 1996 revenues declined 25.4% to $64.1 million, due to lower sales of 12" drives and the mix shift to lower priced 5.25" drives. U.S. manufacturers accounted for 26.4% of worldwide sales revenues, although 66.1% of worldwide revenues were generated in the U.S. market. 47% of 1996 revenues were produced by sales to OEMs and integrators, while 39.3% were from resale channels. The shift in channel mix from 1995 is the result of the introduction of 5.25" drives, which tend to make more intensive use of reseller channels than do 12" drives.

57.3% of 1996 unit shipments were produced by U.S. firms, a huge increase from 1995, resulting from the product mix shift, since the only 5.25" drives produced were made by Pinnacle Micro, a U.S. company. 73% of 1996 unit shipments went to the U.S. market, while 27% were sold in other parts of the world. 1996's leading noncaptive producers were Pinnacle Micro and Philips LMS.

The number of manufacturers of 12" drives in this product group has decreased with the departure of Hitachi and Sony from the 12" drive market, but with the arrival of high capacity 5.25" drives, the total number of producers will again increase, starting in 1998. It is ironic that while 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, non-Japanese companies now produce the majority of 12" and 14" drives.

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. Higher capacity 5.25" and, probably, 12 centimeter MO drives will expand the market for this product group into general industry.

Marketing trends

Following the shock effect of Sony's and Hitachi's departure from the market, shipments of 12" and 14" drives are expected to increase gradually towards the end of the forecast period, as a result of higher capacity drives becoming available and continued interest in the Philips LMS 12" optical library. Shipments of 5.25" drives in this group, which began last year, are expected to increase sharply in 1998 as the result of the introduction of 2.6 gigabyte per side drives beginning in late 1997. The number of 5.25" drive producers active in this segment is also expected to increase sharply, as is the range of products offered.

New 1998 products anticipated are 6 gigabyte 4.72" MO drives, near field recording drives from TeraStor, and multigigabyte optical drives from Quinta. The 4.72" drive will probably read CD-ROM and DVD-ROM media, but not existing 3.5" and 5.25" MO media. The potential availability and pricing of this drive is currently too uncertain to permit forecasting. The competition from 5.25" drives may halt or reverse the tendency of 12" drive prices to climb each year. It is anticipated that all of the 5.25" drives in this product group will be rewritable or multifunction, but not all will necessarily use removable media. It is also expected that 3.5" drives will appear in this product group sometime during the forecast period.

One result of the addition of the multigigabyte rewritable drives expected to be announced in this group will be to cause the average OEM unit price to fall sharply during the forecast period from almost $8,000 to under $1,000. While this will severely stress the 12" market, shipments to companies already committed to 12" media in their libraries may sustain the 12" market for a while. Of the over 432,000 drives in this product group expected to ship in 2000, only 1% will be 12" or 14" drives.

Sales revenues in 2000 are projected to exceed $453 million. Non-U.S. markets are expected to generate the majority of worldwide revenues for this product group in the latter part of the forecast period, following the pattern of 3.5" drives, but until the actual form of the new products is known, this is subject to reversal. Most of the U.S. sales will come from sales of 5.25" drives. 12" drive sales should be helped temporarily by expanding sales of small optical libraries with a single 12" drive, plus a new generation of higher capacity drives, but ultimately will fall to the small diameter onslaught.

Applications

Networks and multiuser systems remained the major application for drives in this group, but the introduction of 5.25" drives in the group resulted in personal computers capturing the largest share of attachments, accounting for 44.7%. Networks and multiuser systems followed with 36.4%. The majority of 12" drives were installed in optical libraries. Libraries attached to mainframes used enough drives to account for 8.7% of group shipments. With the arrival of additional 5.25" (or smaller) drives in this group, the pattern will change drastically, with personal computer applications expected to capture over 64% of the 2000 total, with workstations and networks accounting for nearly 14% each. Very high performance applications, including imaging and video, are expected to capture 4% in 2000, while mainframe attached systems will account for 2.4%.

The above does not take into account the possibility that high capacity optical drives may have the performance and economics to make major inroads into the tape market and at least dent the high capacity, low performance segment of the rigid disk drive market. Until the characteristics of the drives become clear, it is inappropriate to state the above as a firm forecast, but the prudent will take it into account as a real possibility. With Quantum's investment in TeraStor and Seagate's acquisition of Quinta, a startup less than 2 years old, for an astounding $230 million, there is ample evidence that the strategic planners at major disk drive producers see the potential.

Currently, major applications for optical disk drives over 2 gigabytes 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 smaller drives increasingly participate in this product group, archival applications will become less dominant, although many of the 5.25" drives may be used for archiving personal files, as will the newly proposed 4.72" MO drives if they actually materialize on schedule in 1998, as some potential suppliers have suggested. Imaging, video and audio editing, save/restore and data transfer are expected to become significant applications.

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. As 5.25" drives invade this product group, ruggedized versions are expected to appear in defense, aerospace and resource survey applications.

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.

Image and content preparation

* Video, still image and audio editing

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 1996, over 90% of the 12" and 14" drives shipped in this group were attached to optical libraries, but library attachment in this group is expected to gradually decline as 5.25" drives (which are less likely to be used with libraries) form a greater part of the total.

Automated library systems using large capacity drives usually have two or more drives to improve overall response time, although the single drive, small 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 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 have been impacted by 5.25" diameter drives used with library units of 10-20 disk capacity and, in some cases, by large capacity 5.25" magnetic rigid disk drives with capacities of 23 gigabytes or more. 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, or it is acceptable to use a fixed rigid drive in combination with a removable drive that acts as a mailbox device. The advent of 1.3 gigabyte 5.25" based systems limited growth prospects for 12" systems, and the situation will be further aggravated by the expected arrival of high capacity 5.25" drives in 1998.

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 2 gigabytes 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. 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 offer substantially higher rotation rates as a group than the 12" drives, and already have much shorter average access times. Data transfer rates in the 10 megabyte per second range are anticipated.

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, but the drives expected in 1998 represent completely new technologies. While the 4.72" types are likely to be standardized by virtue of the work that has been accomplished by the sponsoring companies, it remains to be seen whether the other new technologies become well enough accepted to result in the undertaking of a standards effort. Of course, those that don't require removable media will not require much beyond compliance with standard interface and packaging requirements.

System design: Many large capacity optical disk storage systems will incorporate an automated library. Several firms, including ATG Cygnet, Cygnet Storage Solutions, FileNet, Philips LMS, 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 (though not all at once), 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 optical 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. Some 12" drives now have dual heads, making the entire capacity of the cartridge available without the need to flip the disk.

As noted earlier, the anticipated 4.72" MO drives will offer 6 gigabytes of on-line capacity on a removable disk. The capacities of the specific disk drives which will result from the TeraStor design program have not yet been announced.

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. On the other hand, 5.25" and smaller drives in this group are likely to be rewritable drives with direct overwrite capability.

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.

The 5.25" and smaller drives in this group are likely to use a mix of pregrooving and sector servo techniques, depending upon whether the drive

technology used must provide backward compatibility with earlier generations or is something new.

Interface: SCSI is the most commonly encountered interface on large optical drives in this group. SCSI is likely to remain the preferred choice because of design commitments, or until drives with higher performance are technically possible. For drives to be sold to manufacturers of optical disk libraries, the use of the SCSI interface is a necessity. When they arrive, 4.72" drives in this group may find some requirement to support the P1394 interface (assuming they retain read compatibility with CD format drives), since they may be called upon to substitute for CD-ROM or DVD-ROM drives in some systems.

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 capacity and areal density may be possible by using them in optical storage systems. However, cost and reliability will probably have to be traded for performance in such designs. Short wavelength semiconductor lasers being developed by IBM, Nichia Chemical and others probably have more applicability, but their availability is uncertain.

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, although it should be pointed out that the drives using MO/rigid drive hybrid designs also require different media structures than conventional MO drives in order to minimize the path length between the head and the recording layer.

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 nonmechanical focusing techniques and improved substrate materials. For smaller diameter drives, RPM can be higher, with most expected to rotate at 3,600 RPM or more.

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 4.72" media will use only plastic substrates.

Forecasting assumptions

1. 5.25" optical disk drives will be major participants in this product group, with price competitive 4.72" and very high capacity drives being introduced in 1998.
2. There will continue to be an adequate supply of media for drives and components in this product group.
3. There will be no generally accepted single standard for 12" drives and media through 2000.
4. Rewritable 12" drives and media will have only marginal impact.

TABLE 35

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
	1997		1998		1999		2000			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	3.2	3.2	3.0	6.0	2.9	5.8	5.6	8.4	5.4	10.8
PCM/Distributor	9.2	12.4	16.4	22.0	19.0	28.4	19.0	34.3	34.5	63.3
OEM/Integrator	.9	1.3	4.5	5.4	5.4	7.2	17.0	30.6	36.5	64.9
TOTAL U.S. REVENUES	13.3	16.9	23.9	33.4	27.3	41.4	41.6	73.3	76.4	139.0
Non-U.S. Manufacturers										
Captive	1.8	5.6	--	1.8	.3	15.3	6.9	27.6	12.0	44.0
PCM/Distributor	7.7	12.8	6.0	10.9	7.7	25.8	16.0	51.2	37.6	100.5
OEM/Integrator	19.6	28.8	14.8	23.3	22.8	37.3	52.8	91.1	95.0	170.1
TOTAL NON-U.S. REVENUES	29.1	47.2	20.8	36.0	30.8	78.4	75.7	169.9	144.6	314.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	42.4	64.1	44.7	69.4	58.1	119.8	117.3	243.2	221.0	453.6
OEM Average Price ($000)		7.921		3.500		1.986		1.101		.937

TABLE 36

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.1	.1	.1	.2	.1	.2	.2	.3	.2	.4
PCM/Distributor	3.1	3.7	11.3	14.5	15.2	20.4	16.2	28.4	32.3	60.5
OEM/Integrator	.9	1.3	5.0	6.0	6.0	8.0	20.0	36.0	45.0	80.0
TOTAL U.S. SHIPMENTS	4.1	5.1	16.4	20.7	21.3	28.6	36.4	64.7	77.5	140.9
Non-U.S. Manufacturers										
Captive	.1	.3	--	.1	.1	6.1	3.0	12.0	6.0	22.0
PCM/Distributor	.6	1.0	.5	.9	7.0	18.5	16.0	44.6	40.0	98.7
OEM/Integrator	1.7	2.5	1.4	2.2	8.5	14.4	41.6	74.5	93.6	170.6
TOTAL NON-U.S. SHIPMENTS	2.4	3.8	1.9	3.2	15.6	39.0	60.6	131.1	139.6	291.3
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6.5	8.9	18.3	23.9	36.9	67.6	97.0	195.8	217.1	432.2
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	51.0	101.7	69.3	125.6	106.2	193.2	203.2	389.0	420.3	821.2

TABLE 37

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues		Forecast 1997		1998		1999		2000	
	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"
U.S. MANUFACTURERS										
Captive	3.2	--	6.0	--	5.8	--	8.4	--	10.8	--
PCM/Distributor	7.2	5.2	7.2	14.8	9.2	19.2	8.8	25.5	10.5	52.8
OEM/Integrator	--	1.3	--	5.4	--	7.2	--	30.6	--	64.9
TOTAL U.S. REVENUES	10.4	6.5	13.2	20.2	15.0	26.4	17.2	56.1	21.3	117.7
NON-U.S. MANUFACTURERS										
Captive	5.6	--	1.8	--	--	15.3	--	27.6	--	44.0
PCM/Distributor	12.8	--	10.9	--	6.0	19.8	7.2	44.0	8.4	92.1
OEM/Integrator	28.8	--	23.3	--	25.3	12.0	26.3	64.8	27.3	142.8
TOTAL NON-U.S. REVENUES	47.2	--	36.0	--	31.3	47.1	33.5	136.4	35.7	278.9
WORLDWIDE RECAP										
Captive	8.8 -24.8%	-- --	7.8 -11.4%	-- --	5.8 -25.6%	15.3 --	8.4 +44.8%	27.6 +80.4%	10.8 +28.6%	44.0 +59.4%
PCM/Distributor	20.0 +5.3%	5.2 --	18.1 -9.5%	14.8 +184.6%	15.2 -16.0%	39.0 +163.5%	16.0 +5.3%	69.5 +78.2%	18.9 +18.1%	144.9 +108.5%
OEM/Integrator	28.8 -47.8%	1.3 --	23.3 -19.1%	5.4 +315.4%	25.3 +8.6%	19.2 +255.6%	26.3 +4.0%	95.4 +396.9%	27.3 +3.8%	207.7 +117.7%
Total Revenues	57.6 -32.9%	6.5 --	49.2 -14.6%	20.2 +210.8%	46.3 -5.9%	73.5 +263.9%	50.7 +9.5%	192.5 +161.9%	57.0 +12.4%	396.6 +106.0%
ANNUAL SHARE, BY DIAMETER	90.0%	10.0%	71.0%	29.0%	38.6%	61.4%	20.8%	79.2%	12.6%	87.4%

TABLE 38

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"
U.S. MANUFACTURERS										
Captive	.1	--	.2	--	.2	--	.3	--	.4	--
PCM/Distributor	.3	3.4	.3	14.2	.4	20.0	.4	28.0	.5	60.0
OEM/Integrator	--	1.3	--	6.0	--	8.0	--	36.0	--	80.0
TOTAL U.S. SHIPMENTS	.4	4.7	.5	20.2	.6	28.0	.7	64.0	.9	140.0
NON-U.S. MANUFACTURERS										
Captive	.3	--	.1	--	--	6.1	--	12.0	--	22.0
PCM/Distributor	1.0	--	.9	--	.5	18.0	.6	44.0	.7	98.0
OEM/Integrator	2.5	--	2.2	--	2.4	12.0	2.5	72.0	2.6	168.0
TOTAL NON-U.S. SHIPMENTS	3.8	--	3.2	--	2.9	36.1	3.1	128.0	3.3	288.0
WORLDWIDE RECAP										
Captive	.4 -20.0%	-- --	.3 -25.0%	-- --	.2 -33.3%	6.1 --	.3 +50.0%	12.0 +96.7%	.4 +33.3%	22.0 +83.3%
PCM/Distributor	1.3 +18.2%	3.4 --	1.2 -7.7%	14.2 +317.6%	.9 -25.0%	38.0 +167.6%	1.0 +11.1%	72.0 +89.5%	1.2 +20.0%	158.0 +119.4%
OEM/Integrator	2.5 -47.9%	1.3 --	2.2 -12.0%	6.0 +361.5%	2.4 +9.1%	20.0 +233.3%	2.5 +4.2%	108.0 +440.0%	2.6 +4.0%	248.0 +129.6%
Total Shipments	4.2 -34.4%	4.7 --	3.7 -11.9%	20.2 +329.8%	3.5 -5.4%	64.1 +217.3%	3.8 +8.6%	192.0 +199.5%	4.2 +10.5%	428.0 +122.9%
ANNUAL SHARE, BY DIAMETER	47.2%	52.8%	15.5%	84.5%	5.2%	94.8%	1.9%	98.1%	1.0%	99.0%

TABLE 39

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1996		Forecast							
	--Shipments--		-----1997----		-----1998----		-----1999----		-----2000----	
	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	5.0		20.5		28.4		64.4		140.5	
Write-Once	.3	6.0%	.3	1.5%	.4	1.4%	.4	.6%	.5	.4%
Rewritable	4.7	94.0%	20.2	98.5%	28.0	98.6%	64.0	99.4%	140.0	99.6%
Total U.S.	5.1		20.7		28.6		64.7		140.9	
Write-Once	.4	7.8%	.5	2.4%	.6	2.1%	.7	1.1%	.9	.6%
Rewritable	4.7	92.2%	20.2	97.6%	28.0	97.9%	64.0	98.9%	140.0	99.4%
NON-U.S. MANUFACTURERS										
Captive Total	.3		.1		6.1		12.0		22.0	
Write-Once	.3	100.0%	.1	100.0%	--	--	--	--	--	--
Rewritable	--	--	--	--	6.1	100.0%	12.0	100.0%	22.0	100.0%
Noncaptive Total	3.5		3.1		32.9		119.1		269.3	
Write-Once	3.5	100.0%	3.1	100.0%	2.9	8.8%	3.1	2.6%	3.3	1.2%
Rewritable	--	--	--	--	30.0	91.2%	116.0	97.4%	266.0	98.8%
Total Non-U.S.	3.8		3.2		39.0		131.1		291.3	
Write-Once	3.8	100.0%	3.2	100.0%	2.9	7.4%	3.1	2.4%	3.3	1.1%
Rewritable	--	--	--	--	36.1	92.6%	128.0	97.6%	288.0	98.9%
WORLDWIDE SHIPMENTS										
Total Shipments	8.9		23.9		67.6		195.8		432.2	
	+39.1%		+168.5%		+182.8%		+189.6%		+120.7%	
Write-Once	4.2	47.2%	3.7	15.5%	3.5	5.2%	3.8	1.9%	4.2	1.0%
	-34.3%		-11.8%		-5.3%		+8.6%		+10.5%	
Rewritable	4.7	52.8%	20.2	84.5%	64.1	94.8%	192.0	98.1%	428.0	99.0%
	--		+329.8%		+217.3%		+199.5%		+122.9%	

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

TABLE 40

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1996 Estimate Units (000)	1996 Estimate %	2000 Projection Units (000)	2000 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	17.3	4.0
MAINFRAME SYSTEMS General purpose	.8	8.7	10.4	2.4
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	3.4	36.4	58.8	13.6
PERSONAL COMPUTERS Business and professional, single user	4.1	44.7	277.5	64.2
WORKSTATIONS Engineering and office, single user	.8	9.0	59.6	13.8
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.1	1.2	8.6	2.0
Total	9.2	100.0	432.2	100.0

TABLE 41

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1996 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	12"-14"	5.25"	Total		12"-14"	5.25"	Total	
Pinnacle Micro	--	3.8	3.8	60.3	--	4.7	4.7	55.3
Philips LMS	1.4	--	1.4	22.2	2.2	--	2.2	25.9
Other U.S.	.2	--	.2	3.2	.3	--	.3	3.5
Other Non-U.S.	.9	--	.9	14.3	.9	--	.9	15.3
TOTAL	2.5	3.8	6.3	100.0	3.8	4.7	8.5	100.0

CD FORMAT OPTICAL DISK LIBRARIES

1997 DISK/TREND REPORT

CD FORMAT OPTICAL DISK LIBRARIES

Coverage

Examples of optical disk libraries in this group include:

12 centimeter (4.72") disk diameter

ASM	CDR 40, CDR 1400
Borett Automation Technologies	MMAS (CD)
Cherub	2000
Cygnet Storage Solutions	infiniDISC
DISC	D300, D600
DSM	CD60, CD-62, CDR-74
Eastman Kodak	CD-ADL 150, CD-144
Elms Systems	DVL-1000
Grundig (K&S)	CDJ-30, CDJ-M200, MCD-35
JVC	1200, 1600
Kubik Enterprises	CDR240M, CD Tower
Matsushita Electric Industrial	SQ-TC510N, LF-J50A, LF-J100A
Nakamichi	MJ-5.16S
NEC	CDR-C302, CDR-4300
Nippon Columbia	DRD-1400
Nistec	ALW-501
NSM	CDR-100, Mercury-40, Satellite
Pioneer	DRM624X, DRM 1804X, DRM5004X
Plasmon Data	D-120, D-240, D-480
Regal Electronics	CDC-4X
Sony	CDL 1100, CDL 2100, CDL 2200
TEAC	CD-68E
TiltRac	M3C, M6C

CD-ROM format optical disk libraries incorporate CD-ROM drives, DVD-ROM drives, CD-R/CD-RW drives and their DVD equivalents, or PD drives. 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. The optical libraries in this product group also include CD-ROM autochangers (often called minichangers) that hold from 4 to 6 disks and fit into a half-high slot.

Market status

1996 shipments grew 102.2% to over 681,000 units, primarily as a result of strong 1996 shipment growth of the Nakamichi 4 disk, internally mounted half-

high autochanger. Non-U.S. suppliers had over 97% of the market. 25.4% of the units were shipped to the U.S., a decline from 1995, due to large shipments of small autochangers to Asian PC manufacturers. Low cost autochangers negatively impacted shipments of 10 to 100 disk units, which were displaced by multiple 1 to 5 disk units at lower cost, but the introduction of libraries at the high end of the range actually caused revenues in the 10 to 100 disk segment to grow.

1996 worldwide revenues grew 57.1% to $141.4 million, largely as a result of large shipments of small autochangers by Nakamichi. The average OEM price in the product group again dropped sharply under the stimulus of the added low end shipments.

Over 99% of the 1996 units shipped held fewer than 10 disks, .4% had from 10 to 100 disks, and .3% of the units shipped used over 100 disks. However, only 71.9% of the revenues for the group came from the under 10 disk segment, while the 10 to 100 and over 100 disk segments accounted for 9.0% and 19.1%, respectively.

Despite the initial success of the small autochangers, shipments dropped sharply in early 1997 as system manufacturers determined that product prices were too high and performance too slow relative to conventional CD-ROM drives for them to adopt small autochangers as mainstream peripherals. Shipments of the small autochangers are expected to resume growth in 1998 as the result of growing demand from CD tower producers. As a result, the revenue share of the under 10 disk segment is expected to decline slightly over the next few years, remaining between 50% and 60%. New, lower price products in the 10 to 100 disk segment have begun to stimulate growth.

ASM, NSM, DSM, DISC, Pioneer, TiltRac, JVC, Cygnet Storage Solutions and others have all announced libraries with 100 disk or greater capacity, with NSM achieving the highest 1996 shipment volume in this category. Matsushita has announced 50 and 100 disk libraries incorporating its PD drive. 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. Several other companies are using karaoke system libraries to which have been added appropriate controller logic and software support.

The smaller CD-ROM libraries compete against server or network attached CD towers which typically contain 4 to 7 drives, although 14, 21 and 28 drive configurations are frequently encountered. CD towers are discussed in the following section.

Marketing trends

Revenues are expected to increase to $149.5 million in 2000, less than anticipated earlier, because of quickly decreasing prices and smaller than anticipated shipments for small autochangers. Over 571,000 libraries in this product group are expected to be shipped in 2000, with almost 98% of them small autochangers for personal computers and CD towers. However, as higher capacity DVD drives enter the market, the need for small autochangers will be lessened for some users, reducing shipment growth rates to an annual 5.2% by the end of the forecast period.

The majority of computer manufacturers now include CD-ROM capability with their file servers, increasing the opportunity for upgrades to a library subsystem. The availability of inexpensive controllers that can interface a library to a network is expected to result in many libraries in this group being directly attachable to local area networks.

The market will continue to favor libraries with fewer than 10 disks or more than 100 disks. 53% of revenues in 2000 are expected to come from libraries with fewer than 10 disks, while 28.7% are anticipated from libraries with over 100 disks. Only 18.3% 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.

Applications

The major applications for CD-ROM format optical libraries continue to be in network file servers and high-end personal computers and workstations. High-end CD-ROM format libraries have applications in large institutional libraries and in organizations that must provide network access to large amounts of documen-

tation 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 in servers and CD towers.

Certain users of CD-ROM data bases that normally 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. On the other hand, users requiring access to a variety of titles will continue to find CD-ROM libraries useful. The availability of CD-RW disks 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. Some larger libraries have been used as CD-R duplicators, but most firms doing quantity duplication prefer operating multiple CD-R drives in parallel for higher throughput.

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 derive from high performance 5.25" library designs, notably from DSM, 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 performance is slow, MSBF is low and the ratio of drives to media units is too low, resulting in undesirably long waiting times after data is requested. 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 all are anticipated features in newer products.

Typical 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.

There is some competition for CD-ROM format libraries from configurations of multiple CD-ROM drives (CD towers), usually attached to file servers or directly to networks, 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 continue to 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, but direct network attached CD-ROM towers are expected to become stronger competitors in the 10 to 100 disk segment.
4. Prices for libraries having 100 disks or more will decline as the result of cost reduction efforts by manufacturers.

TABLE 42

CD FORMAT OPTICAL DISK LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996		Forecast							
	Revenues		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	2.6	3.4	6.9	8.1	7.5	8.9	7.9	9.3	8.3	9.9
OEM/Integrator	7.0	9.8	6.5	8.5	7.1	9.2	7.3	9.7	7.3	10.0
TOTAL U.S. REVENUES	9.6	13.2	13.4	16.6	14.6	18.1	15.2	19.0	15.6	19.9
Non-U.S. Manufacturers										
PCM/Distributor	24.5	47.7	20.0	41.6	21.8	44.5	22.5	45.8	23.9	47.9
OEM/Integrator	21.4	80.5	29.1	57.8	34.2	66.2	40.0	74.7	43.6	81.7
TOTAL NON-U.S. REVENUES	45.9	128.2	49.1	99.4	56.0	110.7	62.5	120.5	67.5	129.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	55.5	141.4	62.5	116.0	70.6	128.8	77.7	139.5	83.1	149.5
OEM Average Price ($000)		.176		.222		.214		.217		.222

TABLE 43

CD FORMAT OPTICAL DISK LIBRARIES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	1,217	2,150	1,630	2,108	1,670	2,070	1,735	2,115	1,830	2,180
OEM/Integrator	7,608	14,013	5,006	7,853	4,095	6,247	3,845	5,545	3,690	5,145
TOTAL U.S. SHIPMENTS	8,825	16,163	6,636	9,961	5,765	8,317	5,580	7,660	5,520	7,325
Non-U.S. Manufacturers										
PCM/Distributor	73,123	167,546	67,594	155,631	66,880	150,295	68,110	152,700	70,410	155,180
OEM/Integrator	91,478	497,628	132,126	290,736	163,635	345,475	193,230	382,560	205,790	408,630
TOTAL NON-U.S. SHIPMENTS	164,601	665,174	199,720	446,367	230,515	495,770	261,340	535,260	276,200	563,810
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	173,426	681,337	206,356	456,328	236,280	504,087	266,920	542,920	281,720	571,135
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	400	1,120	606	1,576	842	2,080	1,109	2,623	1,391	3,195

TABLE 44

CD FORMAT OPTICAL DISK LIBRARIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY LIBRARY SIZE

	1996 Revenues			Forecast											
	1997			1998			1999			2000					
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
PCM/Distributor	.6	.2	2.6	.3	4.8	3.0	.2	5.0	3.7	.1	5.3	3.9	.1	5.6	4.2
OEM/Integrator	3.5	--	6.3	1.9	--	6.6	1.4	--	7.8	1.2	--	8.5	1.0	--	9.0
TOTAL U.S. REVENUES	4.1	.2	8.9	2.2	4.8	9.6	1.6	5.0	11.5	1.3	5.3	12.4	1.1	5.6	13.2
NON-U.S. MANUFACTURERS															
PCM/Distributor	31.3	4.5	11.9	23.5	4.8	13.3	25.0	5.4	14.1	25.3	5.7	14.8	25.7	6.2	16.0
OEM/Integrator	66.1	8.0	6.4	39.6	10.6	7.6	44.3	12.1	9.8	49.0	14.0	11.7	52.3	15.6	13.8
TOTAL NON-U.S. REVENUES	97.4	12.5	18.3	63.1	15.4	20.9	69.3	17.5	23.9	74.3	19.7	26.5	78.0	21.8	29.8
WORLDWIDE RECAP															
PCM/Distributor	31.9	4.7	14.5	23.8	9.6	16.3	25.2	10.4	17.8	25.4	11.0	18.7	25.8	11.8	20.2
	+132.8%	-24.2%	+21.8%	-25.4%	+104.3%	+12.4%	+5.9%	+8.3%	+9.2%	+.8%	+5.8%	+5.1%	+1.6%	+7.3%	+8.0%
OEM/Integrator	69.6	8.0	12.7	41.5	10.6	14.2	45.7	12.1	17.6	50.2	14.0	20.2	53.3	15.6	22.8
	+121.0%	+158.1%	-46.2%	-40.4%	+32.5%	+11.8%	+10.1%	+14.2%	+23.9%	+9.8%	+15.7%	+14.8%	+6.2%	+11.4%	+12.9%
Total Revenues	101.5	12.7	27.2	65.3	20.2	30.5	70.9	22.5	35.4	75.6	25.0	38.9	79.1	27.4	43.0
	+124.6%	+36.6%	-23.4%	-35.7%	+59.1%	+12.1%	+8.6%	+11.4%	+16.1%	+6.6%	+11.1%	+9.9%	+4.6%	+9.6%	+10.5%
ANNUAL SHARE, BY SIZE	71.9%	9.0%	19.1%	56.4%	17.4%	26.2%	55.1%	17.5%	27.4%	54.3%	17.9%	27.8%	53.0%	18.3%	28.7%

Note: Headings define number of disks stored per library.

TABLE 45

CD FORMAT OPTICAL DISK LIBRARIES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY LIBRARY SIZE

	1996 Shipments			Forecast											
				1997			1998			1999			2000		
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
PCM/Distributor	1,860	50	240	830	993	285	630	1,110	330	510	1,230	375	400	1,360	420
OEM/Integrator	13,500	--	513	7,280	--	573	5,500	--	747	4,700	--	845	4,200	--	945
TOTAL U.S. SHIPMENTS	15,360	50	753	8,110	993	858	6,130	1,110	1,077	5,210	1,230	1,220	4,600	1,360	1,365
NON-U.S. MANUFACTURERS															
PCM/Distributor	165,180	1,006	1,360	152,800	1,217	1,614	147,000	1,420	1,875	149,000	1,590	2,110	151,000	1,830	2,350
OEM/Integrator	495,200	1,746	682	287,300	2,456	980	341,000	3,180	1,295	377,000	3,900	1,660	402,000	4,600	2,030
TOTAL NON-U.S. SHIPMENTS	660,380	2,752	2,042	440,100	3,673	2,594	488,000	4,600	3,170	526,000	5,490	3,770	553,000	6,430	4,380
WORLDWIDE RECAP															
PCM/Distributor	167,040	1,056	1,600	153,630	2,210	1,899	147,630	2,530	2,205	149,510	2,820	2,485	151,400	3,190	2,770
	+247.2%	-48.0%	+45.9%	-8.0%	+109.3%	+18.7%	-3.9%	+14.5%	+16.1%	+1.3%	+11.5%	+12.7%	+1.3%	+13.1%	+11.5%
OEM/Integrator	508,700	1,746	1,195	294,580	2,456	1,553	346,500	3,180	2,042	381,700	3,900	2,505	406,200	4,600	2,975
	+80.1%	+7.4%	-31.7%	-42.1%	+40.7%	+30.0%	+17.6%	+29.5%	+31.5%	+10.2%	+22.6%	+22.7%	+6.4%	+17.9%	+18.8%
Total Shipments	675,740	2,802	2,795	448,210	4,666	3,452	494,130	5,710	4,247	531,210	6,720	4,990	557,600	7,790	5,745
	+104.4%	-23.3%	-1.8%	-33.7%	+66.5%	+23.5%	+10.2%	+22.4%	+23.0%	+7.5%	+17.7%	+17.5%	+5.0%	+15.9%	+15.1%
ANNUAL SHARE, BY SIZE	99.3%	.4%	.3%	98.3%	1.0%	.7%	98.1%	1.1%	.8%	97.9%	1.2%	.9%	97.7%	1.4%	.9%

Note: Headings define number of disks stored per library.

CD FORMAT DISK TOWERS

CD FORMAT DISK TOWERS

Coverage

Examples of CD format disk towers in this group include:

Host attached

Advanced Media Services	MAX Tower
Boffin	JB321, Tower 14
CD International	CDJ2800, CDT1200
Cutting Edge	CDPowerShare
Excel Computer	CD-7, CDD-14
Kintronics	CD-ROM Tower
Legacy Storage Systems	CD7000
Meridian Data	CD Net Ultimate Storage
Micro Design International	SE4CD8XDT, SECD12XET8
Optical Access International	Maxtet/CD
Plextec	CDT-7XX, CDT-14XX
Plextor	CD-12X4, CD-12X7
Procom Technology	7-Plus, 14-Plus, 28-Plus
Rexas	CDRS100, CDRS200
Smart and Friendly	CD Tower, CDJ 16008
SMS Data Products	1070 Tower, 10700P Tower, S70028
TAC Systems	CD Tower
Todd Enterprises	T-8050, VL14
Vision Computers	STRADUS

Network attached

Advanced Media Services	CD-Server
Allion Computer	CD-Serv/Tower
Atronics	IDEal CDServer
Axonix	CD-Sharer
Boffin	CDV14/100, P1414
CD International	CDS4900, CDS8400
CMS Enhancements	Eclipse
Cutting Edge	CDPowerChanger, CDPowerServ
DTS Computer	DP300
Dynatek Automation	CDT662PD/ETH
Excel Computer	CDS-14, EX-14
Kintronics	CD-ROM Server
Legacy Storage Systems	Vantage
Lexus	CD ROM Server
Meridian Data	CD Net Ultimate Server
Micro Design international	CD-Express Connect
Microtest	DiscPort Enterprise Server
Network Storage Solutions	Spanstor-CD
Optical Access International	Netserve/53X, Netserve/CD
Plextec	CD-LAN series
Plextor	NP-63CS-7, PS-12CS-NNW
Procom Technology	CD FORCE RAX, Hyper CD, CCA28-E1

Network attached (continued)

SciNet	Series 2000, LS Series
SMS Data Products	S7007NOV, 1070DP Tower
TAC Systems	LANRedi
Tekram	CS700
Ten X Technology	TenXpert-1/24P
Todd Enterprises	T-8050-AD
Vision Computers	NOVUS

Producers of CD towers typically purchase drives and enclosures, and assemble them into a tower configuration. Purchased enclosures usually contain power supplies. The towers may be host attached, usually through a SCSI interface to a stand-alone (and usually multiuser) computer or network server, or may be network attached, an increasingly encountered configuration. In the latter case, the tower assembler usually purchases and integrates a network server module from a third party, although a few firms manufacture their own server modules. The server module interfaces directly to a local area network, avoiding the need for a complete PC or midrange server system.

Market status

1996 worldwide shipments of CD towers were 37,523 units, accounting for $146 million in revenue. 68.4% of the towers had less than 10 drives, followed by the 10 to 25 drive segment with 24.1% drives. Only 7.5% had more than 25 drives. 50.4% of the units shipped in 1996 were host attached, while 49.7% were network attached. This does not include products intended solely or primarily for CD-R duplication, which are not included in this analysis.

The U.S. market accounted for 81.5% of the towers shipped and 80.6% of 1996 revenues. U.S. firms accounted for 84.2% of revenues and 82.7% of unit shipments overall, but tended to increase their participation share for the larger subsystems.

Network server modules are provided to tower manufacturers by multiple manufacturers, including Axis Communications, Compact Devices, Meridian Data, Microtest and Ornetix. They may be shipped as stand-alone modules, enclosure mounted modules or in the form of add-in boards. Some tower manufacturers, such as SciNet, manufacture their own controllers, and it seems

likely that the larger tower manufacturers may evolve into manufacturing their own controller designs in order to increase their internally produced content.

Marketing trends

Tower shipments are forecasted to grow to over 71,600 units in 2000, while revenues will increase to $285.9 million. U.S. producers will remain the dominant suppliers, although non-U.S. manufacturers will see some increase in share. Larger systems will tend to gain share during the forecast period as a result of user preferences and competition from rigid drive cached CD-ROM subsystems. The United States is expected to remain the largest market through 2000.

While the 1996 market for host attached towers exceeded that for network attached towers, the network attached market is growing at a much faster rate, and is expected to exceed the host attached segment in 1997, accounting for 71.3% of the towers shipped in 2000. Both user demand and the desire of tower manufacturers to generate higher value added content are fueling this shift.

DVD-ROM drives will make their appearance in towers in 1997 and will appear in an increasing percentage of towers. Many towers will have a mix of CD-ROM and DVD-ROM drives, until DVD-ROM drives approach CD-ROM drives in price, at which time DVD-ROM installations will predominate.

Applications

CD towers are used where multiple users must have simultaneous access to the same CD-ROM titles. Libraries may impose excessively long access time, due to the need to physically swap disks, whereas the tower has the required disks on-line at all times. On the other hand, a library is preferred where a large number of disks must be accessible, but are unlikely to be accessed by multiple users simultaneously.

The rapidly growing base of Intranet installations is accelerating the growth of the network attached CD tower market, but host attached servers are still popular for businesses such as law offices, small medical groups, and other small work group sites.

Technical trends

The most obvious technical trend observable is the rapid shift in tower interfaces from host attached to network attached. This change is driven by the desire of the ultimate customer to have flexibility and simplicity in his network configuration. Net attached towers typically operate with a variety of network protocols, and if equipped with a suitable controller, can serve as a website on an Intranet. The controllers themselves are becoming more sophisticated, with many evolving towards complete computing systems, including hard disk drives and substantial RAM memory, although their complexity is transparent to the network and the user. As this type of product generates substantially more margin dollars for their producers, economic considerations drive this trend at least as much as product design considerations.

Software provided with towers is becoming increasingly competent in permitting network administrators to manage the tower over the network, and the absence of such support in a tower manufacturer's product line is a significant disadvantage. The ability to hot swap drives and power supplies is also appearing in some towers, as is the ability to monitor tower status and environmental conditions. This is the natural result of users becoming increasingly dependent on the data stored in the tower and redefining it as mission critical, requiring improved data availability as a result.

Many tower manufacturers are replacing some or all individual CD-ROM drives with small CD-ROM autochangers capable of holding 4 or 5 disks, thereby permitting the users to have the capacity advantages of an optical library as well as the performance benefits of a tower.

Products that compete directly with CD towers include CD format libraries and subsystems that cache the content of multiple CD-ROM drives on a multigigabyte rigid magnetic drive. The libraries provide higher storage capacity, but have slower performance because the disks must be physically exchanged for the user to access content, whereas the tower has its disks mounted and available all the time. Caching is a greater threat. Rigid drives already offer 23 gigabyte capacities and new models will be available in the future at an ever decreasing cost per megabyte. A Seagate Elite 23 rigid drive will store the content of over 30 CD-ROM disks or 4 DVD-ROM disks. A controller equipped with such a

drive and a single CD-ROM drive for use as a mailbox device can easily replace a library or tower. Products with similar architectures are currently entering the marketplace, although it is expected that it will take a few years for them to make a serious dent in the tower market.

Forecasting assumptions

1. Towers will continue their shift to network attached models.
2. Pricing will tend to stay in a narrow range, since network controllers are increasing in complexity and prices for drives will tend to reflect the most recently available (and more expensive) drives.
3. Competition from cached CD-ROMs on rigid disk drives will not have a significant effect during the forecast period.

TABLE 46

CD FORMAT DISK TOWERS

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast							
	1997		1998		1999		2000			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	95.7	106.8	120.6	136.2	130.3	146.0	144.9	161.5	186.7	205.0
OEM/Integrator	14.5	16.6	19.3	22.3	19.0	22.3	21.5	25.0	23.2	26.7
TOTAL U.S. REVENUES	110.2	123.4	139.9	158.5	149.3	168.3	166.4	186.5	209.9	231.7
Non-U.S. Manufacturers										
PCM/Distributor	2.3	12.5	3.3	18.8	5.2	28.6	7.2	35.1	8.4	40.1
OEM/Integrator	5.2	10.1	4.3	11.1	3.5	11.9	3.1	12.8	2.9	14.1
TOTAL NON-U.S. REVENUES	7.5	22.6	7.6	29.9	8.7	40.5	10.3	47.9	11.3	54.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	117.7	146.0	147.5	188.4	158.0	208.8	176.7	234.4	221.2	285.9
OEM Average Price ($000)		3.328		3.461		3.369		3.286		3.127

TABLE 47

CD FORMAT DISK TOWERS

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	23,483	26,212	28,575	32,403	33,030	37,190	37,170	41,633	41,060	45,796
OEM/Integrator	4,292	4,832	5,349	6,206	5,390	6,289	6,270	7,257	7,070	8,112
TOTAL U.S. SHIPMENTS	27,775	31,044	33,924	38,609	38,420	43,479	43,440	48,890	48,130	53,908
Non-U.S. Manufacturers										
PCM/Distributor	722	3,289	951	5,208	1,672	8,957	2,415	11,145	2,838	12,763
OEM/Integrator	2,090	3,190	1,703	3,443	1,503	3,861	1,411	4,247	1,289	4,934
TOTAL NON-U.S. SHIPMENTS	2,812	6,479	2,654	8,651	3,175	12,818	3,826	15,392	4,127	17,697
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	30,587	37,523	36,578	47,260	41,595	56,297	47,266	64,282	52,257	71,605
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	30	37	67	84	108	141	156	205	208	276

TABLE 48

CD FORMAT DISK TOWERS

WORLDWIDE REVENUES ($M)

BREAKDOWN BY TOWER SIZE

	1996 Revenues			Forecast											
				1997			1998			1999			2000		
	<10	10 - 25	>25	<10	10 - 25	>25	<10	10 - 25	>25	<10	10 - 25	>25	<10	10 - 25	>25
U.S. MANUFACTURERS															
PCM/Distributor	41.3	37.2	28.3	48.2	53.7	34.3	58.5	44.9	42.6	60.5	50.5	50.5	61.5	54.7	88.8
OEM/Integrator	6.6	5.7	4.3	9.4	7.6	5.3	8.4	8.0	5.9	9.2	9.2	6.6	9.9	9.6	7.2
TOTAL U.S. REVENUES	47.9	42.9	32.6	57.6	61.3	39.6	66.9	52.9	48.5	69.7	59.7	57.1	71.4	64.3	96.0
NON-U.S. MANUFACTURERS															
PCM/Distributor	5.9	4.8	1.8	10.7	5.7	2.4	19.7	6.3	2.6	25.0	7.0	3.1	28.9	7.7	3.5
OEM/Integrator	6.1	2.4	1.6	6.2	3.2	1.7	6.2	3.9	1.8	6.6	4.1	2.1	7.5	4.2	2.4
TOTAL NON-U.S. REVENUES	12.0	7.2	3.4	16.9	8.9	4.1	25.9	10.2	4.4	31.6	11.1	5.2	36.4	11.9	5.9
WORLDWIDE RECAP															
PCM/Distributor	47.2	42.0	30.1	58.9	59.4	36.7	78.2	51.2	45.2	85.5	57.5	53.6	90.4	62.4	92.3
	--	--	--	+24.8%	+41.4%	+21.9%	+32.8%	-13.8%	+23.2%	+9.3%	+12.3%	+18.6%	+5.7%	+8.5%	+72.2%
OEM/Integrator	12.7	8.1	5.9	15.6	10.8	7.0	14.6	11.9	7.7	15.8	13.3	8.7	17.4	13.8	9.6
	--	--	--	+22.8%	+33.3%	+18.6%	-6.4%	+10.2%	+10.0%	+8.2%	+11.8%	+13.0%	+10.1%	+3.8%	+10.3%
Total Revenues	59.9	50.1	36.0	74.5	70.2	43.7	92.8	63.1	52.9	101.3	70.8	62.3	107.8	76.2	101.9
	--	--	--	+24.4%	+40.1%	+21.4%	+24.6%	-10.1%	+21.1%	+9.2%	+12.2%	+17.8%	+6.4%	+7.6%	+63.6%
ANNUAL SHARE, BY SIZE	41.1%	34.3%	24.6%	39.6%	37.3%	23.1%	44.5%	30.2%	25.3%	43.3%	30.2%	26.5%	37.8%	26.7%	35.5%

Note: Headings define number of drives installed per tower.

TABLE 49

CD FORMAT DISK TOWERS

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY TOWER SIZE

	1996 Shipments			Forecast											
				1997			1998			1999			2000		
	<10	10 - 25	>25	<10	10 - 25	>25	<10	10 - 25	>25	<10	10 - 25	>25	<10	10 - 25	>25
U.S. MANUFACTURERS															
PCM/Distributor	17,492	6,612	2,108	20,969	8,650	2,784	22,900	10,820	3,470	24,850	12,575	4,208	26,750	14,100	4,946
OEM/Integrator	3,149	1,205	478	4,306	1,338	562	4,173	1,490	626	4,820	1,740	697	5,430	1,910	772
TOTAL U.S. SHIPMENTS	20,641	7,817	2,586	25,275	9,988	3,346	27,073	12,310	4,096	29,670	14,315	4,905	32,180	16,010	5,718
NON-U.S. MANUFACTURERS															
PCM/Distributor	2,351	783	155	4,081	931	196	7,660	1,070	227	9,670	1,215	260	11,110	1,360	293
OEM/Integrator	2,640	440	110	2,740	577	126	3,080	639	142	3,405	672	170	4,030	715	189
TOTAL NON-U.S. SHIPMENTS	4,991	1,223	265	6,821	1,508	322	10,740	1,709	369	13,075	1,887	430	15,140	2,075	482
WORLDWIDE RECAP															
PCM/Distributor	19,843	7,395	2,263	25,050	9,581	2,980	30,560	11,890	3,697	34,520	13,790	4,468	37,860	15,460	5,239
	--	--	--	+26.2%	+29.6%	+31.7%	+22.0%	+24.1%	+24.1%	+13.0%	+16.0%	+20.9%	+9.7%	+12.1%	+17.3%
OEM/Integrator	5,789	1,645	588	7,046	1,915	688	7,253	2,129	768	8,225	2,412	867	9,460	2,625	961
	--	--	--	+21.7%	+16.4%	+17.0%	+2.9%	+11.2%	+11.6%	+13.4%	+13.3%	+12.9%	+15.0%	+8.8%	+10.8%
Total Shipments	25,632	9,040	2,851	32,096	11,496	3,668	37,813	14,019	4,465	42,745	16,202	5,335	47,320	18,085	6,200
	--	--	--	+25.2%	+27.2%	+28.7%	+17.8%	+21.9%	+21.7%	+13.0%	+15.6%	+19.5%	+10.7%	+11.6%	+16.2%
ANNUAL SHARE, BY SIZE	68.4%	24.1%	7.5%	68.0%	24.3%	7.7%	67.3%	24.9%	7.8%	66.6%	25.2%	8.2%	66.2%	25.3%	8.5%

Note: Headings define number of drives installed per tower.

TABLE 50

CD FORMAT DISK TOWERS

WORLDWIDE SHIPMENTS (SINGLE UNITS)

HOST/NETWORK ATTACHMENT ANALYSIS

	1996 --Shipments--		Forecast							
			1997		1998		1999		2000	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Noncaptive Total	31,044.0		38,609.0		43,479.0		48,890.0		53,908.0	
Host	14,317.0	46.1%	14,421.0	37.4%	14,050.0	32.3%	13,532.0	27.7%	12,834.0	23.8%
Network	16,727.0	53.9%	24,188.0	62.6%	29,429.0	67.7%	35,358.0	72.3%	41,074.0	76.2%
Total U.S.	31,044.0		38,609.0		43,479.0		48,890.0		53,908.0	
Host	14,317.0	46.1%	14,421.0	37.4%	14,050.0	32.3%	13,532.0	27.7%	12,834.0	23.8%
Network	16,727.0	53.9%	24,188.0	62.6%	29,429.0	67.7%	35,358.0	72.3%	41,074.0	76.2%
NON-U.S. MANUFACTURERS										
Noncaptive Total	6,479.0		8,651.0		12,818.0		15,392.0		17,697.0	
Host	4,576.0	70.6%	4,936.0	57.1%	6,519.0	50.9%	7,134.0	46.3%	7,720.0	43.6%
Network	1,903.0	29.4%	3,715.0	42.9%	6,299.0	49.1%	8,258.0	53.7%	9,977.0	56.4%
Total Non-U.S.	6,479.0		8,651.0		12,818.0		15,392.0		17,697.0	
Host	4,576.0	70.6%	4,936.0	57.1%	6,519.0	50.9%	7,134.0	46.3%	7,720.0	43.6%
Network	1,903.0	29.4%	3,715.0	42.9%	6,299.0	49.1%	8,258.0	53.7%	9,977.0	56.4%
WORLDWIDE SHIPMENTS										
Total Shipments	37,523.0		47,260.0		56,297.0		64,282.0		71,605.0	
	--		+25.9%		+19.1%		+14.2%		+11.4%	
Host	18,893.0	50.4%	19,357.0	41.0%	20,569.0	36.5%	20,666.0	32.1%	20,554.0	28.7%
	--		+2.5%		+6.3%		+.5%		-.4%	
Net	18,630.0	49.7%	27,903.0	59.0%	35,728.0	63.5%	43,616.0	67.9%	51,051.0	71.3%
	--		+49.8%		+28.0%		+22.1%		+17.0%	

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

READ/WRITE OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

1997 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
1 - 39 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

3.5" disk diameter

Fujitsu	M2531A, M2532B1
PFU	MC700A, MC700B

5.25" disk diameter

ASM	ASM 21SL, ASM 22, ASM 54
DSM	4000
Fujitsu	F6448/JX, M2522/AX
Grundig (K&S)	Megastore 1000
Hewlett-Packard	C1100A/B, C1713T, 40fx, 80fx
Hitachi	OL172S-20A
IBM	3995-C-20, 3995-C40
Kubota	K2020
Maxoptix	MX520, PX520
NEC	N1137-58, OL5120, OL5220
Plasmon Data Systems	M20 series, M32 series
Sony	OSL 2001, OSL 2500

12" disk diameter

ATG Cygnet	AC 16000, GF 6910
Cygnet Storage Solutions	1602, ASM-123W
DSM	28
Philips LMS	LF 6600, LF 6602

5.25" optical disk 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 mechanisms from Fujitsu (PFU uses the Fujitsu mechanism) are available as of mid-1996. 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

Unit shipments declined 18.1% to 10,477 libraries in 1996, with all categories falling short of 1995 totals, as manufacturers in this product group struggled against competition from high capacity 5.25" magnetic rigid disk drives capable of storing up to 23 gigabytes at selling prices only a fraction of optical library prices. 1996 sales revenues for the product group were even more severely impacted, falling 20.5% to $66.5 million. 58.2% of 1996 revenues and 62.2% of 1996 shipments were generated by U.S. manufacturers, a slight increase over 1995. Hewlett-Packard was the leading 5.25" library supplier in this product group, while Philips LMS was again the dominant 12" library supplier. 60% of unit shipments were made to U.S. destinations.

3.5" library shipments remained a disappointment, primarily because the relatively low capacity of the 3.5" drive makes 3.5" libraries less competitive than other possible configurations. 3.5" libraries were expected to become more attractive after 1996 as more 640+ megabyte 3.5" drives became available, but so far revitalized 3.5" library shipments have not occurred.

Marketing trends

Because of competition from alternative technologies, unit shipments are expected to be flat through 2000, though total revenues will decline slightly to $61.2 million. Shipments at the low capacity end of this product group will be increasingly impacted in the future by 5.25" and 3.5" magnetic disk drives capable of storing much higher capacities than today's drives offer. This product group will also see future competition from libraries employing the PD drive and DVD-RAM drives. Because of the unique features of the Philips LMS libraries, modest year on year growth is anticipated for 12" libraries, but resumption of growth for 5.25" libraries will require successful introduction of advanced MO drives offering very high capacity on removable media, a condition not yet certain to be met.

OEMs and system integrators are expected to account for 27.9% of unit shipments in 2000, while 60.6% will be through PCM/Distributors. This shift to re-seller channels is the anticipated consequence of a flat market, with manufacturers seeking to cut marketing costs by increasing their emphasis on distribution channels rather than direct or OEM sales. With a flat shipment pattern expected, the share of shipments between 12" and 5.25" libraries is also expected to be relatively unchanged. Of total worldwide sales revenues of $61.2 million in 2000, 57% is expected to be generated by U.S. manufacturers. About 54% of the worldwide library revenues in this group are expected to be generated in the U.S. market in that year.

As a result of competition from high capacity rigid disk drives, 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 arrival of the Seagate Elite 23 and its expected higher capacity follow-ons will only accelerate this trend.

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 and ATG Cygnet 12" libraries occupy the middle ground. While moderately priced, 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 rewritable media is not required, the small 12" library may displace some 5.25" libraries in both single user and multiuser systems. The small 12" libraries, the only write-once libraries in this product group, are expected to sustain 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. The impact of the 2.6 gigabyte per side drives

anticipated in 1998 and the existing Pinnacle Micro Apex will keep the 5.25" segment of this group from further major declines, but the impact will not be strong enough to reignite significant growth.

Eventual introduction of libraries using the 12 centimeter DVD-RAM drives is a possibility. 3.5" libraries will use the 600+ megabyte drives, but 3.5" libraries offering much less capacity than 5.25" libraries, and limited further by single sided recording, will be viewed as relatively unattractive. As noted earlier, the major competition to this product group comes from high capacity rigid magnetic disk drives such as the Seagate Elite 23, which offer the capacity of a small optical library at a lower price and with better performance, and from libraries based upon DVD-RAM drives when they become available in 1998.

Performance, in terms of average media exchange time, is expected to improve somewhat for high-end optical disk libraries in this product group, 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. Very high capacity MO drives will not influence this product group until late in the forecast period. The impact will be modest.
2. The 5.25" format will remain the most commonly used.

3. 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.
4. The availability of higher capacity optical drives will tend to increase the growth rate of the upper end of this product group.

TABLE 51

OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	5.5	9.2	4.9	8.4	4.5	7.8	4.2	7.2	4.2	7.2
PCM/Distributor	11.5	19.2	11.5	19.1	11.8	19.5	11.8	19.4	11.6	19.2
OEM/Integrator	6.2	10.3	5.9	9.8	5.7	9.5	5.5	9.1	5.1	8.6
TOTAL U.S. REVENUES	23.2	38.7	22.3	37.3	22.0	36.8	21.5	35.7	20.9	35.0
Non-U.S. Manufacturers										
Captive	--	2.2	--	2.0	--	2.1	--	2.2	--	2.2
PCM/Distributor	8.1	13.3	8.0	13.5	7.4	13.2	7.1	12.6	7.2	12.8
OEM/Integrator	6.2	12.3	5.9	11.9	5.9	11.6	5.8	11.4	5.7	11.2
TOTAL NON-U.S. REVENUES	14.3	27.8	13.9	27.4	13.3	26.9	12.9	26.2	12.9	26.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	37.5	66.5	36.2	64.7	35.3	63.7	34.4	61.9	33.8	61.2
OEM Average Price ($000)		7.036		7.036		7.038		6.926		6.744

TABLE 52

OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	702	1,170	632	1,083	600	1,040	590	1,010	595	1,020
PCM/Distributor	1,950	3,255	2,050	3,400	2,150	3,550	2,260	3,720	2,310	3,820
OEM/Integrator	1,257	2,095	1,200	2,000	1,150	1,920	1,145	1,910	1,120	1,880
TOTAL U.S. SHIPMENTS	3,909	6,520	3,882	6,483	3,900	6,510	3,995	6,640	4,025	6,720
Non-U.S. Manufacturers										
Captive	1	171	--	170	--	175	--	181	--	186
PCM/Distributor	1,812	2,669	1,774	2,606	1,715	2,550	1,675	2,495	1,695	2,540
OEM/Integrator	564	1,117	552	1,084	560	1,078	550	1,050	553	1,056
TOTAL NON-U.S. SHIPMENTS	2,377	3,957	2,326	3,860	2,275	3,803	2,225	3,726	2,248	3,782
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6,286	10,477	6,208	10,343	6,175	10,313	6,220	10,366	6,273	10,502
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	37	60	43	71	49	81	55	91	62	102

TABLE 53

OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues			Forecast											
	1997			1998			1999			2000					
	12-14"	5.25"	3.5"	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	--	9.2	--	--	8.4	--	--	7.8	--	--	7.2	--	--	7.2	--
PCM/Distributor	--	19.2	--	--	19.1	--	--	19.5	--	--	19.4	--	--	19.2	--
OEM/Integrator	--	10.3	--	--	9.8	--	--	9.5	--	--	9.1	--	--	8.6	--
TOTAL U.S. REVENUES	--	38.7	--	--	37.3	--	--	36.8	--	--	35.7	--	--	35.0	--
NON-U.S. MANUFACTURERS															
Captive	.1	2.1	--	--	2.0	--	--	2.1	--	--	2.2	--	--	2.2	--
PCM/Distributor	6.7	4.7	1.9	7.3	4.5	1.7	7.5	4.0	1.7	7.2	3.8	1.6	7.2	4.0	1.6
OEM/Integrator	9.9	2.3	.1	9.5	2.4	--	9.4	2.2	--	9.2	2.2	--	9.0	2.2	--
TOTAL NON-U.S. REVENUES	16.7	9.1	2.0	16.8	8.9	1.7	16.9	8.3	1.7	16.4	8.2	1.6	16.2	8.4	1.6
WORLDWIDE RECAP															
Captive	.1	11.3	--	--	10.4	--	--	9.9	--	--	9.4	--	--	9.4	--
	-75.0%	-22.1%	--	--	-8.0%	--	--	-4.8%	--	--	-5.1%	--	--	--	--
PCM/Distributor	6.7	23.9	1.9	7.3	23.6	1.7	7.5	23.5	1.7	7.2	23.2	1.6	7.2	23.2	1.6
	+42.6%	-4.0%	-24.0%	+9.0%	-1.3%	-10.5%	+2.7%	-.4%	--	-4.0%	-1.3%	-5.9%	--	--	--
OEM/Integrator	9.9	12.6	.1	9.5	12.2	--	9.4	11.7	--	9.2	11.3	--	9.0	10.8	--
	-42.4%	-31.9%	-90.0%	-4.0%	-3.2%	--	-1.1%	-4.1%	--	-2.1%	-3.4%	--	-2.2%	-4.4%	--
Total Revenues	16.7	47.8	2.0	16.8	46.2	1.7	16.9	45.1	1.7	16.4	43.9	1.6	16.2	43.4	1.6
	-25.1%	-17.4%	-42.9%	+.6%	-3.3%	-15.0%	+.6%	-2.4%	--	-3.0%	-2.7%	-5.9%	-1.2%	-1.1%	--
ANNUAL SHARE, BY DIAMETER	25.1%	72.0%	2.9%	26.0%	71.5%	2.5%	26.5%	70.9%	2.6%	26.5%	71.0%	2.5%	26.5%	71.0%	2.5%

TABLE 54

OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments			Forecast 1997			1998			1999			2000		
	12-14"	5.25"	3.5"	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	--	1,170	--	--	1,083	--	--	1,040	--	--	1,010	--	--	1,020	--
PCM/Distributor	--	3,255	--	--	3,400	--	--	3,550	--	--	3,720	--	--	3,820	--
OEM/Integrator	--	2,095	--	--	2,000	--	--	1,920	--	--	1,910	--	--	1,880	--
TOTAL U.S. SHIPMENTS	--	6,520	--	--	6,483	--	--	6,510	--	--	6,640	--	--	6,720	--
NON-U.S. MANUFACTURERS															
Captive	6	165	--	--	170	--	--	175	--	--	181	--	--	186	--
PCM/Distributor	289	2,130	250	321	2,065	220	340	2,000	210	350	1,940	205	360	1,980	200
OEM/Integrator	452	615	50	454	630	--	458	620	--	460	590	--	462	594	--
TOTAL NON-U.S. SHIPMENTS	747	2,910	300	775	2,865	220	798	2,795	210	810	2,711	205	822	2,760	200
WORLDWIDE RECAP															
Captive	6	1,335	--	--	1,253	--	--	1,215	--	--	1,191	--	--	1,206	--
	-45.5%	-9.8%	--	--	-6.1%	--	--	-3.0%	--	--	-2.0%	--	--	+1.3%	--
PCM/Distributor	289	5,385	250	321	5,465	220	340	5,550	210	350	5,660	205	360	5,800	200
	+32.6%	-3.3%	-13.8%	+11.1%	+1.5%	-12.0%	+5.9%	+1.6%	-4.5%	+2.9%	+2.0%	-2.4%	+2.9%	+2.5%	-2.4%
OEM/Integrator	452	2,710	50	454	2,630	--	458	2,540	--	460	2,500	--	462	2,474	--
	-41.3%	-34.4%	-84.7%	+.4%	-3.0%	--	+.9%	-3.4%	--	+.4%	-1.6%	--	+.4%	-1.0%	--
Total Shipments	747	9,430	300	775	9,348	220	798	9,305	210	810	9,351	205	822	9,480	200
	-25.2%	-15.7%	-51.3%	+3.7%	-.9%	-26.7%	+3.0%	-.5%	-4.5%	+1.5%	+.5%	-2.4%	+1.5%	+1.4%	-2.4%
ANNUAL SHARE, BY DIAMETER	7.1%	90.1%	2.8%	7.5%	90.5%	2.0%	7.7%	90.3%	2.0%	7.8%	90.3%	1.9%	7.8%	90.4%	1.8%

TABLE 55

OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1996 --Shipments--		Forecast							
			1997		1998		1999		2000	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	1,170.0		1,083.0		1,040.0		1,010.0		1,020.0	
Rewritable	1,170.0	100.0%	1,083.0	100.0%	1,040.0	100.0%	1,010.0	100.0%	1,020.0	100.0%
Noncaptive Total	5,350.0		5,400.0		5,470.0		5,630.0		5,700.0	
Rewritable	5,350.0	100.0%	5,400.0	100.0%	5,470.0	100.0%	5,630.0	100.0%	5,700.0	100.0%
Total U.S.	6,520.0		6,483.0		6,510.0		6,640.0		6,720.0	
Rewritable	6,520.0	100.0%	6,483.0	100.0%	6,510.0	100.0%	6,640.0	100.0%	6,720.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	171.0		170.0		175.0		181.0		186.0	
Write-Once	6.0	3.5%	--	--	--	--	--	--	--	--
Rewritable	165.0	96.5%	170.0	100.0%	175.0	100.0%	181.0	100.0%	186.0	100.0%
Noncaptive Total	3,786.0		3,690.0		3,628.0		3,545.0		3,596.0	
Write-Once	741.0	19.6%	775.0	21.0%	798.0	22.0%	810.0	22.8%	822.0	22.9%
Rewritable	3,045.0	80.4%	2,915.0	79.0%	2,830.0	78.0%	2,735.0	77.2%	2,774.0	77.1%
Total Non-U.S.	3,957.0		3,860.0		3,803.0		3,726.0		3,782.0	
Write-Once	747.0	18.9%	775.0	20.1%	798.0	21.0%	810.0	21.7%	822.0	21.7%
Rewritable	3,210.0	81.1%	3,085.0	79.9%	3,005.0	79.0%	2,916.0	78.3%	2,960.0	78.3%
WORLDWIDE SHIPMENTS										
Total Shipments	10,477.0		10,343.0		10,313.0		10,366.0		10,502.0	
	-18.0%		-1.2%		-.2%		+.5%		+1.3%	
Write-Once	747.0	7.1%	775.0	7.5%	798.0	7.7%	810.0	7.8%	822.0	7.8%
	-25.1%		+3.7%		+3.0%		+1.5%		+1.5%	
Rewritable	9,730.0	92.9%	9,568.0	92.5%	9,515.0	92.3%	9,556.0	92.2%	9,680.0	92.2%
	-17.4%		-1.6%		-.5%		+.4%		+1.3%	

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

READ/WRITE OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

1997 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
40 - 69 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Adaptive Information Systems	A6970
ASM	ASM 52
DISC	D60
Hewlett-Packard	160fx, C1162C
Hitachi	OL172-48
IBM	3395-C22
Kubota	K4020
Maxoptix	MX540, PX552
NEC	N7925-84, OL5260
Plasmon Data Systems	M52-260-X
Sony	OSL 6000-21, OSL 6000-41

12" disk diameter

DSM	48
FileNet	OSAR 50 GTL

The optical disk libraries in this group are mainstream products for classical library uses in imaging and archiving systems, frequently attached to network platforms. The 12" library 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 as well as for a variety of systems designed for technical documentation applications.

Market status

Optical disk library shipments in this product group rose .4% to 1,639 units worldwide in 1996. Although shipments of 5.25" libraries in the 40 to 69 cartridge range declined slightly because of customer preferences for larger 5.25" libraries, improved captive shipments of 12" libraries more than offset the 5.25" shipment

decline. Earlier capacity increases in 12" optical disk drives caused 12" library shipments in this group to expand, diverting shipments from the "Greater than 70 cartridge" product group, because fewer cartridges are needed to hold the required amount of data to be stored. Sales revenues actually grew 17.6% to $32.1 million, reflecting a larger proportion of higher priced 12" libraries in the mix.

1996 shipments of 5.25" units greatly exceeded shipments of 12" units, capturing 90.5% of the worldwide total. The U.S. market accounted for 49% of unit shipments and 45.8% of revenues. 12" libraries, only 9.5% of 1996 unit shipments, generated over 44% of product group revenues, as a result of their higher price tags and shipment growth.

Plasmon Data Systems repeated as the leading supplier in this optical disk library product group, followed by Hewlett-Packard and Hitachi, although Hewlett-Packard is expected to challenge Plasmon for leadership in this group in future periods.

Marketing trends

Moderate growth is projected for this product group during the current forecast period, resulting in unit shipments of 2,197 in 2000 and worldwide revenues of $31.5 million. Shipments of 12" optical disk libraries will be impacted by the departure of Sony and Hitachi from the 12" optical disk drive market, and are expected to decline in future periods, while shipments of 5.25" libraries, helped by the availability of larger capacity drives and lower prices, are expected to grow at a moderate pace.

While it is possible that very high capacity 5.25" optical disk drives will eventually shift preferences to this product group from the "Greater than 70 cartridge" group, following the recent pattern of shipments for 12" libraries, the effect cannot be forecasted until the characteristics of the new drives are known. Still, it is a possibility worth watching, as the expected existence of 5.2 gigabytes per cartridge drives appearing in 1998 should show whether such a future preference is likely.

Unit shipments to the U.S. in 2000 are expected to represent 46% of total worldwide unit shipments, while the U.S. market is forecasted to produce 47.3% of revenues.

Applications

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

Dedicated office systems remain the most significant application, followed by general purpose networked systems. Technical applications were third in importance. This pattern is expected to be maintained throughout the forecast period. Libraries directly attached to networks are expected to increasingly appear in the product group.

A considerable percentage of the 5.25" optical disk libraries in this product group are used in technical design environments where they serve an engineering design team. Few libraries in this product group 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 be expected to use.

Single-site video-on-demand library 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 for the purpose of increasing on-line data availability, an increased capacity per drive, and increased availability of dual cartridge elevator pickers on various libraries in this class. Optical disk libraries that can mix media types within an individual library, with the picker mechanism adaptable

enough to route media to and from the appropriate drives are anticipated in the future.

There may be future competition for conventional optical disk 5.25" libraries in this product group from libraries incorporating DVD-RAM drives. Because DVD-RAM drive performance is likely to be relatively slow, such competition is expected to be most effective where small servers and small work groups are involved. Because the DVD-RAM drive price will probably be low relative to 5.25" MO disk drives, an equivalently priced DVD-RAM based library could have more drives, hence could contain more data actively available at any given time, and could have a good chance to compete in performance effectively in a limited number of situations that did not require much disk swapping. The 2.6 gigabyte on-line capacity of DVD-RAM is equivalent to that of 5.25" MO drives expected in 1998.

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 disk library to a local area network are a result of the shift to computer based controllers.

Forecasting assumptions

1. Optical disk drive applications involving archival storage will continue to favor 12" write-once disk drives and media. Most of the other optical disk applications will favor 5.25" rewritable or multifunction disk drive based optical libraries.
2. There are no immediate expectations in this product group for optical disk libraries using formats other than the existing 12" and 5.25" formats. The impact of possible DVD based libraries are accounted for in the 5.25" forecast.
3. There will be no fundamental changes in optical disk library 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 1997 and 1998 may restimulate customer interest for products in this group, resulting in new growth after a period of flat sales.

5. DVD-RAM based libraries will have only minor impact on shipments of libraries in this group.

TABLE 56

OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996		Forecast							
	Revenues		1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.4	11.5	5.9	10.4	6.0	10.2	5.7	9.7	4.8	8.6
PCM/Distributor	2.2	3.7	2.7	5.0	2.9	5.2	3.1	5.6	3.4	6.0
OEM/Integrator	1.3	2.1	1.7	2.7	1.5	2.6	1.5	2.7	1.5	2.7
TOTAL U.S. REVENUES	9.9	17.3	10.3	18.1	10.4	18.0	10.3	18.0	9.7	17.3
Non-U.S. Manufacturers										
Captive	--	2.6	--	2.0	--	2.1	--	2.3	--	2.5
PCM/Distributor	1.8	3.7	1.8	3.9	2.1	4.3	2.0	4.2	2.0	4.4
OEM/Integrator	3.0	8.5	2.1	6.8	3.3	7.3	3.3	7.5	3.2	7.3
TOTAL NON-U.S. REVENUES	4.8	14.8	3.9	12.7	5.4	13.7	5.3	14.0	5.2	14.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	14.7	32.1	14.2	30.8	15.8	31.7	15.6	32.0	14.9	31.5
OEM Average Price ($000)		17.492		15.152		14.602		14.167		13.298

TABLE 57

OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1996 Shipments		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	103	179	120	210	139	239	150	257	144	260
PCM/Distributor	144	240	180	330	195	345	220	400	245	435
OEM/Integrator	93	154	108	180	102	184	104	196	110	212
TOTAL U.S. SHIPMENTS	340	573	408	720	436	768	474	853	499	907
Non-U.S. Manufacturers										
Captive	--	100	--	95	--	100	--	110	--	120
PCM/Distributor	272	514	272	550	286	592	285	605	290	630
OEM/Integrator	191	452	161	447	201	494	214	524	222	540
TOTAL NON-U.S. SHIPMENTS	463	1,066	433	1,092	487	1,186	499	1,239	512	1,290
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	803	1,639	841	1,812	923	1,954	973	2,092	1,011	2,197
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	7	14	8	16	9	18	10	20	11	22

TABLE 58

OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues		Forecast							
			1997		1998		1999		2000	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	9.8	1.7	8.0	2.4	7.1	3.1	6.2	3.5	4.8	3.8
PCM/Distributor	--	3.7	--	5.0	--	5.2	--	5.6	--	6.0
OEM/Integrator	.1	2.0	.3	2.4	.3	2.3	.3	2.4	.2	2.5
TOTAL U.S. REVENUES	9.9	7.4	8.3	9.8	7.4	10.6	6.5	11.5	5.0	12.3
NON-U.S. MANUFACTURERS										
Captive	.9	1.7	.2	1.8	--	2.1	--	2.3	--	2.5
PCM/Distributor	.3	3.4	.3	3.6	.2	4.1	--	4.2	--	4.4
OEM/Integrator	3.2	5.3	2.3	4.5	1.6	5.7	1.3	6.2	.9	6.4
TOTAL NON-U.S. REVENUES	4.4	10.4	2.8	9.9	1.8	11.9	1.3	12.7	.9	13.3
WORLDWIDE RECAP										
Captive	10.7 +143.2%	3.4 -27.7%	8.2 -23.4%	4.2 +23.5%	7.1 -13.4%	5.2 +23.8%	6.2 -12.7%	5.8 +11.5%	4.8 -22.6%	6.3 +8.6%
PCM/Distributor	.3 --	7.1 +10.9%	.3 --	8.6 +21.1%	.2 -33.3%	9.3 +8.1%	-- --	9.8 +5.4%	-- --	10.4 +6.1%
OEM/Integrator	3.3 +32.0%	7.3 -21.5%	2.6 -21.2%	6.9 -5.5%	1.9 -26.9%	8.0 +15.9%	1.6 -15.8%	8.6 +7.5%	1.1 -31.2%	8.9 +3.5%
Total Revenues	14.3 +107.2%	17.8 -12.7%	11.1 -22.4%	19.7 +10.7%	9.2 -17.1%	22.5 +14.2%	7.8 -15.2%	24.2 +7.6%	5.9 -24.4%	25.6 +5.8%
ANNUAL SHARE, BY DIAMETER	44.6%	55.4%	36.1%	63.9%	29.0%	71.0%	24.4%	75.6%	18.7%	81.3%

Note: 12" libraries include 14" libraries.

TABLE 59

OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	89	90	80	130	74	165	67	190	53	207
PCM/Distributor	--	240	--	330	--	345	--	400	--	435
OEM/Integrator	2	152	6	174	7	177	6	190	5	207
TOTAL U.S. SHIPMENTS	91	482	86	634	81	687	73	780	58	849
NON-U.S. MANUFACTURERS										
Captive	20	80	5	90	--	100	--	110	--	120
PCM/Distributor	3	511	3	547	2	590	--	605	--	630
OEM/Integrator	41	411	25	422	18	476	14	510	10	530
TOTAL NON-U.S. SHIPMENTS	64	1,002	33	1,059	20	1,166	14	1,225	10	1,280
WORLDWIDE RECAP										
Captive	109 +87.9%	170 -7.1%	85 -22.0%	220 +29.4%	74 -12.9%	265 +20.5%	67 -9.5%	300 +13.2%	53 -20.9%	327 +9.0%
PCM/Distributor	3 --	751 +8.4%	3 --	877 +16.8%	2 -33.3%	935 +6.6%	-- --	1,005 +7.5%	-- --	1,065 +6.0%
OEM/Integrator	43 -41.9%	563 -9.8%	31 -27.9%	596 +5.9%	25 -19.4%	653 +9.6%	20 -20.0%	700 +7.2%	15 -25.0%	737 +5.3%
Total Shipments	155 +17.4%	1,484 -1.1%	119 -23.2%	1,693 +14.1%	101 -15.1%	1,853 +9.5%	87 -13.9%	2,005 +8.2%	68 -21.8%	2,129 +6.2%
ANNUAL SHARE, BY DIAMETER	9.5%	90.5%	6.6%	93.4%	5.2%	94.8%	4.2%	95.8%	3.1%	96.9%

Note: 12" libraries include 14" libraries.

TABLE 60

OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1996		Forecast							
	--Shipments--		-----1997----		-----1998----		-----1999----		-----2000----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	179.0		210.0		239.0		257.0		260.0	
Write-Once	89.0	49.7%	80.0	38.1%	74.0	31.0%	67.0	26.1%	53.0	20.4%
Rewritable	90.0	50.3%	130.0	61.9%	165.0	69.0%	190.0	73.9%	207.0	79.6%
Noncaptive Total	394.0		510.0		529.0		596.0		647.0	
Write-Once	2.0	.5%	6.0	1.2%	7.0	1.3%	6.0	1.0%	5.0	.8%
Rewritable	392.0	99.5%	504.0	98.8%	522.0	98.7%	590.0	99.0%	642.0	99.2%
Total U.S.	573.0		720.0		768.0		853.0		907.0	
Write-Once	91.0	15.9%	86.0	11.9%	81.0	10.5%	73.0	8.6%	58.0	6.4%
Rewritable	482.0	84.1%	634.0	88.1%	687.0	89.5%	780.0	91.4%	849.0	93.6%
NON-U.S. MANUFACTURERS										
Captive Total	100.0		95.0		100.0		110.0		120.0	
Write-Once	20.0	20.0%	5.0	5.3%	--	--	--	--	--	--
Rewritable	80.0	80.0%	90.0	94.7%	100.0	100.0%	110.0	100.0%	120.0	100.0%
Noncaptive Total	966.0		997.0		1,086.0		1,129.0		1,170.0	
Write-Once	44.0	4.6%	28.0	2.8%	20.0	1.8%	14.0	1.2%	10.0	.9%
Rewritable	922.0	95.4%	969.0	97.2%	1,066.0	98.2%	1,115.0	98.8%	1,160.0	99.1%
Total Non-U.S.	1,066.0		1,092.0		1,186.0		1,239.0		1,290.0	
Write-Once	64.0	6.0%	33.0	3.0%	20.0	1.7%	14.0	1.1%	10.0	.8%
Rewritable	1,002.0	94.0%	1,059.0	97.0%	1,166.0	98.3%	1,225.0	98.9%	1,280.0	99.2%
WORLDWIDE SHIPMENTS										
Total Shipments	1,639.0		1,812.0		1,954.0		2,092.0		2,197.0	
	+.4%		+10.6%		+7.8%		+7.1%		+5.0%	
Write-Once	155.0	9.5%	119.0	6.6%	101.0	5.2%	87.0	4.2%	68.0	3.1%
	+17.4%		-23.1%		-15.0%		-13.8%		-21.7%	
Rewritable	1,484.0	90.5%	1,693.0	93.4%	1,853.0	94.8%	2,005.0	95.8%	2,129.0	96.9%
	-1.0%		+14.1%		+9.5%		+8.2%		+6.2%	

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

READ/WRITE OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES

1997 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
70 OR MORE CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Adaptive Information Systems	A6900-500, A6900-502
ASM	ASM 102, ASM 104, ASM 158
DISC	D255U, D510-2, D1050-2
DSM	5300, 7100
EMASS	AML/J
Fujitsu	F6445/A1, F6445/A2, F6445/A2X2
Grundig (K&S)	Megastore
Hewlett-Packard	C1705T, 200fx, 300st, 600fx
Hitachi	OL500-270, OL502-228
IBM	3995-C24, 3995-C26, 3395-C28
Kubik Enterprises	MO-120
NEC	N3661-XX
Plasmon Data Systems	M104-260-X, M156-260-X
Sony	OSL 15000, OSL 25000

12" and 14" disk diameter

Cygnet Storage Solutions	1800
DSM	100-2000
Eastman Kodak	2000 ADL+, 2000E
FileNet	Model 0150, Model 0140

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 5.25" optical libraries are now the majority component of the group.

Market status

1996 unit shipments grew 3% to 4,190 units, but revenues declined 12.3% to $128.2 million. Within the product group, shipments of 5.25" libraries rose 8.8% to 3,832 units, but shipments in the 12" to 14" segment fell 34.6% to 358 units. The reasons for the decline include a shift to the 40 to 69 cartridge group, as increasing drive capacity allows users to store their data with fewer cartridges,

perception that the 5.25" segment has stronger standards and that interchange is more universal, and favorable economics for 5.25" libraries relative to 12" libraries. Worldwide sales revenues for 1996 declined for both product segments. 61.5% of this product group's revenues were generated from sales in the United States, and 74.3% of worldwide revenues were generated by U.S. manufacturers, both up from 1995 as a result of the mix shift in the product group, which favored U.S. manufacturers of 5.25" libraries. Hewlett-Packard repeated as the shipment leader for the group in 1996, followed by Plasmon Data and, distantly, by Fujitsu. Eastman Kodak leads in the 12" to 14" product segment.

OEM/Integrator channel shipments were 46.4% of the total, again down from the previous year. Captive shipments rose slightly to 11.5%, while PCM/Distributor activity for the libraries in this group rose to 42% of shipments. Distribution 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. The higher proportion of 5.25" libraries in the group product mix tends to increase the share of sales through distribution.

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

Unit shipments in 2000 are forecasted to grow to 5,982 units, over 95% of which will be 5.25" libraries. A minor annual decline is expected for the 12" to 14" segment, which will be impacted by the declining number of 12" drive manufacturers. About 52.3% of the libraries will be shipped to U.S. markets. U.S. suppliers are expected to remain strong because of their very strong system support capabilities and well developed sales channels. No 3.5" disk libraries in this group are anticipated through 2000, but competition from inexpensive 12 centimeter disk libraries with DVD-RAM drives may have moderate impact on sales for this product group.

Sales revenues for this group are expected to exceed $130 million in 2000, again a reduction from previous forecasts, because of the shifting product mix in the group to 5.25" libraries with lower average prices and lower shipments than previously anticipated. 56% of revenues are expected to be generated in the U.S. System size, in terms of the number of stored cartridges, has been increasing, but may level off as higher capacity cartridges allow smaller libraries to store the same amount of data. The appearance of higher capacity optical drives over the next several years will tend to keep library subsystem prices from declining rapidly, but as noted, is likely to be a brake on the tendency for library size to increase, since fewer drives will be needed for a given on-line capacity.

12" to 14" libraries are expected to retain only 4.6% of unit shipments in 2000, but will account for 20% of revenue in that year. The lower prices of the 5.25" libraries and their increasing capacities will produce a more positive growth rate for 5.25" libraries than for 12" libraries throughout the forecast period.

Most 12" libraries will continue to use write-once media. The 5.25" libraries are strongly oriented toward rewritable 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. European customers also tend to favor the use of write-once media, which will help maintain the market for 12" systems.

Libraries using rewritable disk drives, already over 91% of unit shipments, are expected to further increase their share of the market during the forecast period. Almost all of the rewritable drives will be 5.25" diameter drives (or DVD-RAM drives), but Nikon's rewritable 12" drives are also available for libraries in this product group.

Applications

Financial and government institutions are the major users of optical disk drive libraries in this product group, although data warehousing applications in corporate environments are expected to grow as well. Systems employing hierarchical storage management also represent an opportunity for libraries in this group, but

interest is strongly oriented to the rewritable 5.25" libraries rather than write-once configurations because of the desire to reuse the rather expensive media.

The IBM 3995 optical library introduced in 1991 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 optical disk libraries that have appeared so far have used X-Y positioners accessing multiple bays of disk cartridge storage cells. Some 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.

5.25" drives with capacities of 2.6 gigabytes (1.3 gigabytes per side) appeared in quantity in 1996 and shipments of 5.2 gigabyte (2.6 gigabytes per side) drives are anticipated in 1998. Drives with on-line capacities over 5 gigabytes are expected to appear in 1998, but their appearance in libraries in this group is problematic until the specifications of these drives become clear and production is reliably established. 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, but they will also tend to shift user purchases to libraries with smaller numbers of disks. 12" to 14" drive storage capabilities have increased to the 10-25 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 often found 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. Rotary designs have not yet met with widespread user acceptance.

Forecasting assumptions

1. The appearance of higher capacity 5.25" drives and the lower prices of 5.25" drives and libraries will continue to drive the movement to 5.25" drive usage in this product group, but will also limit growth due to user shifts to libraries with smaller numbers of disks. 12" to 14" is the only other format expected to be significant in the forecast period.
2. There will be no significant changes in basic technology affecting these libraries over the period of the forecast.
3. Governments, financial institutions and other large users will continue to be strong markets for libraries in this product group.

TABLE 61

OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1996 Revenues		Forecast 1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	25.3	33.3	16.3	27.2	14.7	24.0	13.7	22.4	13.1	21.5
PCM/Distributor	15.3	25.2	16.9	30.5	17.6	33.4	18.7	36.5	19.8	39.0
OEM/Integrator	26.6	36.8	26.6	37.0	26.3	39.7	27.0	41.2	27.3	42.4
TOTAL U.S. REVENUES	67.2	95.3	59.8	94.7	58.6	97.1	59.4	100.1	60.2	102.9
Non-U.S. Manufacturers										
Captive	--	2.8	--	3.4	--	--	--	--	--	--
PCM/Distributor	3.1	15.2	3.1	10.4	4.0	11.9	4.4	12.9	4.3	12.5
OEM/Integrator	8.5	14.9	9.0	16.2	10.7	16.0	8.7	15.7	8.7	15.4
TOTAL NON-U.S. REVENUES	11.6	32.9	12.1	30.0	14.7	27.9	13.1	28.6	13.0	27.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	78.8	128.2	71.9	124.7	73.3	125.0	72.5	128.7	73.2	130.8
OEM Average Price ($000)		26.581		24.790		23.582		22.660		21.894

TABLE 62

OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	318	465	288	465	295	475	295	475	290	470
PCM/Distributor	650	1,070	770	1,390	840	1,590	935	1,825	1,040	2,050
OEM/Integrator	787	1,222	852	1,343	955	1,545	1,020	1,680	1,075	1,795
TOTAL U.S. SHIPMENTS	1,755	2,757	1,910	3,198	2,090	3,610	2,250	3,980	2,405	4,315
Non-U.S. Manufacturers										
Captive	--	20	--	25	--	--	--	--	--	--
PCM/Distributor	204	690	224	640	228	714	262	788	281	822
OEM/Integrator	485	723	535	803	551	817	422	831	440	845
TOTAL NON-U.S. SHIPMENTS	689	1,433	759	1,468	779	1,531	684	1,619	721	1,667
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,444	4,190	2,669	4,666	2,869	5,141	2,934	5,599	3,126	5,982
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	9	15	12	19	15	25	18	30	21	36

TABLE 63

OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1996 Revenues		Forecast							
	1997		1998		1999		2000			
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	23.8	9.5	17.2	10.0	13.5	10.5	11.6	10.8	10.4	11.1
PCM/Distributor	--	25.2	--	30.5	--	33.4	--	36.5	--	39.0
OEM/Integrator	12.4	24.4	11.7	25.3	11.2	28.5	10.6	30.6	10.2	32.2
TOTAL U.S. REVENUES	36.2	59.1	28.9	65.8	24.7	72.4	22.2	77.9	20.6	82.3
NON-U.S. MANUFACTURERS										
Captive	--	2.8	--	3.4	--	--	--	--	--	--
PCM/Distributor	.6	14.6	.6	9.8	.5	11.4	.3	12.6	.2	12.3
OEM/Integrator	5.4	9.5	5.4	10.8	5.6	10.4	5.5	10.2	5.4	10.0
TOTAL NON-U.S. REVENUES	6.0	26.9	6.0	24.0	6.1	21.8	5.8	22.8	5.6	22.3
WORLDWIDE RECAP										
Captive	23.8 +9.2%	12.3 +8.8%	17.2 -27.7%	13.4 +8.9%	13.5 -21.5%	10.5 -21.6%	11.6 -14.1%	10.8 +2.9%	10.4 -10.3%	11.1 +2.8%
PCM/Distributor	.6 +20.0%	39.8 +13.7%	.6 --	40.3 +1.3%	.5 -16.7%	44.8 +11.2%	.3 -40.0%	49.1 +9.6%	.2 -33.3%	51.3 +4.5%
OEM/Integrator	17.8 -47.0%	33.9 -22.8%	17.1 -3.9%	36.1 +6.5%	16.8 -1.8%	38.9 +7.8%	16.1 -4.2%	40.8 +4.9%	15.6 -3.1%	42.2 +3.4%
Total Revenues	42.2 -24.5%	86.0 -4.7%	34.9 -17.3%	89.8 +4.4%	30.8 -11.7%	94.2 +4.9%	28.0 -9.1%	100.7 +6.9%	26.2 -6.4%	104.6 +3.9%
ANNUAL SHARE, BY DIAMETER	33.0%	67.0%	28.1%	71.9%	24.6%	75.4%	21.8%	78.2%	20.0%	80.0%

TABLE 64

OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1996 Shipments		Forecast							
			1997		1998		1999		2000	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	145	320	120	345	100	375	89	395	83	410
PCM/Distributor	--	1,070	--	1,390	--	1,590	--	1,825	--	2,050
OEM/Integrator	163	1,059	160	1,183	155	1,390	150	1,530	145	1,650
TOTAL U.S. SHIPMENTS	308	2,449	280	2,918	255	3,355	239	3,750	228	4,110
NON-U.S. MANUFACTURERS										
Captive	--	20	--	25	--	--	--	--	--	--
PCM/Distributor	5	685	5	635	4	710	3	785	2	820
OEM/Integrator	45	678	45	758	47	770	46	785	45	800
TOTAL NON-U.S. SHIPMENTS	50	1,383	50	1,418	51	1,480	49	1,570	47	1,620
WORLDWIDE RECAP										
Captive	145 -5.2%	340 +16.4%	120 -17.2%	370 +8.8%	100 -16.7%	375 +1.4%	89 -11.0%	395 +5.3%	83 -6.7%	410 +3.8%
PCM/Distributor	5 -37.5%	1,755 +23.3%	5 --	2,025 +15.4%	4 -20.0%	2,300 +13.6%	3 -25.0%	2,610 +13.5%	2 -33.3%	2,870 +10.0%
OEM/Integrator	208 -46.1%	1,737 -3.9%	205 -1.4%	1,941 +11.7%	202 -1.5%	2,160 +11.3%	196 -3.0%	2,315 +7.2%	190 -3.1%	2,450 +5.8%
Total Shipments	358 -34.6%	3,832 +8.8%	330 -7.8%	4,336 +13.2%	306 -7.3%	4,835 +11.5%	288 -5.9%	5,320 +10.0%	275 -4.5%	5,730 +7.7%
ANNUAL SHARE, BY DIAMETER	8.5%	91.5%	7.1%	92.9%	6.0%	94.0%	5.1%	94.9%	4.6%	95.4%

TABLE 65

OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1996		Forecast							
	--Shipments--		-----1997----		-----1998----		-----1999----		-----2000----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	465.0		465.0		475.0		475.0		470.0	
Write-Once	145.0	31.2%	120.0	25.8%	100.0	21.1%	80.0	16.8%	60.0	12.8%
Rewritable	320.0	68.8%	345.0	74.2%	375.0	78.9%	395.0	83.2%	410.0	87.2%
Noncaptive Total	2,292.0		2,733.0		3,135.0		3,505.0		3,845.0	
Write-Once	163.0	7.1%	160.0	5.9%	155.0	4.9%	150.0	4.3%	145.0	3.8%
Rewritable	2,129.0	92.9%	2,573.0	94.1%	2,980.0	95.1%	3,355.0	95.7%	3,700.0	96.2%
Total U.S.	2,757.0		3,198.0		3,610.0		3,980.0		4,315.0	
Write-Once	308.0	11.2%	280.0	8.8%	255.0	7.1%	230.0	5.8%	205.0	4.8%
Rewritable	2,449.0	88.8%	2,918.0	91.2%	3,355.0	92.9%	3,750.0	94.2%	4,110.0	95.2%
NON-U.S. MANUFACTURERS										
Captive Total	20.0		25.0		--		--		--	
Rewritable	20.0	100.0%	25.0	100.0%	--	--	--	--	--	--
Noncaptive Total	1,413.0		1,443.0		1,531.0		1,619.0		1,667.0	
Write-Once	50.0	3.5%	50.0	3.5%	51.0	3.3%	49.0	3.0%	47.0	2.8%
Rewritable	1,363.0	96.5%	1,393.0	96.5%	1,480.0	96.7%	1,570.0	97.0%	1,620.0	97.2%
Total Non-U.S.	1,433.0		1,468.0		1,531.0		1,619.0		1,667.0	
Write-Once	50.0	3.5%	50.0	3.4%	51.0	3.3%	49.0	3.0%	47.0	2.8%
Rewritable	1,383.0	96.5%	1,418.0	96.6%	1,480.0	96.7%	1,570.0	97.0%	1,620.0	97.2%
WORLDWIDE SHIPMENTS										
Total Shipments	4,190.0		4,666.0		5,141.0		5,599.0		5,982.0	
	+3.0%		+11.4%		+10.2%		+8.9%		+6.8%	
Write-Once	358.0	8.5%	330.0	7.1%	306.0	6.0%	279.0	5.0%	252.0	4.2%
	-33.8%		-7.7%		-7.2%		-8.7%		-9.6%	
Rewritable	3,832.0	91.5%	4,336.0	92.9%	4,835.0	94.0%	5,320.0	95.0%	5,730.0	95.8%
	+8.6%		+13.2%		+11.5%		+10.0%		+7.7%	

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

CD FORMAT DISK DRIVE SPECIFICATIONS

Coverage: The following pages list CD format disk drives intended for computer data storage which are now announced or in new production. This includes CD-ROM, CD-R, CD-RW, DVD-ROM, DVD-R, and DVD-RAM. PD drives are included because they read CD-ROM media. 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".

Drive type: Drive type is indicated as CD-ROM, CD-R, CD-RW, DVD-ROM, or PD as appropriate. Rewritable drives in this section use phase change technology unless otherwise indicated.

Relative speed: The data transfer rate relative to the original CD-ROM drives, which operated at "1X" speed, expressed as 4X, 8X, etc. The fastest rate is given. Most drives operate at several rates, falling back to a lower speed when reading poorly replicated disks or otherwise limited. For CAV drives, the range of effective relative speeds is given.

Interface: Specific interfaces are listed for most of the drives.

Speed control: The following abbreviations are used:

CAV = constant angular velocity.
CLV = constant linear velocity.
ZCAV = zoned constant angular velocity.
PCAV = partial constant angular velocity, a CAV/CLV hybrid

Capacities: Capacities are listed as "U" for unformatted and "F" for formatted. For optical drives that can access only one side of the media, drives are categorized in terms of one side capacity, even if the drive uses two-sided media. As optical media is preformatted, the capacity given is the formatted capacity. Track capacity in CD format drives is variable, so this parameter will be "N/A" except in rare cases where drives have multiple operating modes. 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: All CD format drives use a continuous servo tracking scheme.

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 (such as the PD drive) operates in more than one mode or offers more than one capacity.

CD-ROM drives list the nominal data transfer rate for the fastest operating mode (6X, 8X, 12X, 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.

1997 DISK/TREND optical disk product groups

For the 1997 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.

Read/write optical disk drives:

Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

CD format disk towers:

Group 51: CD format disk towers

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 52: Optical disk libraries with 1 to 39 cartridge capacity.
Group 53: Optical disk libraries with 40 to 69 cartridge capacity.
Group 54: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER		ACER PERIPHERALS	ACER PERIPHERALS	ACER PERIPHERALS	ACER PERIPHERALS	ACER PERIPHERALS
CD FORMAT DRIVE		CD-610A	CD-612A	CD-616A	CD-616P	CD-620A
DISK/TREND GROUP		20	20	20	20	20
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE:	Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
	Relative speed	10X	8X-15X	8X-18X	8X-16X	8X-20X
	Rotational speed (RPM)	5300-2000	3200	3400	3300	3800
	Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
	Disk insertion	Tray	Tray	Tray	Tray	Tray
	Speed control	CLV	CAV/CLV	CAV/CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY						
	Nominal 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	748 Mode 2 F: 656 Mode 1
	Data surfaces per spindle	1	1	1	1	1
	Track density (TPI)	15875	15875	15875	15875	15875
	Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE						
	Buffer/cache size (KBytes)	128	128	128	128	128
	Average positioning time (msec)	150				
	Average access time (msec)	161	120	120	120	125
	Data transfer rate (MBytes/sec)					
	Internal	1.53	1.2-2.25	1.2-2.7	1.2-2.4	1.2-3.0
	External	11.6 PIO Mode 3	16.6 PIO Mode 4	16.7 PIO Mode 4	16.7 PIO Mode 4	16.7 PIO Mode 4
SIZE (mm: H x W x D)		42 x 146 x 211	42 x 146 x 198	42 x 146 x 198	42 x 146 x 198	42 x 146 x 198
FIRST CUSTOMER SHIPMENT		7/96				3/97
COMMENTS		Philips mechanism.	Philips mechanism.	Philips mechanism.	Philips mechanism.	Philips mechanism.

MANUFACTURER	ACER PERIPHERALS	ACER PERIPHERALS	ADI	ADI	ADI
CD FORMAT DRIVE	CD-624A	CD-685A	CP-12000	CP-2008	CP-2412
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X-24X	8X	12X	8X-20X	12X-24X
Rotational speed (RPM)	5600	4240-1600	6360-2400	4240-4000	6360-4800
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128	128	128
Average positioning time (msec)		150			
Average access time (msec)	125	164		120	
Data transfer rate (MBytes/sec) Internal External	1.8-3.6 16.7 PIO Mode 4	1.24 8.3 PIO Mode 3	1.8	1.2-3.0	1.8-3.6
SIZE (mm: H x W x D)	42 x 146 x 198	42 x 146 x 211	41 x 146 x 190	41 x 146 x 190	41 x 146 x 190
FIRST CUSTOMER SHIPMENT	5/97	2/96	4Q96	3/97	4Q97
COMMENTS	Philips mechanism.	Philips mechanism.	Philips mechanism.	Philips mechanism.	JVC mechanism. Preliminary specification.

MANUFACTURER	ADI	ADVANCED INFORMATION (AOPEN)	ADVANCED INFORMATION (AOPEN)	ADVANCED INFORMATION (AOPEN)	ADVANCED INFORMATION (AOPEN)
CD FORMAT DRIVE	CR-2040E	CD-916E	CD-920E	CD-924E	CD-932E
DISK/TREND GROUP	21	20	20	20	20
MARKET	PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X WR/4X RD	16X	20X	24X	32X
Rotational speed (RPM)	2120-800			6000	8000
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 650	782 Mode 2 F: 656 Mode 1	782 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	782 Mode 2 F: 656 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	128		128	128
Average positioning time (msec)					
Average access time (msec)					
Data transfer rate (MBytes/sec) Internal External		2.4	3.0	1.8-3.6	4.8
SIZE (mm: H x W x D)	42.6 x 149 x 211	42 x 149 x 196.5	42 x 149 x 196.5	42 x 149 x 196.5	42 x 149 x 196.5
FIRST CUSTOMER SHIPMENT	3/97	1Q97	2Q97	3Q97	4Q97
COMMENTS			Can read CD-RW media.	Can read CD-RW media.	Can read CD-RW media.

MANUFACTURER	ADVANCED INFORMATION (AOPEN)	ADVANCED INFORMATION (AOPEN)	ADVANCED INFORMATION (AOPEN)	ADVANCED INFORMATION (AOPEN)	AZTECH SYSTEMS
CD FORMAT DRIVE	CDS-112E	CD-1420C	CRW-620	CRW-622	CDA 1068-011
DISK/TREND GROUP	20	21	21	21	20
MARKET	Captive,OEM,PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Dye Polymer	Phase Change	Phase Change	Replication
DRIVE: Drive type	CD-ROM	CD-R	CD-RW	CD-RW	CD-ROM
Relative speed	12X	2X WR/4X RD	2X WR/6X RD	2X WR/6X RD	10X
Rotational speed (RPM)		2120-400			5000-2174
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Caddy	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	782 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	782 Mode 2 F: 656 Mode 1	782 Mode 2 F: 656 Mode 1	630 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	512	1000	1000	128
Average positioning time (msec)		--/363			130
Average access time (msec)		--/390	--/350 RD	--/350 RD	142
Data transfer rate (MBytes/sec) Internal External	1.8	.3/.6	.3 WR/.9 RD	.3 WR/.9 RD	1.5
SIZE (mm: H x W x D)	42 x 149 x 196.5	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 203	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	3Q96	1996	3Q97	3Q97	3/96
COMMENTS		Ricoh mechanism.	Ricoh mechanism.	Ricoh mechanism.	Supports DMA Mode 2.

MANUFACTURER	AZTECH SYSTEMS	AZTECH SYSTEMS	AZTECH SYSTEMS	AZTECH SYSTEMS	BEHAVIOR TECH COMPUTER
CD FORMAT DRIVE	CDA 1268-021	CDA 1668-011	CDA 868-011 Zeta	Zeta 12X	BCD 10X
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM	OEM, PCM	PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	16X	8X	12X	10X
Rotational speed (RPM)	6360-2400		4240-1600	6360-2400	4900-2000
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CAV/CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 550 Mode 1	F: 550 Mode 1	630 Mode 2 F: 540 Mode 1	640 Mode 2 F: 530 Mode 1	635 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128	128	256
Average positioning time (msec)			175	145	150
Average access time (msec)	120	120	189	155	180
Data transfer rate (MBytes/sec) Internal External	1.8 16.6 PIO Mode 4	1.8-2.4 16.6 PIO Mode 4	1.23	1.8	1.5 11.1 PIO Mode 3
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		42 x 146 x 201.8
FIRST CUSTOMER SHIPMENT	3/97	4/97	1/96		1996
COMMENTS					

MANUFACTURER		BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER
CD FORMAT DRIVE		BCD 12X	BCD 20X	BCD 24X	BCD 8X	BCE 621E
DISK/TREND GROUP		20	20	20	20	21
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Recording technology	Replication	Replication	Replication	Replication	Phase Change
DRIVE:	Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-RW
	Relative speed	12X	20X	24X	8X	2X WR/6X RD
	Rotational speed (RPM)	5000-2400	4500-4000	5000-4800	4240-1600	
	Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
	Disk insertion	Tray	Tray	Tray	Tray	Tray
	Speed control	CLV	CAV/CLV	CAV/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY						
	Nominal capacity (MBytes)	F: 650	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
	Data surfaces per spindle	1	1	1	1	1
	Track density (TPI)	15875	15875	15875	15875	15875
	Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE						
	Buffer/cache size (KBytes)	128	128	128	256	1000
	Average positioning time (msec)	118			150	
	Average access time (msec)	148	110	110	180	290
	Data transfer rate (MBytes/sec)					
	Internal	1.78	3.1	3.6	1.2	.35/1.05
	External	11.1	16.6 PIO Mode 4	16.6 PIO Mode 4	11.1 PIO Mode 3	
SIZE (mm: H x W x D)		42 x 146 x 201.8	42 x 146.5 x 210	42 x 146.5 x 210	42 x 146 x 201.8	42 x 149 x 210.5
FIRST CUSTOMER SHIPMENT		1Q97	3Q97	3Q97	1996	3Q97
COMMENTS						

MANUFACTURER	BEHAVIOR TECH COMPUTER	CD-ROM, INC.	CYBERDRIVE	CYBERDRIVE	CYBERDRIVE
CD FORMAT DRIVE	BCR 6SR	CRI 1800	CY120D	CY120S	CY160D
DISK/TREND GROUP	21	20	20	20	20
MARKET	OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X WR/6X RD	8X	12X	12X	16X
Rotational speed (RPM)		4240-1600	6360-2400	6360-2400	5000-3200
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	635 Mode 2 F: 553 Mode 1	F: 540	660 Mode 2 F: 540 Mode 1	660 Mode 2 F: 540 Mode 1	660 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000	128	128, 256 option	128, 256 option	128, 256 option
Average positioning time (msec)		175			
Average access time (msec)	290	189	150	150	150
Data transfer rate (MBytes/sec) Internal External	.35/1.05	1.20 10.0 synch.	1.8	1.8 10.0 synch.	2.4
SIZE (mm: H x W x D)	42 x 149 x 210.5	41.3 x 146.1 x 203.2	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q96	10/96	3Q96	3Q96	1Q97
COMMENTS			Purchased mechanism.	Purchased mechanism.	Purchased mechanism.

MANUFACTURER	CYBERDRIVE	CYBERDRIVE	CYBERDRIVE	DELTA ELECTRONICS	DELTA ELECTRONICS
CD FORMAT DRIVE	CY200D	CY240D	CY240S	OJC-F101	OJC-W101
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	20X	24X	24X	12X-24X	12X-20X
Rotational speed (RPM)	5000-4000	5000-4800	5000-4800	6360-4800	6360-4000
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CAV/CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY Nominal capacity (MBytes)	660 Mode 2 F: 540 Mode 1	660 Mode 2 F: 540 Mode 1	660 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE Buffer/cache size (KBytes)	128, 256 option	128, 256 option	128, 256 option	128, 256	128, 256
Average positioning time (msec)					
Average access time (msec)	110	130	130		130
Data transfer rate (MBytes/sec) Internal External	3.0	3.6	3.6 10.0 synch.	1.8-3.6	1.8-3.0
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	41 x 146 x 203	41 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q97	3Q97	3Q97	3Q97	3Q97
COMMENTS	Purchased mechanism.	Purchased mechanism.	Purchased mechanism.	Purchased mechanism.	Purchased mechanism.

MANUFACTURER	DELTA ELECTRONICS	EASTMAN KODAK	ELITEGROUP COMPUTER SYSTEMS	FUNAI ELECTRIC	FUNAI ELECTRIC
CD FORMAT DRIVE	ODR-6121	PCD Writer 600	SMART 100X	E2850	E2950
DISK/TREND GROUP	21	21	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-R	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X WR/4X RD	6X	12X/100X	8X	10X-16X
Rotational speed (RPM)	3180-400	3646-1165	6360-2400	4240-1600	5500-3500
Interface	IDE/ATAPI	SCSI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 635 Mode 2 553 Mode 1	F: 580/682	F: 660	F: 540	F: 540
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)		1000-8000	256	256	256
Average positioning time (msec)		1271		--	
Average access time (msec)	370	1288	150/10*	150	100
Data transfer rate (MBytes/sec)					
Internal	.9/.3	.921	1.2/15.0	1.23	1.5-2.4
External		4.0 synch.	16.6/33.2	PIO Mode 3	PIO Mode 3
SIZE (mm: H x W x D)	41 x 146 x 203	145 x 430 x 380	41.3 x 146 x 203	42.5 x 148 x 198	41.3 x 146 x 198
FIRST CUSTOMER SHIPMENT	3Q97	2Q94	1997	4/96	3/96
COMMENTS	Philips mechanism.	75 disk loader option.	*With hard disk drive buffer software.	Spin up: 2.5 seconds.	Spin up: 3 seconds.

MANUFACTURER	FUNAI ELECTRIC	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI
CD FORMAT DRIVE	NC/CD-ROM	C4325A 6020ep CD-Writer	C4343A 6020i CD-Writer	C4345A 6020es CD-Writer	CDR-7930
DISK/TREND GROUP	20	21	21	21	20
MARKET	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Recording technology	Replication	Dye Polymer	Dye Polymer	Dye Polymer	Replication
DRIVE: Drive type	CD-ROM	CD-R	CD-R	CD-R	CD-ROM
Relative speed	8X	2X WR/6X RD	2X WR/6X RD	2X WR/6X RD	8X
Rotational speed (RPM)	4280-1600	3180-400	3180-400	3180-400	4240-1600
Interface	IDE/ATAPI	Parallel Port	SCSI-2	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 680	682 F: 581	682 F: 581	682 F: 581	F: 742
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	1000	1000	1000	128
Average positioning time (msec)	150	290	290	290	136
Average access time (msec)	164	345 WR/310 RD	345 WR/310 RD	345 WR/310 RD	150
Data transfer rate (MBytes/sec) Internal External	1.2 11.1	.30 WR/.900 RD	.30 WR/.900 RD	.30 WR/.900 RD	1.2 11.1 PIO Mode 3
SIZE (mm: H x W x D)	64 x 335 x 250	41.5 x 146 x 206	41.5 x 146 x 206	41.5 x 146 x 206	41.3 x 146 x 190
FIRST CUSTOMER SHIPMENT	2Q96				2Q96
COMMENTS		External mount.		External mount.	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
CD FORMAT DRIVE	CDR-8130	CDR-8330	CDR-S200	GD-1000	GD-2000
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM
Relative speed	16X	24X	8X-20X	1X/8X*	2X/20X*
Rotational speed (RPM)	4200-3200	5500	4240	1536-582	3056-1149**
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	EIDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV (PCAV)	CAV	CAV	CLV	CLV/CAV*
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 650	F: 650	742 Mode 2 F: 650 Mode 1	4700 F: 8500 2 surf.	4760 F: 8500
Data surfaces per spindle	1	1	1	1, 2	1, 2
Track density (TPI)	15875	15875	15875	34324	34324
Maximum linear density (BPI)	27600	27600	27600	96000	96000
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128	256	512/256*
Average positioning time (msec)	82			190/150*	150/100*
Average access time (msec)	90	90	150	202/164*	155/107*
Data transfer rate (MBytes/sec) Internal External	1.2-2.4	1.5-3.6 16.6 PIO Mode 4	1.2-3.0	1.38/1.2* 16.6	2.76/3.0* 16.6
SIZE (mm: H x W x D)	41.3 x 146 x 190	41.3 x 146 x 190	12.7 x 128.6 x 129	41.3 x 146 x 190	41.3 x 146 x 190
FIRST CUSTOMER SHIPMENT	1Q97	3Q97	7/97	1Q97	5/97
COMMENTS	Can read CD-RW media.	Can read CD-RW media.	For Notebook computers.	*CD-ROM mode.	*CD-ROM mode. Dual laser pick up. **4600 CAV for CD-ROM.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HOPAX INDUSTRIES	HOPAX INDUSTRIES
CD FORMAT DRIVE	GF-1000	GF-1050	GF-1055	HO-820	HO-824
DISK/TREND GROUP	21	21	21	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Phase Change	Phase Change	Phase Change	Replication	Replication
DRIVE: Drive type	DVD-RAM	DVD-RAM	DVD-RAM	CD-ROM	CD-ROM
Relative speed	1X/2X*/8X**	1X/2X*/8X**	1X/2X*/8X**	8X-20X	8X-24X
Rotational speed (RPM)	1536-582	1536-582	1536-582	4240-4000	4240-4800
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	2600/ F: 4700/8800	2600/ F: 4700/8800	2600/ F: 4700/8800	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1, 2	1, 2	1, 2	1	1
Track density (TPI)				15875	15875
Maximum linear density (BPI)				27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000	1000	1000	256	256
Average positioning time (msec)				130	110
Average access time (msec)	200/120**	200/120**	200/120**	140	120
Data transfer rate (MBytes/sec)					
Internal	1.38/2.76*	1.38/2.76*	1.38/2.76*	1.2-3.0	1.2-3.6
External	16.6 PIO Mode 4	5.0/10.0 synch.	5.0/10.0 synch.		
SIZE (mm: H x W x D)	41.3 x 146 x 208	41.3 x 146 x 208	65 x 212 x 275	41.5 x 146 x 208	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	1997	1997	1997	1997	1997
COMMENTS	*DVD-ROM mode. **CD-ROM mode. Dual laser pickup.	*DVD-ROM mode. **CD-ROM mode. Dual laser pickup.	*DVD-ROM mode. **CD-ROM mode. External mount. Dual laser pickup.	Purchased mechanisms.	Purchased mechanisms.

MANUFACTURER	IMES	IMES	IMES	JVC	JVC
CD FORMAT DRIVE	ICD-1200AT ICD-8X	ICD-3600AT	ICD-P300	XR-S202	XR-S230
DISK/TREND GROUP	20	20	20	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Recording technology	Replication	Replication	Replication	Organic Dye	Organic Dye
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-R	CD-R
Relative speed	8X	10X-24X	2X	2X WR/4X RD	2X WR/6X RD
Rotational speed (RPM)	4240-1600	5000	1060-400	1060-400	3180-400
Interface	IDE/ATAPI	IDE/ATAPI	Printer Port	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Top	Tray	Tray
Speed control	CLV	CAV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	F: 540 Mode 1	F: 580/680	F: 580/680
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	32	1000	1000
Average positioning time (msec)	160	85	450	335	
Average access time (msec)		100	500	390	300
Data transfer rate (MBytes/sec)					
Internal	1.2	1.5-3.6	.307	.307/.614	.307/.900
External	11.1 PIO Mode 3	16.7 PIO Mode 4			10.0 synch.
SIZE (mm: H x W x D)		41.3 x 146 x 190	41 x 146 x 210	71 x 265 x 294	67 x 220 x 265
FIRST CUSTOMER SHIPMENT		3Q97		3/96	3Q97
COMMENTS				External mount.	External mount.

MANUFACTURER	JVC	JVC	JVC	LG ELECTRONICS	LG ELECTRONICS
CD FORMAT DRIVE	XR-W2010	XR-W2020	XR-W2022	CRD-8160B	CRD-8161B
DISK/TREND GROUP	21	21	21	20	20
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Organic Dye	Organic Dye	Organic Dye	Replication	Replication
DRIVE: Drive type	CD-R	CD-R	CD-R	CD-ROM	CD-ROM
Relative speed	2X WR/4X RD	2X WR/6X RD	2X WR/6X RD	16X	16X
Rotational speed (RPM)	1060-400	3180-400	3180-400	4240-1600	4240-1600
Interface	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Slot
Speed control	CLV	CLV	CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 580/680	F: 580/680	F: 580/680	690 Mode 2 F: 540 Mode 1	690 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000	1000	1000	128	128
Average positioning time (msec)	335			100	100
Average access time (msec)	390	300	300		
Data transfer rate (MBytes/sec) Internal External	.307/.614	.307/.900 10.0 synch.	.307/.900 10.0 synch.	2.4	2.4
SIZE (mm: H x W x D)	43 x 149 x 215	43 x 149 x 208	43 x 149 x 208	41.5 x 146 x 201	41.5 x 146 x 201
FIRST CUSTOMER SHIPMENT	1/96	1Q97	1Q97	4Q96	3/97
COMMENTS	Variable packet writing.	Variable packet writing.	Variable packet writing.		

MANUFACTURER	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS
CD FORMAT DRIVE	CRD-8240B	CRD-8241B	CRN-8080B	CRN-8081B	CRN-8240B
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	24X	24X	8X	8X	24X
Rotational speed (RPM)	4240-1600	4240-1600	4240-1600	4240-1600	4240-1600
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Slot	Tray	Tray	Tray
Speed control	CAV	CAV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	690 Mode 2 F: 540 Mode 1	690 Mode 2 F: 540 Mode 1	690 Mode 2 F: 540 Mode 1	690 Mode 2 F: 540 Mode 1	690 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128		128
Average positioning time (msec)	90	90	180	180	
Average access time (msec)			192	192	150
Data transfer rate (MBytes/sec) Internal External	3.5	3.5	1.2	1.2	3.5
SIZE (mm: H x W x D)	41.5 x 146 x 201	41.5 x 146 x 201	12.7 x 129 x 130	12.7 x 129 x 130	12.7 x 128 x 129
FIRST CUSTOMER SHIPMENT	6/97	6/97	4Q96	4Q96	9/97
COMMENTS			Panasonic connector type.	TEAC connector type.	

MANUFACTURER	LG ELECTRONICS	LION OPTICS	LION OPTICS	LION OPTICS	LITE-ON TECHNOLOGY
CD FORMAT DRIVE	DRD-810B	XC-800EI	XC-800SI	XE-800EE	LTN-242
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	DVD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X/8X*	8X	8X	8X	12X-24X
Rotational speed (RPM)		4240-1600	4240-1600	4240-1600	
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 4700/8500	650 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1, 2	1	1	1	1
Track density (TPI)	34324	15875	15875	15875	15875
Maximum linear density (BPI)	96000	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	256	256	256	128
Average positioning time (msec)		175	175	175	
Average access time (msec)	200/100*	189	189	189	100
Data transfer rate (MBytes/sec)					
Internal	1.35/1.2*	1.200	1.200	1.200	1.8-3.6
External	11.1 PIO Mode 3	11.1 PIO	11.1 PIO	11.1 PIO	
SIZE (mm: H x W x D)	41.5 x 146 x 206	41.5 x 146 x 208	41.5 x 146 x 208	60 x 160 x 290	
FIRST CUSTOMER SHIPMENT	5/97	1Q96	1996	1996	5/97
COMMENTS	*CD-ROM mode.				

MANUFACTURER	LITE-ON TECHNOLOGY	LITE-ON TECHNOLOGY	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LTN-262	LTN-264	CR-172	CR-505	CR-506
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	12X-20X	20X	8X	8X
Rotational speed (RPM)	5300-2000		4240	3180-1200	4240-1600
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV (PCAV)	CAV/CLV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	748 Mode 2 F: 656 Mode 1	F: 682 Mode 2	F: 682 Mode 2
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	128	128	128	256
Average positioning time (msec)	120			175	150
Average access time (msec)		100	150	193	164
Data transfer rate (MBytes/sec) Internal External	1.35-2.4	1.8-3.0	3.0 max.	.914	1.2
SIZE (mm: H x W x D)	42 x 146 x 191		12.7 x 146 x 190	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1Q97	4/97	2Q97	2Q96	2Q96
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	CR-508	CR-582	CR-583	CR-585	KXL-783A
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	24X	6X	8X	10.3X-24X	8X
Rotational speed (RPM)		3180-1200	4240-1600	4800	4240-1600
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2, PCMCIA
Disk insertion	Tray	Tray	Tray	Tray	Top
Speed control	CAV	CLV	CLV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 656	F: 682 Mode 2	F: 656	748 Mode 2 F: 656 Mode 1	F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27900	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	128	128	128	128
Average positioning time (msec)	85	175	150	85	
Average access time (msec)		193	164		180
Data transfer rate (MBytes/sec)					
Internal	1.54-3.6	.914	1.2	1.54-3.6	1.2
External	10.0	13.3 PIO Mode 3	13.3 PIO Mode 3	13.3 PIO Mode 3	7.0 asynch.
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 190	41.3 x 146 x 193	41.3 x 146 x 195	35 x 138 x 204
FIRST CUSTOMER SHIPMENT	2Q97	2Q96	2Q96	2Q97	4Q96
COMMENTS					Portable unit, includes speakers.

MANUFACTURER		MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE		KXL-800A-N KXL-803A-N	KXL-D740 KXL-D745	LK-MC606BP LK-MC606BQ	LK-MC608BP	LK-MC608S
DISK/TREND GROUP		20	20	20	20	20
MARKET		PCM	PCM	PCM	PCM	PCM
MEDIA:	Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE:	Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
	Relative speed	11X	4X	24X	8X	8X
	Rotational speed (RPM)	4240-2200	2120-800		4240-200	4240-200
	Interface	SCSI-2, PCMCIA	SCSI-2, PCMCIA	SCSI-2	SCSI-2	SCSI-2
	Disk insertion	Top	Top	Tray	Tray	Tray
	Speed control	CAV/CLV	CLV	CAV/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY						
	Nominal capacity (MBytes)	F: 650	F: 540	682 Mode 2 F: 540 Mode 1	F: 682	F: 682
	Data surfaces per spindle	1	1	1	1	1
	Track density (TPI)	15875	15875	15875	15875	15875
	Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE						
	Buffer/cache size (KBytes)	128	128		256	256
	Average positioning time (msec)			85	136	136
	Average access time (msec)	160	295		150	150
	Data transfer rate (MBytes/sec) Internal External	1.2-1.65	0.6 7.0 asynch.	3.6	1.2 10.0 synch.	1.2 10.0 synch.
SIZE (mm: H x W x D)		35 x 138 x 204	35 x 138 x 204	41.3 x 146 x 203	41.3 x 146 x 203	57 x 158 x 314
FIRST CUSTOMER SHIPMENT		1/97	1/96	2Q97	3Q96	3Q96
COMMENTS		KXL-803 includes speakers. Portable drives Sold in Japan.	KXL-D745 includes sound card support.			External mount.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LK-MC686B LK-MC86BP	LK-MC688BP	LK-RV8581AT	SR-8581B	SR-8582B
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	PCM	PCM	OEM	OEM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM	DVD-ROM
Relative speed	24X	8X	1X/6X*	1X/6X*	2X/24X*
Rotational speed (RPM)		4240-200			
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	CLV	CAV*/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	682 Mode 2 F: 540 Mode 1	F: 682	F: 8500 F: 4700	8500 F: 4700	8500 F: 4700
Data surfaces per spindle	1	1	1, 2	1, 2	1, 2
Track density (TPI)	15875	15875	34324	34324	34324
Maximum linear density (BPI)	27600	27600	96000	96000	96000
PERFORMANCE					
Buffer/cache size (KBytes)		128	128	128	512
Average positioning time (msec)	85	136			
Average access time (msec)		150	270/180*	270/180*	170/100*
Data transfer rate (MBytes/sec) Internal External	3.6	1.2 13.3 PIO Mode 3	1.35	1.38/.9*	2.76/3.6*
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 190	41.3 x 146 x 209	41.3 x 146 X 209	41.3 x 146 X 209
FIRST CUSTOMER SHIPMENT	2Q97	3Q96	1Q97		3Q97
COMMENTS			For DOSV PC. *CD-ROM mode. MPEG2 kit.	*CD-ROM Mode.	*CD-ROM mode. CD-R & DVD-RAM compatible. Preliminary specification.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	UJDCD8710	UJDCD8730	CW-7501	CW-7502B	LF-1000AB
DISK/TREND GROUP	20	20	21	21	21
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Dye Polymer	Dye Polymer	Ph.Chg.,Replic.
DRIVE: Drive type	CD-ROM	CD-ROM	CD-R	CD-R	Rewrit.,Rd.Only
Relative speed	10X	10X	2X WR/4X RD	4X WR/8X RD	--/4X*
Rotational speed (RPM)	2600-3300	2600-3300	2120-400	4240-800	2026/2120-800*
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CLV	CLV	ZCAV/CLV*
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 540	F: 540	F: 682	F: 682	668 PD F: 540 CD-ROM
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	21166/15875*
Maximum linear density (BPI)	27600	27600	27600	27600	29195/27600*
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	1000/256	1000	256
Average positioning time (msec)			222		165/195*
Average access time (msec)	190	190	272/250		179.8/222*
Data transfer rate (MBytes/sec) Internal External	1.5	1.5	.3 WR/.6 RD	1.2/.6	.518-1.14/.6* 5.0 synch.
SIZE (mm: H x W x D)	12.7 x 128 x 132	12.7 x 128 x 130	41.3 x 146 x 203	41.3 x 146 x 203	58 x 158 x 318
FIRST CUSTOMER SHIPMENT	10/96	9/96	1Q96	2Q97	1Q95
COMMENTS	Pin connector.	Pin connector.		Preliminary specification.	*For CD-ROM mode. For Macintosh. External mount.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LF-1001JAN	LF-1001JB	LF-1001JDN	LF-1004AB LF-1004ABK LF-1004JD* LF-1094 PD Drive	LF-1005JD
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.
DRIVE: Drive type	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only
Relative speed	6X*	6X*	6X*	--/4X**	6X*
Rotational speed (RPM)	2026/3180-1200*	2026/3180-1200*	2026/3180-1200*	2026/2120-800**	2026/3180-1200*
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Disk insertion		Tray		Tray	
Speed control	ZCAV/CLV*	ZCAV/CLV*	ZCAV/CLV*	ZCAV/CLV**	ZCAV/CLV*
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	21166/15875*	21166/15875*	21166/15875*	21166/15875**	21166/15875*
Maximum linear density (BPI)	29195/27600*	29195/27600*	29195/27600*	29195/27600**	29195/27600*
PERFORMANCE					
Buffer/cache size (KBytes)	256	256	256	256	256
Average positioning time (msec)	109/130*	109/130*	109/130*	165/195**	109/130*
Average access time (msec)	131.5/148*	131.5/148*	131.5/148*	179.8/222**	131.5/148*
Data transfer rate (MBytes/sec) Internal External	.518-1.41 (PC) .900*	.518-1.41 (PC) .900*	.518-1.41 (PC) .900*	.518-1.14/.6* 5.0 synch.	.518-1.41 (PC) .900*
SIZE (mm: H x W x D)				41.3 x 146.1 x 196	
FIRST CUSTOMER SHIPMENT	3Q96	3Q96	3Q96	1Q95	3Q96
COMMENTS	*For CD-ROM mode. For Macintosh.	*For CD-ROM mode. External mount.	*For CD-ROM mode. For DOS V and PC9800.	**For CD-ROM mode. *For Macintosh. -ABK includes controller.	*For CD-ROM mode. For DOS V PC.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LF-1095 LF-1095GZS	LF-1195 LF-1195GZS	LF-1196	LF-1500J LF-1500JDN	LK-MW602B LK-MW602BP LK-RW602
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
MEDIA: Recording technology	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Dye Polymer
DRIVE: Drive type	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only	CD-R
Relative speed	--/6X*	--/6X*	--/8X*	--/8X*	2X WR/4X RD
Rotational speed (RPM)	2026/3180-1200*	2026/3180-1200*	2026/4240-800*	2026/4240-1600*	2120-200
Interface	SCSI-2	ATAPI	IDE/ATAPI	SCSI-2, PCMCIA	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	ZCAV/CLV**	ZCAV/CLV*	ZCAV/CLV*	ZCAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	F: 650	682 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	21166/15875**	21166/15875*	21166/15875*	21166/15875*	15875
Maximum linear density (BPI)	29195/27600**	29195/27600*	29195/27600*	29195/27600*	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	256	512	512	1000/256
Average positioning time (msec)	109	109	88	88	222
Average access time (msec)	123.8	123.8	102.8	1028	270/250
Data transfer rate (MBytes/sec) Internal External	.518-1.14/.9* 5.0 synch.	.518-1.41/.9* 5.0 synch.	.518-1.41/1.2* 5.0 synch.	.518-1.141/1.2* 5.0	.300/.600 5.0
SIZE (mm: H x W x D)	41.3 x 146.1 x 196	41.3 x 146.1 x 196	41.3 x 146.1 x 196	35 x 143 x 218	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1996	6/96	3Q97	1997	1995
COMMENTS	**For CD-ROM mode.	*For CD-ROM mode.	*For CD-ROM mode.	*For CD-ROM mode. -JDN has PCMCIA interface.	--RW602 sold only in Japan.

MANUFACTURER	MITSUBISHI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
CD FORMAT DRIVE	MDV-D10	CRMC-FX120	CRMC-FX140	CRMC-FX240	CRMC-FX800
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	DVD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X/8X*	12X	16X	12X-24X	8X
Rotational speed (RPM)	1600-570	6360-2400	6360-3200	6360-4800	4240-1600
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CAV/CLV	CAV/CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 4700/8500	F: 540	F: 540 Mode 1	F: 540 Mode 1	650 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1, 2	1	1	1	1
Track density (TPI)	34000	15875	15875	15875	15875
Maximum linear density (BPI)	96000	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	256	256	256	256
Average positioning time (msec)		130	120	90	150
Average access time (msec)	160/140*	139			163
Data transfer rate (MBytes/sec) Internal External	1.38/1.2* 11.3 PIO Mode 3	1.8	1.8-2.4 16.6 PIO Mode 4	1.8-3.6 16.6 PIO Mode 4	1.229
SIZE (mm: H x W x D)	41.3 x 146 x 208	42 x 148 x 202	41.3 x 146 x 201	41.3 x 146 x 201	41.3 x 146 x 200
FIRST CUSTOMER SHIPMENT	3Q96	3Q96		4/97	4/96
COMMENTS	*CD-ROM. Dual laser pickup.			Can read CD-RW media.	

MANUFACTURER	MITSUMI ELECTRIC	MOUNTAIN OPTECH	MOUNTAIN OPTECH	NEC	NEC
CD FORMAT DRIVE	CR-2600TE	CS-680	SE-680 SI-680 ST-680	ODX-653P	ODX-654P
DISK/TREND GROUP	21	20	20	21	21
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Phase Change	Phase Change
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	Rewrit.,Rd.Only	Rewrit.,Rd.Only
Relative speed	2X WR/6X RD	8X	5X	--/6X*	--/6X*
Rotational speed (RPM)	3180-400	2120-800	2120-800	2026/3180-1200*	2026/3180-1200*
Interface	IDE/ATAPI	SCSI	SCSI	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	ZCAV/CLV*	ZCAV/CLV*
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	650 Mode 2 F: 580 Mode 1	640 Mode 2 F: 540 Mode 1	640 Mode 2 F: 540 Mode 1	664 PD F: 650 CD-ROM	664 PD F: 650 CD-ROM
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	21116/15875*	21116/15875*
Maximum linear density (BPI)	27600	27600	27600	29195/27600*	29195/27600*
PERFORMANCE					
Buffer/cache size (KBytes)	1000	256	256	256	256
Average positioning time (msec)	220 RD			125/160*	125/160*
Average access time (msec)	238				
Data transfer rate (MBytes/sec) Internal External	.9 RD/.3 WR	1.2	.75	.518-1.14/.9*	.518-1.14/.9*
SIZE (mm: H x W x D)	41.3 x 146 x 205			41.3 x 146 x 196	41.3 x 146 x 196
FIRST CUSTOMER SHIPMENT	4Q96	4Q95	4Q95	3Q96	3Q96
COMMENTS			Ruggedized CD-ROM.	*CD-ROM mode.	*CD-ROM mode.

MANUFACTURER		NEC	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS
CD FORMAT DRIVE		ODX-656	CDR-1400	CDR-1410	CDR-1600 MultiSpin MPSS 16XI	CDR-1610 MultiSpin MPSS 16XS
DISK/TREND GROUP		21	20	20	20	20
MARKET		OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA:	Recording technology	Phase Change	Replication	Replication	Replication	Replication
DRIVE:	Drive type	Rewrit.,Rd.Only	CD-ROM	CD-ROM	CD-ROM	CD-ROM
	Relative speed	--/8X*	8X	8X	12X-16X	12X-16X
	Rotational speed (RPM)	2027/4240-1600*	4240-1840	4240-1840		
	Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	SCSI-2
	Disk insertion	Tray	Tray	Tray	Tray	Tray
	Speed control	ZCAV/CLV*	CLV	CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY						
	Nominal capacity (MBytes)	664 PD F: 650 CD-ROM	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1	F: 540 Mode 1	F: 540 Mode 1
	Data surfaces per spindle	1	1	1	1	1
	Track density (TPI)	21116/15875*	15875	15875	15875	15875
	Maximum linear density (BPI)	29195/27600*	27600	27600	27600	27600
PERFORMANCE						
	Buffer/cache size (KBytes)	256	128	128	128	256
	Average positioning time (msec)	110/120*	125	125	100	100
	Average access time (msec)	150/150*	140	140		
	Data transfer rate (MBytes/sec) Internal External	.518-1.14/1.2* 5.1/3.4*	1.2	1.2	1.8-2.4	1.8-2.4
SIZE (mm: H x W x D)		41.3 x 146 x 203	42.8 x 149 x 208	42.8 x 149 x 208	42.8 x 149 x 210	42.8 x 149 x 210
FIRST CUSTOMER SHIPMENT		1Q97	2Q96	2Q96		
COMMENTS		*CD-ROM mode.				

MANUFACTURER	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	OCEAN OFFICE AUTOMATION	OCEAN OFFICE AUTOMATION
CD FORMAT DRIVE	CDR-1700	CDR-1800	CDR-1810	CDR 820	CDR 824
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM	OEM	PCM	PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X-20X	12X-24X	12X-24X	20X	24X
Rotational speed (RPM)	6240	6360-3600	6360-3600	4560	5472
Interface	IDE/ATAPI	IDE/ATAPI	Ultra SCSI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1	F: 680	F: 680
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	256	256	256
Average positioning time (msec)	--	--	--	100	90
Average access time (msec)	97	95	95	120	110
Data transfer rate (MBytes/sec) Internal External	1.2-3.0	1.8-3.6	1.8-3.6	3.0	3.6
SIZE (mm: H x W x D)	42.8 x 149 x 208	42.8 x 149 x 208	42.8 x 149 x 208	41.5 x 146 x 178	41.5 x 146 x 178
FIRST CUSTOMER SHIPMENT	3Q97	3Q97	3Q97	7/97	3Q97
COMMENTS					

MANUFACTURER	OLYMPUS	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE
CD FORMAT DRIVE	CD-R2X6	8622 EIDE Maverick 12X	8622 SCSI Maverick 12X	8623	8831 IDE Maverick 16X
DISK/TREND GROUP	21	20	20	20	20
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X WR/6X RD	12X	12X	12X	16X
Rotational speed (RPM)	3600-460	6360-2400	6360-2400	6360-2400/4380*	4240-3200
Interface	SCSI-2	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Caddy	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 650	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
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	256	256*	256	256
Average positioning time (msec)	200	140	150	110/80*	112
Average access time (msec)	215	150	160	120/87*	
Data transfer rate (MBytes/sec)					
Internal	.9/.3	1.8	1.8	1.8/1.2-2.4*	1.2-2.4
External	10.0 synch.		10.0 synch.		
SIZE (mm: H x W x D)	41.3 x 146 x 203	41 x 146 x 210	41 x 146 x 195	41 x 146 x 195	41 x 146 x 191.5
FIRST CUSTOMER SHIPMENT	2Q97	2Q96	3Q96	4Q96	
COMMENTS	External mount option.	Purchased mechanism.	*1 MB option. Purchased mechanism.	*In CAV mode. Purchased mechanism.	Purchased mechanism.

MANUFACTURER	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE	PHILIPS	PHILIPS
CD FORMAT DRIVE	8841	Stingray 8422	Stingray 8522	PCA 16SC	CDD 2600
DISK/TREND GROUP	20	20	20	20	21
MARKET	OEM, PCM	OEM, PCM	OEM	PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-R
Relative speed	16X max.	8X	10X	12X/16X	2X WR/6X RD
Rotational speed (RPM)		4240-1600	5300-2000		3180-1200
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CLV	CLV	CAV/CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal 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: 540 Mode 1	630 Mode 2 F: 550 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	256	256	256	1000
Average positioning time (msec)		196	188		290
Average access time (msec)	150	210	200	110	345 WR/310 RD
Data transfer rate (MBytes/sec) Internal External	2.4	1.200	1.500	1.8-2.4 5.0	.307 WR/.921 RD
SIZE (mm: H x W x D)	42.2 x 148.5 x 195	41.3 x 146 x 210	41 x 146 x 210	41.5 x 146 x 198	41.5 x 146 x 206
FIRST CUSTOMER SHIPMENT		3Q95	1Q96	2Q97	4Q96
COMMENTS	Purchased mechanism.	Purchased mechanism.	Purchased mechanism.	External mount option.	Incremental packet writing.

MANUFACTURER	PHILIPS	PHILIPS	PINNACLE MICRO	PINNACLE MICRO	PIONEER
CD FORMAT DRIVE	CDD 3600	CDD 3610 OMNIwriter	4X4	RCDW 226	DR-411 DR-A10X
DISK/TREND GROUP	21	21	21	21	20
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	OEM
MEDIA: Recording technology	Phase Change	Phase Change	Dye Polymer	Dye Polymer	Replication
DRIVE: Drive type	CD-RW	CD-RW	CD-R	CD-R	CD-ROM
Relative speed	2X WR/6X RD	2X WR/6X RD	4X WR/4X RD	2X WR/6X RD	10X
Rotational speed (RPM)	3180-400	3180-400	2120-800	3180-400	5300-2000
Interface	SCSI-2	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1	681 Mode 2 F: 580 Mode 1	681 Mode 2 F: 580 Mode 1	635 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000	1000	1000	1000	128
Average positioning time (msec)	290	290	220	220	65/140*
Average access time (msec)	345 WR/310 RD	345 WR/310 RD	247	225	80/150*
Data transfer rate (MBytes/sec) Internal External	.307 WR/.921 RD 5.0 synch.	.307 WR/.921 RD	.600/.600 8.5 synch.	.300/.900 5.0 synch.	.66-1.55
SIZE (mm: H x W x D)	41.5 x 146 x 206	41.5 x 146 x 206	41.3 x 146 x 211	41.3 x 146 x 211	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q97	2Q97	1996	1996	4Q96
COMMENTS	Incremental packet writing.	Incremental packet writing. OMNIwriter is external mode.	Purchased mechanism. External mount option.	Purchased mechanism. External mount option.	*CLV mode. DR-411 is bulk pack model.

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	DR-433 DR-U10X	DR-444 DR-A12X	DR-466 DR-U12X	DR-511	DR-A24X
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	10X	12X	12X	24X	24X
Rotational speed (RPM)	5300-2000				
Interface	SCSI-2	IDE/ATAPI	SCSI-2		IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CAV/CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	685 Mode 2 F: 540 Mode 1	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	635 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128	128	128
Average positioning time (msec)	65/140*	80	80		70
Average access time (msec)	80/150*	100	100		90
Data transfer rate (MBytes/sec) Internal External	.66-1.55	1.8	1.8	1.2-3.6	3.6
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 202.5	41.3 x 146 x 202.5	41.3 x 146 x 202	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q96	1Q97	1Q97	5/97	3Q97
COMMENTS	*CLV mode. DR-433 is bulk pack model.	Preliminary specification.	Preliminary specification.	Can read CD-RW media.	

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	DR-D504X	DR-S104X DR-U104X	DR-U24X	DRD-134X	DRM-1804X
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X	4X	24X	4.4X	4X
Rotational speed (RPM)	2120-800	2120-800		2332-880	2120-200
Interface		SCSI-2	SCSI	SCSI-2	SCSI
Disk insertion		Tray	Tray		
Speed control	CLV	CLV	CAV/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 550	F: 540	635 Mode 2 F: 540 Mode 1	F: 540	F: 540
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000		128	1000	256
Average positioning time (msec)	280	190	70	110	300
Average access time (msec)	307	245	90	128.7	328
Data transfer rate (MBytes/sec) Internal External	.614	.614	3.6	.66	.614
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 202	41.3 x 146 x 203	41.3 x 146 x 203	198 x 262 x 422
FIRST CUSTOMER SHIPMENT	1Q95	3Q94	3Q97		1994
COMMENTS	For use with CD library.	DR-S104X is external model.		For use with CD library.	Integral with 18 disk changer

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	DRM-624X	DVD-A01	DVD-U01	PCP-PR1W PCP-PR2M	DR-R504X
DISK/TREND GROUP	20	20	20	20	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Drive type	CD-ROM	DVD-ROM	DVD-ROM	CD-ROM	CD-R
Relative speed	24X	1X/10X*	1X/10X*	10X	4X
Rotational speed (RPM)	2332-880	1530-570	1530-570	5300-2000	2120-800
Interface	SCSI-2	IDE/ATAPI	SCSI-2	SCSI/EIDE	
Disk insertion	Tray	Tray	Tray	Tray	
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 540	8500 F: 4700	8500 F: 4700	F: 540 Mode 1	F: 550
Data surfaces per spindle	1	1, 2	1, 2	1	1
Track density (TPI)	15875	34424	34424	15875	15875
Maximum linear density (BPI)	27600	96000	96000	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	512/128*	512/128*		1000
Average positioning time (msec)	70	150/120*	150/120*	90	110
Average access time (msec)	90	200/150*	200/150*		137
Data transfer rate (MBytes/sec) Internal External	1.8-3.0	1.38/1.50*	1.35/1.5*	1.5	.614
SIZE (mm: H x W x D)	88.3 x 210 x 370	41.3 x 146 x 203	41.3 x 156 x 203		41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	3Q97				1Q95
COMMENTS		*CD-ROM Mode.	*CD-ROM mode.	Portable drive.	For use with CD library.

MANUFACTURER	PIONEER	PIONEER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT DRIVE	DVD-R	DW-S114X	PX 12CSe	PX 12CSi	PX 12TSe
DISK/TREND GROUP	21	21	20	20	20
MARKET	OEM, PCM	OEM	PCM	OEM, PCM	PCM
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Replication	Replication	Replication
DRIVE: Drive type	DVD-R	CD-R	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X	4X	12X	12X	12X
Rotational speed (RPM)		2120-800	6360-2400	6360-2400	
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Caddy	Caddy	Tray
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 3950	F: 550	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)		15875	15875	15875	15875
Maximum linear density (BPI)		27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)		1000	512	512	512
Average positioning time (msec)		603	95	95	105
Average access time (msec)		630	105	105	125
Data transfer rate (MBytes/sec) Internal External	1	.614	1.8 10.0 synch.	1.8 10.0 synch.	1.8 10.0 synch.
SIZE (mm: H x W x D)	115 x 210 x 399	41.3 x 146 x 203	56.9 x 147 x 202	41.5 x 147 x 201.9	56.9 x 177.8 x 305.6
FIRST CUSTOMER SHIPMENT	3Q97	3Q95	4Q96	4Q96	4Q96
COMMENTS	Preliminary specification.		External mount.		External mount.

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT DRIVE	PX 12TSi	PX 20TSe	PX 20TSi	PX 63CS 6PleX	PX 65CS 6PleX
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	12X-20X	12X-20X	6X	6X
Rotational speed (RPM)		6360-4000	6360-4000	3180-1200	3180-1200
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Caddy	Caddy
Speed control	CLV	CAV/CLV	CAV/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal 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
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	512	512	256	256
Average positioning time (msec)	95			127	127
Average access time (msec)	105	95	95	145	145
Data transfer rate (MBytes/sec)					
Internal	1.8	3.0	3.0	.922	.922
External	10.0 synch.	10.0 synch.	10.0 synch.	5.0 synch.	5.0 synch.
SIZE (mm: H x W x D)	41.7 x 147 x 202	56.9 x 177.8 x 305.6	41.7 x 147 x 202	41.3 x 146.1 x 202	56.9 x 177.8 x 305.6
FIRST CUSTOMER SHIPMENT	4Q96	4/97	4/97	2Q95	6/95
COMMENTS		External mount.			External mount.

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	RICOH	RICOH	RICOH
CD FORMAT DRIVE	PX R24CSe	PX R24CSi	MP6200A	MP6200S	MP6211S
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Dye,Phase Chng.	Dye,Phase Chng.	Dye,Phase Chng.
DRIVE: Drive type	CD-R	CD-R	CD-RW	CD-RW	CD-RW
Relative speed	2X WR/4X RD	2X WR/4X RD	2X WR/6X RD	2X WR/6X RD	2X WR/6X RD
Rotational speed (RPM)	2120-400	2120-400	3180-400	3180-400	3180-400
Interface	SCSI-2	SCSI-2	ATAPI	SCSI-2	SCSI-2
Disk insertion	Caddy	Caddy	Tray	Tray/Caddy	Caddy
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	512	2000	2000	2000
Average positioning time (msec)	390	390	350 RD	350 RD	350 RD
Average access time (msec)	445 WR/418 RD	445 WR/418 RD	368	368	368
Data transfer rate (MBytes/sec) Internal External	.3 WR/.6 RD 5.0 synch.	.3 WR/.6 RD 5.0 synch.	.3 WR/.9 RD 5.0 synch.	.3 WR/.9 RD 5.0 synch.	.3 WR/.9 RD 5.0 synch.
SIZE (mm: H x W x D)	41.7 x 147 x 202	56.9 x 177.8 x 305.6	41.3 x 101.6 x 203	41.3 x 101.6 x 203	41.3 x 101.6 x 203
FIRST CUSTOMER SHIPMENT	2Q96	2Q96	3/97	3/97	3/97
COMMENTS			Packet writing.	Packet writing.	Packet writing. External version. Position: horizontally or vertically.

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
CD FORMAT DRIVE	SCR-1231	SCR-1638	SCR-2030	SCR-2037	SCR-831
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	8X-16X	8X-20X	20X	8X
Rotational speed (RPM)	6360-2400	NA	NA	NA	4240-1600
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CAV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 680	F: 680	F: 680	F: 680	F: 680
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	128	256	128	256
Average positioning time (msec)					
Average access time (msec)	150	150	90	150	150
Data transfer rate (MBytes/sec) Internal External	1.8	1.2-2.4	1.2-3.0	3.0	1.2
SIZE (mm: H x W x D)	42 x 149 x 200	12.7 x 128 x 129	41.3 x 149 x 202	12.7 x 128 x 129	42 x 149 x 200
FIRST CUSTOMER SHIPMENT					
COMMENTS			Can read CD-RW media.		

MANUFACTURER	SAMSUNG ELECTRONICS	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC
CD FORMAT DRIVE	SDR-130	CRD-168P	CRD-820P	CRD-S78P	CRD-S98P
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	DVD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X/8X*	8X	20X	8X	8X
Rotational speed (RPM)		4240-1600		4240-1600	4240-1600
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 4700/8500	F: 640	F: 640	F: 640	F: 640
Data surfaces per spindle	1, 2	1	1	1	1
Track density (TPI)	34324	15875	15875	15875	15875
Maximum linear density (BPI)	96000	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512		128	128	128
Average positioning time (msec)		150	80	290	300
Average access time (msec)	200/150*	164		304	314
Data transfer rate (MBytes/sec) Internal External	1.35/1.2*	1.2	1.2-3.0	1.2	1.2
SIZE (mm: H x W x D)	41.5 x 146 x 199	41.3 x 146 x 203	41 x 146 x 190	17 x 131 x 140	12.7 x 129 x 139
FIRST CUSTOMER SHIPMENT		3Q96	1997		
COMMENTS	*CD-ROM. CD-R compatible				

MANUFACTURER	SANYO ELECTRIC	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	CRD-R24S CRD-RS2000	CDU415	CDU511	CDU571	CDU611
DISK/TREND GROUP	21	20	20	20	20
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X WR/4X RD	8X-12X	8X-16X	8X-16X	10X-24X
Rotational speed (RPM)	2120-800	4100-2400	4266-3621	4266-3621	5200
Interface	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Slot	Tray
Speed control	CLV	CAV/CLV	CAV/CLV	CAV/CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 640	F: 656 Mode 1	F: 656 Mode 1	F: 540 Mode 1	F: 656 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)		256	128	128	128
Average positioning time (msec)	300				
Average access time (msec)	327	130	105	103	90
Data transfer rate (MBytes/sec) Internal External	.600	1.16-1.8 10.0 synch.	1.29-2.4 16.7 PIO Mode 4	1.29-2.4 16.7 PIO Mode 4	3.6-1.5
SIZE (mm: H x W x D)	41.3 x 146 x 188.5	41.4 x 146 x 203	41.4 x 146 x 203	41.4 x 146 x 203	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT		4Q96	4Q96	4Q96	2Q97
COMMENTS	RS2000 is external mount.		13.6X average speed.		

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	CSD-880E	DD-2001 Data Discman	DD-55 Data Discman	DD-66 Data Discman	DD-75 Data Discman
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	PCM	PCM	PCM	PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	1X	1X	1X	1X
Rotational speed (RPM)	4240-1600	500-300	500-300	500-300	500-300
Interface	IDE/ATAPI				
Disk insertion	Tray				
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 540 Mode 1	F: 184	F: 184	F: 184	F: 184
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256				
Average positioning time (msec)	160	NS	NS	NS	NS
Average access time (msec)	174	NS	NS	NS	NS
Data transfer rate (MBytes/sec) Internal External	1.2	NS	NS	NS	NS
SIZE (mm: H x W x D)	41.3 x 146 x 203	39 x 160 x 110	34 x 160 x 110	34 x 160 x 110	39 x 160 x 110
FIRST CUSTOMER SHIPMENT	7/96	1996	1994	1995	1996
COMMENTS					

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	DDU-100E	PRD-250WN	PRD-650MC PRD-650WN CD-ROM Discman	SCPH1000 Playstation	CDU526R
DISK/TREND GROUP	20	20	20	20	21
MARKET	OEM, PCM	PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Drive type	DVD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-R
Relative speed	1X/8X*	4X	6X	--	2X WR/6X RD
Rotational speed (RPM)		2120-800	3180-1200	NS	
Interface	IDE/ATAPI	PCMCIA	PCMCIA	Proprietary	
Disk insertion	Tray				
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 4700/8500	F: 540	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	F: 650
Data surfaces per spindle	1, 2	1	1	1	1
Track density (TPI)		15875	15875	15875	15875
Maximum linear density (BPI)		27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	128	128		
Average positioning time (msec)		250	280/128*	NS	
Average access time (msec)		277		NS	
Data transfer rate (MBytes/sec) Internal External	1.35/1.2* 16.7 PIO Mode 4	.600	.6/.9*	.300	.9/.3
SIZE (mm: H x W x D)	41.4 x 146 x 203	27 x 132 x 172		60 x 270 x 188	
FIRST CUSTOMER SHIPMENT	1Q97	1996	4Q96	4Q94	3/97
COMMENTS	*CD-ROM mode. Dual laser pickup.		Portable. *With PC adapter.		CD-RFS file system.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	CDU924S	CDU926S	CDU928E	CSP-9611S Spressa 9611	Spressa 940 Spressa 9411
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer
DRIVE: Drive type	CD-R	CD-R	CD-R	CD-R	CD-R
Relative speed	2X WR/4X RD	2X WR/4X RD	2X WR/8X RD	2X WR/6X RD	2X WR/4X RD
Rotational speed (RPM)	1160-400 WR	3180-400	4240-400	3180-400	2120-400
Interface	SCSI-2		IDE/ATAPI	SCSI-2	SCSI-2
Disk insertion			Caddy	Caddy	
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	F: 540 Mode 1	F: 540 Mode 1	650 Mode 2 F: 553 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000		512	512	1000
Average positioning time (msec)	223 RD/245 WR		250		--/230
Average access time (msec)	250 RD/300 WR				--/257
Data transfer rate (MBytes/sec) Internal External	.600 4.0 synch.	.3 WR/.9 RD	.3 WR/1.2 RD 16.6 PIO Mode 4	.3 WR/.9 RD 10.0 synch.	.307/.614
SIZE (mm: H x W x D)	41.4 x 146 x 203		41.4 x 146 x 203	70 x 210 x 293	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q96	1Q97	2Q97		6/96
COMMENTS			Packet writing.	Packet writing. External mount.	9411 is external model.

MANUFACTURER	TAE IL MEDIA	TAE IL MEDIA	TAKAYA	TAKAYA	TATUNG
CD FORMAT DRIVE	CDD-7120	CDD-7200	CD-1016	CD-812	CD-1620E
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	20X	16X	12X	12X-20X
Rotational speed (RPM)			5400-3900	6360-2400	6360-4000
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CAV/CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 540 Mode 1	F: 540 Mode 1	F: 540 Mode 1	F: 540 Mode 1	742 Mode 2 F: 650 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128	128	128, 256
Average positioning time (msec)	110	110	130	150	100
Average access time (msec)	125	120			115
Data transfer rate (MBytes/sec) Internal External	2.4	3.0	16.6 PIO Mode 4	16.6 PIO Mode 4	3.0
SIZE (mm: H x W x D)	42 x 146 x 205	42 x 146 x 205	43 x 149 x 196	43 x 149 x 196	41.5 x 146 x 203
FIRST CUSTOMER SHIPMENT	1/97	2Q97	7/97	12/96	1997
COMMENTS					Matsushita mechanism.

MANUFACTURER	TATUNG	TEAC	TEAC	TEAC	TEAC
CD FORMAT DRIVE	CD-1624E	CD-211E	CD-211PE	CD-220E	CD-316E
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X-24X	11X	10X	8X-20X	8X-16X
Rotational speed (RPM)	6360-4800	5860-2200	4240-2300	4240-4000	4240-3200
Interface	IDE/ATAPI	IDE/ATAPI	PC Card Type 2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Top	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	CAV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	742 Mode 2 F: 650 Mode 1	F: 540 Mode 1	F: 540 Mode 1	F: 540 Mode 1	650 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128, 256	128	128	128	128
Average positioning time (msec)	100	200			
Average access time (msec)	115	210	200	180	200
Data transfer rate (MBytes/sec) Internal External	3.6	1.65 16.6 PIO Mode 4	1.5 16.6 PIO Mode 4	1.2-3.0	1.2-2.4
SIZE (mm: H x W x D)	41.5 x 146 x 203	12.7 x 128 x 130	41.3 x 150.4 x 152.4	12.7 x 128 x 130	13.7 x 131 x 140.5
FIRST CUSTOMER SHIPMENT	1997	12/96	1997	6/97	3/97
COMMENTS	Matsushita mechanism.			For Notebook.	For Notebook.

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
CD FORMAT DRIVE	CD-38E	CD-48E	CD-512E	CD-516E	CD-516S
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	8X	12X	16X	16X
Rotational speed (RPM)	4240-1600	4240-1600	6360-2400	4200-3620	4200-3620
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	650 Mode 2 F: 535 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128		128	512
Average positioning time (msec)	190	135	160	150	150
Average access time (msec)		150			
Data transfer rate (MBytes/sec) Internal External	1.2	1.2	1.8 16.6 PIO Mode 4	2.4 16.6 PIO Mode 4	2.4 10.0 synch.
SIZE (mm: H x W x D)	13.7 x	17 x 130.5 x 140.5	41.3 x 146 x 192	41.3 x 146 x 197	41.3 x 146 x 197
FIRST CUSTOMER SHIPMENT	9/96	5/96	10/96	2/97	2/97
COMMENTS					

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TOSHIBA
CD FORMAT DRIVE	CD-524E	CD-R50S	CD-R55S	PD-518E	SD-M1001
DISK/TREND GROUP	20	21	21	21	20
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Dye Polymer	Dye Polymer	Phase Change	Replication
DRIVE: Drive type	CD-ROM	CD-R	CD-R	PD	DVD-ROM
Relative speed	12X-24X	4X WR/4X RD	4X WR/8X RD	8X*	1X/8X*
Rotational speed (RPM)	6360-4800	2400-800	4240-800	4240-1600*	1530-570
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	ZCAV/CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	F: 650	F: 4700/8750
Data surfaces per spindle	1	1	1	1	1, 2
Track density (TPI)	15875	15875	15875	21116/15875*	34324
Maximum linear density (BPI)	27600	27600	27600	29195/27600*	96000
PERFORMANCE					
Buffer/cache size (KBytes)	128	1000	1000	128	256
Average positioning time (msec)		193		110/115*	140/110*
Average access time (msec)	95	220	220		220/120*
Data transfer rate (MBytes/sec) Internal External	1.8-3.6	.600	.6 WR/1.2 RD	1.2	1.350/1.2* 10.0 synch.
SIZE (mm: H x W x D)	41.3 x 146 x 192	41.3 x 146 x 192	41.3 x 146 x 192		41.5 x 146 x 192.5
FIRST CUSTOMER SHIPMENT	6/97	7/96	3Q97	5/97	1Q97
COMMENTS	For Desktop.		Variable packet writing.	*CD-ROM mode.	*CD-ROM mode.

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
CD FORMAT DRIVE	SD-M1002	TXM-3801F1 XM-3801B	TXM-3801F1	TXM-5701 XM-5701B	TXM-5701F1
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	PCM	OEM, PCM	PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	DVD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X/8X*	15X	15X	12X	12X
Rotational speed (RPM)	1530-570	3000-5088	5088-8000	6360-2400	6360-2400
Interface	IDE/ATAPI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CAV/CLV (PCAV)	CAV/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 4700/8750	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1, 2	1	1	1	1
Track density (TPI)	34324	15875	15875	15875	15875
Maximum linear density (BPI)	96000	25400	25400	25400	25400
PERFORMANCE					
Buffer/cache size (KBytes)	256	256	256	256	256
Average positioning time (msec)	140/110*	90	90	115	115
Average access time (msec)	220/120*	100	99	125	125
Data transfer rate (MBytes/sec) Internal External	1.350/1.2* 11.1/13.3	2.1 10.0 synch.	2.25 10.0 synch.	1.843 10.0 synch.	1.8 10.0 synch.
SIZE (mm: H x W x D)	41.5 x 146 x 192.5	41.5 x 146 x 190	68.6 x 246.4 x 254	41.5 x 146 x 190	68.6 x 246.4 x 254
FIRST CUSTOMER SHIPMENT	1Q97	4Q96	2Q97	4Q96	2Q97
COMMENTS	*CD-ROM mode.	Reads CD-RW media. TXM-3801F1 is external mount.	External mount.		External mount.

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
CD FORMAT DRIVE	XM-1602B	XM-5701	XM-5702B	XM-6002B	XM-6102
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8.5X-20X	12X	12X	16X	24X
Rotational speed (RPM)	4505-2400	6360-2400	6360-2400	6360-3200	6360-3200
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	CAV/CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	25400	25400	25400	25400	25400
PERFORMANCE					
Buffer/cache size (KBytes)	128	256	256	256	256
Average positioning time (msec)	125	115	115	90	85
Average access time (msec)	135	125	125	100	90
Data transfer rate (MBytes/sec)					
Internal	1.28-3.0	1.843	1.843	2.4	3.6
External	11.1 PIO Mode 3	10.0 synch.	13.3 DMA Mode 1	13.3 PIO Mode 3	13.3 PIO Mode 3
SIZE (mm: H x W x D)	12.7 x 128 x 129	41.5 x 146 x 190	41.5 x 146 x 190	41.1 x 144.5 x 188.2	41.1 x 144.5 x 188.2
FIRST CUSTOMER SHIPMENT	2Q97	4Q96	4Q96	2Q97	2Q97
COMMENTS				Reads CD-RW media.	Reads CD-RW media.

MANUFACTURER	UNITRON	UNITRON	UNITRON	UNITRON	USDRIVES
CD FORMAT DRIVE	UCD08S	UCD20S	UCD24N	UCD24S	16DT
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	8X-20X	8X-24X	8X-24X	16X
Rotational speed (RPM)	4240-200	4240-4000	4240-4800	4240-4800	5000-3200
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 660 Mode 1	F: 660 Mode 1	635 Mode 2 F: 553 Mode 1	F: 660 Mode 1	650 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	256	128		128, 256 option
Average positioning time (msec)					
Average access time (msec)	170	130	170	130	150
Data transfer rate (MBytes/sec) Internal External	1.2	3.0	3.6	3.6	2.4
SIZE (mm: H x W x D)	41.5 x 146 x 210	41.5 x 146 x 210	12.7 x 130 x 140	41.5 x 146 x 210	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1996	1997	6/96	1997	1Q97
COMMENTS	Sony mechanism.	Purchased mechanism.	For Notebook computer.	Purchased mechanism.	Purchased mechanism.

MANUFACTURER	USDRIVES	USDRIVES	USDRIVES	WEARNES PERIPHERALS	WEARNES PERIPHERALS
CD FORMAT DRIVE	20DS	24DT	24ST	CDD-1220	CDD-1620
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	20X max.	24X max.	24X max.	12X	16X
Rotational speed (RPM)	5000-4000	5000-4800	5000-4800	6360-2400	4240-3600
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CAV/CLV	CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	F: 540 Mode 1	742 Mode 2 F: 650 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128, 256 option	128, 256 option	128, 256 option	128/256	128
Average positioning time (msec)				130	
Average access time (msec)	110	130	130	145	130
Data transfer rate (MBytes/sec) Internal External	3.0	3.6	3.6 10.0 synch.	1.8 11.1 PIO Mode 3	1.2-2.4 11.1 PIO Mode 3
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		42 x 149 x 210.5
FIRST CUSTOMER SHIPMENT	2Q97	3Q97	3Q97	1Q97	1997
COMMENTS	Purchased mechanism.	Purchased mechanism.	Purchased mechanism.		

MANUFACTURER	WEARNES PERIPHERALS	WEARNES PERIPHERALS	WEARNES PERIPHERALS	WEARNES PERIPHERALS	WEARNES PERIPHERALS
CD FORMAT DRIVE	CDD-1820	CDD-2420	CDD-620	CDD-820	CDR-622
DISK/TREND GROUP	20	20	20	20	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-R
Relative speed	18X	24X	6X	8X	2X WR/6X RD
Rotational speed (RPM)	4240-3600	4240-3600	3180-1200	4240-1600	3180-400
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	742 Mode 2 F: 650 Mode 1	742 Mode 2 F: 650 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	740 Mode 2 F: 550 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128/256	256	256	256	512
Average positioning time (msec)			185	185	
Average access time (msec)	130	130	203	199	
Data transfer rate (MBytes/sec)					
Internal	1.2-2.7	1.5-3.6	.900	1.2	.3 WR/.9 RD
External	11.1 PIO Mode 3	11.1 PIO Mode 3			
SIZE (mm: H x W x D)	42 x 149 x 210.5	42 x 149 x 210.5	42 x 149 x 210.5	42 x 149 x 210.5	42 x 149 210.5
FIRST CUSTOMER SHIPMENT	1997	1997	3Q95	1Q96	1Q97
COMMENTS					Packet writing.

MANUFACTURER	WEARNES PERIPHERALS	WEARNES PERIPHERALS	YAMAHA	YAMAHA	YAMAHA
CD FORMAT DRIVE	WPI CDR-230	WPI CDR-432	CDR-100	CDR200t CDR200t-VK	CDR200t2-VK
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer
DRIVE: Drive type	CD-R	CD-R	CD-R	CD-R	CD-R
Relative speed	2X WR/4X RD	2X WR/4X RD	4X	4X WR/6X RD	4X WR/6X RD
Rotational speed (RPM)	2160-400	2160-400	2120-800	3180-400	3180-400
Interface	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Caddy	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	740 Mode 2 F: 550 Mode 1	740 Mode 2 F: 550 Mode 1	661 Mode 2 F: 580 Mode 1	666 Mode 2 F: 540 Mode 1	666 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	29870	29870	29870
PERFORMANCE					
Buffer/cache size (KBytes)	1000	1000	512	1000	1000
Average positioning time (msec)	350	350	NS		
Average access time (msec)	405 WR/377 RD	405 WR/377 RD	500	250	250
Data transfer rate (MBytes/sec) Internal External	.300 WR/.600 RD	.300 WR/.600 RD	.614/.307/.153 2.0 asynch.	.3 WR/.6 RD 4.2	.3 WR/.6 RD 4.2
SIZE (mm: H x W x D)	42 x 149 x 210.5	42 x 149 x 210.5	41.3 x 146 x 203	41.3 x 146 x 203	68 x 170 x 327
FIRST CUSTOMER SHIPMENT	2Q96	3Q96	1Q94	2Q97	2Q97
COMMENTS				Packet writing.	Packet writing. External mount.

MANUFACTURER	YAMAHA	YAMAHA	YAMAHA	YAMAHA	YAMAHA
CD FORMAT DRIVE	CDR400c CDR400c-NB	CDR400t CDR400t-NB CDR400t-VK	CDR400t2 CDR400t2-VK	CDR401t CDR401t-NB CDR401t-VK	CRW4001t CDR4001t-NB
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer	Phase Change
DRIVE: Drive type	CD-R	CD-R	CD-R	CD-R	CD-RW
Relative speed	4X WR/6X RD	4X WR/6X RD	4X WR/6X RD	4X WR/6X RD	4XWR/2XRW/6XRD
Rotational speed (RPM)	3180-800	3180-800	3180-800	3180-800	3180-400
Interface	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Caddy	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	666 Mode 2 F: 540 Mode 1	666 Mode 2 F: 540 Mode 1	666 Mode 2 F: 540 Mode 1	666 Mode 2 F: 540 Mode 1	666 Mode 2 F: 540 Mode 1
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	29870	29870	29870	29870	29870
PERFORMANCE					
Buffer/cache size (KBytes)	2000	2000	2000	2000	2000
Average positioning time (msec)					
Average access time (msec)	250	250	250	250	230
Data transfer rate (MBytes/sec) Internal External	.6 WR/.9 RD 4.2 asynch.	.6 WR/.9 RD 4.2 asynch.	.6 WR/.9 RD 4.2 asynch.	.6 WR/.9 RD 5.5	.6/.3/.9 5.5
SIZE (mm: H x W x D)	41 x 146 x 203	41.3 x 146 x 203	68 x 170 x 327	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1Q97	1Q97	1Q97	2Q97	3Q97
COMMENTS	Packet writing.	Packet writing.	Packet writing. External mount.	Packet writing.	Packet writing.

MANUFACTURER	YUNG FU (LXYCON)	YUNG FU (LXYCON)	YUNG FU (LXYCON)	YUNG FU (LXYCON)	
CD FORMAT DRIVE	CDX-1200	CDX-1600	CDX-800E	CDX-880SC	
DISK/TREND GROUP	20	20	20	20	
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	
MEDIA: Recording technology	Replication	Replication	Replication	Replication	
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	
Relative speed	12X	12X-16X	8X	8X	
Rotational speed (RPM)	6360-2400	6360-3200	4240-1600	4240-1600	
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI,PC Cd	SCSI-2	
Disk insertion	Tray	Tray	Top	Tray	
Speed control	CLV	CLV	CLV	CLV	
CAPACITY/RECORDING DENSITY					
Nominal capacity (MBytes)	F: 635	F: 635	F: 635	F: 635	
Data surfaces per spindle	1	1	1	1	
Track density (TPI)	15875	15875	15875	15875	
Maximum linear density (BPI)	27600	27600	27600	27600	
PERFORMANCE					
Buffer/cache size (KBytes)	256	256	256	256	
Average positioning time (msec)			240		
Average access time (msec)	150	150	260	190	
Data transfer rate (MBytes/sec) Internal	1.8	2.4	1.2	1.2	
External				5.0	
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	38 x 135 x 190	41.3 x 146 x 203	
FIRST CUSTOMER SHIPMENT	1997	1997	1Q96	1996	
COMMENTS			Philips mechanism. Portable.		

READ/WRITE OPTICAL DISK DRIVE SPECIFICATIONS

1997 DISK/TREND REPORT

OPTICAL DISK DRIVE SPECIFICATIONS

Coverage: The following pages list optical disk drives (excluding CD format drives, which are covered in another section) 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.).

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. Where the drive is a magneto-optic type and supports multifunctionality using MO-WORM (CCW) media, "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 "F" for formatted. For optical drives that can access only one side of the media, drives are categorized in terms of one side capacity, 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.

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.

Average access time: The average access time is the sum of average positioning time plus rotational latency. Optical drive 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.

Spin-up/spin-down time: The time for the disk to accelerate to operating speed after insertion/time to decelerate to a stop so that the disk can be removed.

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.

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.

1997 DISK/TREND optical disk product groups

For the 1997 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.

Read/write optical disk drives:

Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

CD format disk towers:

Group 51: CD format disk towers

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 52: Optical disk libraries with 1 to 39 cartridge capacity.
Group 53: Optical disk libraries with 40 to 69 cartridge capacity.
Group 54: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER	ATG	ATG	ATG	ATG	ATG
DRIVE	GD 16000	GD 6000	GD 6001	GD 9001	GD 9001/S GD 9001S/E
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	300 mm	300 mm	300 mm	300 mm	300 mm
Recording technology	Ablative	Ablative	Ablative	Ablative	Ablative
DRIVE: Operating mode	Write Once	Write Once	Write Once	Write Once	Write Once
Interface	SCSI-2	SCSI	SCSI	SCSI, SCSI-2	SCSI, SCSI-2
Speed control & zones	ZCAV	CAV	CAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 16000 F: 16000	F: 3200	F: 3200	F: 4500	F: 5100
Capacity per track (Bytes)	N/A	F: 52428	F: 52428	N/A	N/A
Data surfaces per spindle	2	1	1	1	1
Tracks per surface	86667	62500	62500	82000	82000
Track density (TPI)	28200	25400	25400	25400	25400
Maximum linear density (BPI)		28200	28200	25400	25400
Rotational speed (RPM)	1042	1143	1143	914	914
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear Motor	Linear Motor	Linear Motor	Linear Motor
Servo type	Sampled	Sampled	Sampled	Sampled	Sampled
Average positioning time (msec)	90	90	90	90	90
Average rotational delay (msec)	29	26.2	26.2	33	33
Average access time (msec)	119	116.2	116.2	123	123
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	3.3	1.0	1.0	1.0	1.0
Buffer/cache size (Kbytes)					
SIZE (mm: H x W x D)	178 x 430 x 580	174 x 440 x 530	174 x 440 x 530	177 x 482 x 532.5	177 x 482 x 532.5
FIRST CUSTOMER SHIPMENT	3Q96	3Q89	4Q90	1991	2Q92
COMMENTS	Read compatibility for GD 6001.		Differs from GD 6000 in the cartridge (single operation loading).	Can read GD 6000 disks.	Can read GD 6000 disks and read/write GD 9001.

MANUFACTURER	EASTMAN KODAK	EASTMAN KODAK	FUJITSU	FUJITSU	FUJITSU
DRIVE	ODW25	System 2000	2512A MOcity	DynaMO 640 PC	DynaMO 640Si
DISK/TREND GROUP	23	23	22	22	22
MARKET	Captive,OEM,PCM	Captive, OEM	PCM	PCM	OEM
MEDIA: Disk diameter	356 mm	356 mm	86 mm	86 mm	86 mm
Recording technology	Phase Change	Phase Change	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Write Once	Write Once	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	MCAV-S	MCAV-S	CAV/ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 25000	F: 7412	F: 128/230	F: 640/540	F: 638/534
Capacity per disk (Mbytes)	F: 25000	F: 14824	F: 128/230	F: 640/540	F: 638/534
Capacity per track (Bytes)	N/A	N/A	F: 12800/N/A	F: 34815	F: 34815
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	104910	104824	10000/17940	18480/42042	18316
Track density (TPI)	25400	25399	15875/18273	23090	23000
Maximum linear density (BPI)	39597	25200	24400/29296	52900	53000
Rotational speed (RPM)	1488-636	1362-654	3600	3600	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear	Voice Coil
Servo type	Sampled	Sampled	Continuous	Continuous	Continuous
Average positioning time (msec)	170	137	30	35	35
Average rotational delay (msec)	33	33	8.3	8.3	8.3
Average access time (msec)	170	170	38.3	43.3	43.3
Spin-up/Spin-down times (sec)	2.3/1.2	2.4/1.4		7/4	7/4
Data transfer rate (MBytes/sec)					
Internal	1.8	1.0	1.3-2.1	2.3-3.9	2.3-3.9
External	5.0/10.0/20.0	5.0/10.0/20.0	5.0 synch.	10.0 synch.	10.0 synch.
Buffer/cache size (Kbytes)	8000, 16000	128	256	2000	2000
SIZE (mm: H x W x D)	241 x 445 x 678	800 x 455 x 714*	25.4 x 101.6 x 146	55 x 170 x 225	25.4 x 101.6 x 160
FIRST CUSTOMER SHIPMENT	2Q97	3Q94	1995	4Q96	6/97
COMMENTS		*Includes controller.	Sold in Europe.	External mount. Direct overwrite.	Direct overwrite.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2512A DynaMO 230	M2513A Cat-4	M2541B DynaMO 230 Portable	M2541BD MicroCat-3	M2541BF Pismo
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, 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	IDE	Power Book
Speed control & zones	CAV/ZCAV	ZCAV	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	 F: 128/230 F: 128/230	 F: 640/540 F: 640/540	 F: 128/230 F: 128/230	 F: 128/230 F: 128/230	 F: 128/230 F: 128/230
Capacity per track (Bytes)	F: 12800/N/A	F: 34816	F: 12800/N/A	F: 12800/N/A	F: 12800/N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	18480/42042	10000/17940	10000/17940	10000/17940
Track density (TPI)	15875/18275	23090	15875/18275	15875/18275	15875/18275
Maximum linear density (BPI)	24400/29300	52900	24400/29300	24400/29300*	24400/29300*
Rotational speed (RPM)	3600	3600	2700	2700	2700
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	70	70	65
Average rotational delay (msec)	8.3	8.3	11	11.1	11.1
Average access time (msec)	38.3	38.3	81	81.1	76.1
Spin-up/Spin-down times (sec)		7/4	7/6	7/6	7/6
Data transfer rate (MBytes/sec) Internal External	 1.3-2.1 5.0 synch.	 2.3-3.9 5.0/10.0 synch.	 .975-1.575 6.0/8.0	 1.0-1.6 6.0/8.0	 1.0-1.6
Buffer/cache size (Kbytes)	256	2000/512	128	128	128
SIZE (mm: H x W x D)	25.4 x 101.6 x 146	25.4 x 101.6 x 146	17 x 101.6 x 140	17.2 x 101.6 x 140	17.2 x 101.6 x 140
FIRST CUSTOMER SHIPMENT	3/94	4/96	10/95	1996	1996
COMMENTS	DynaMO is external subsystem.	Direct overwrite.	DynaMO is external subsystem. Direct overwrite.	*2,7 RLL Code.	*2,7 RLL code.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	HEWLETT-PACKARD	HITACHI
DRIVE	M2541BS PCMCIA	M2541S MicroMO	ZEBO	C1113F C1114F 2600fx	OD172 OU172
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	PCM	OEM, PCM	Captive,OEM,PCM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Multifunct-(MO)	Multifunct-(MO)
Interface	PCMCIA	PCMCIA	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	CAV	CAV/ZCAV	ZCAV	MCAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	 F: 128/230 F: 128/230	 F: 128/230 F: 128/230	 F: 640/540 F: 640/540	 F: 1300 F: 2600	 F:322/1012/1303 F:644/2024/2607
Capacity per track (Bytes)	F: 12800/N/A	F: 12800/N/A	F: 34816	N/A	Varies by zone
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	10000/17940	18480/42042	75732*	74883 (logical)
Track density (TPI)	15875/18275	15875/18273	23090		23000
Maximum linear density (BPI)	24400/29300*	24400/29296*	52900		50000*
Rotational speed (RPM)	2700	2700	3600	3000/3600**	3000
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	70	65	35	25	39
Average rotational delay (msec)	11.1	11	8.3	10	10
Average access time (msec)	81.1	76	43.3	35	49
Spin-up/Spin-down times (sec)	7/6	7/6	7/4	5.5/3.0	7.5/4.5
Data transfer rate (MBytes/sec) Internal External	1.0-1.6	1.0-1.6 8.0	3.9 10.0 synch.	3.4	2.3-4.6 10.0 synch.
Buffer/cache size (Kbytes)	128	128(512 option)	2000	1000	1000
SIZE (mm: H x W x D)	25.3 x 113.5 x 164.8	25.3 x 113.5 x 164.8	116 x 60 x 200		41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1996	1Q96	1997	2/96	3Q96
COMMENTS	*2,7 RLL Code.	*2,7 RLL Code. Battery pack available.	External mount. Direct overwrite. Sold in Japan.	2600fx is external mount. *Logical tracks **With lower capacity media. 1,7 RLL Code.	*1,7 RLL Code. LIM Direct Overwrite. OU is external mount.

MANUFACTURER	HITACHI	HITACHI	KUBOTA	MAXOPTIX	MAXOPTIX
DRIVE	OL-F172	OL-F172S/D-21	T4000	T4-1300	T4-2600
DISK/TREND GROUP	22	22	22	22	22
MARKET	Captive,OEM,PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Multifunct-(MO)	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	ZCAV	ZCAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F:322/1012/1303 F:644/2024/2607	F: 1304 F: 2607	F: 1300 F: 2600	F: 652/512/322 F:1304/1024/654	F: 1304/652/322 F:2607/1304/644
Capacity per track (Bytes)	Varies by zone	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	74883 (logical)	74883 (logical)	26010	37600/25000	26010*
Track density (TPI)	23000	23000	22100	18273/16933	22100
Maximum linear density (BPI)	50000*	50000*	51000	29540*	51000
Rotational speed (RPM)	3000	3000	3000	3000	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)	39	39	39	39	39
Average rotational delay (msec)	10	10	10	10	10
Average access time (msec)	49	49	49	49	49
Spin-up/Spin-down times (sec)	7.5/4.5: 5/2.5	5.0/2.5	7.6/4.5	7.6/4.5	7.6/4.5
Data transfer rate (MBytes/sec) Internal External	2.3-4.6 10.0 synch.	2.3-4.6 10.0 synch.	1.15-4.65 10.0 synch.	2.0 4.0 synch.	3.37 10.0 synch.
Buffer/cache size (Kbytes)	1000	1000	1000	1024	1024
SIZE (mm: H x W x D)	82.8 x 146 x 203	82.8 x 146 x 203	84 x 247 x 265	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1Q96	1997	1996	1/95	4Q95
COMMENTS	*1,7 RLL Code. LIM Direct Overwrite.	*1,7 RLL Code. Direct Overwrite.	Sold in Japan. External mount.	*2,7 RLL Code.	*75735 logical tracks.

MANUFACTURER	MAXOPTIX	MOST	MOUNTAIN OPTECH	MOUNTAIN OPTECH	MOUNTAIN OPTECH
DRIVE	T5-2600	Jupiter 2 RMD 626	CS-250 R/W SE-250 R/W SI-250 R/W ST-250 R/W	CS-2600 SE-2600 SEL-2600 ST-2600	CS-2600X2 ST-2600X2
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	86 mm	130 mm	130 mm
Recording technology	Magneto-Optic	MO (LIM-DOW)	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	SCSI, SCSI-2	SCSI	SCSI	SCSI
Speed control & zones	CAV	CAV/ZCAV	ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 1304/652/322 F:2607/1304/644	F: 325/650/1300 F:650/1300/2600	F: 230	F: 325/650/1300 F:650/1300/2600	F: 325/650/1300 F:650/1300/2600
Capacity per track (Bytes)	N/A	N/A	F: 12800	F:	F:
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	26010*	26086	11510/17853*	74883 (logical)	74883 (logical)
Track density (TPI)	22100	22087	18273	23000	23000
Maximum linear density (BPI)	51000	50160	29540	50000	50000
Rotational speed (RPM)	3868	3600	3600	3375-4800	3375-4800
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)	20	24	40	39	39
Average rotational delay (msec)	7.7	8.3	8.3	10	10
Average access time (msec)	27.7	32.3	48.3	49	49
Spin-up/Spin-down times (sec)	4.5/2.5	3.7/2.5		7.5/4.5	7.5/4.5
Data transfer rate (MBytes/sec) Internal	4.6	4.055	1.475 max.		
External	10.0 synch.	5.0 synch.		5.0 synch.	5.0 synch.
Buffer/cache size (Kbytes)	1024	1000/4000	64	1024	1024
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203.2	44.5 x 117.5 x 206.4	41.9 x 146.1 x 203.2	
FIRST CUSTOMER SHIPMENT	2Q97	6/96	1Q95	1996	1996
COMMENTS	*75735 logical tracks.	Direct over-write (LIM-DOW) compatible. Updatable microcode. Diff. SCSI opt.	Ruggedized. *Logical tracks CS-250 is commercial version.	Rack mount and external mount options.	2 drives in enclosure.

MANUFACTURER	NEC	NEC	NEC	NIKON	NIKON
DRIVE	N1137-57 N7915-85 ODD-155 PC-0D502	ODD-160	N6513-23 N7913	DD53-B1 DD53-S1	DD121-1AJ DD121-1AS
DISK/TREND GROUP	22	22	23	22	23
MARKET	Captive	OEM	Captive	OEM, PCM	OEM
MEDIA: Disk diameter	130 mm	130 mm	300 mm	130 mm	300 mm
Recording technology	Magneto-Optic	Magneto-Optic	Ablative	Magneto-Optic*	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Write Once	Rewritable	Rewritable
Interface	SCSI	SCSI-2	Prop., SCSI	SCSI-2	SCSI-2
Speed control & zones	ZCAV	ZCAV	MCAV	ZCAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 650/325 F: 1300/650	F: 1300 F: 2600	F: 2500 F: 2500	F: 325/650/1300 F:650/1300/2600	F: 4000*
Capacity per track (Bytes)	N/A	N/A	F: NS	F:15872/17408**	F:102442/108222
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	2600	49000	23050/75375	41881/41196
Track density (TPI)	18273	21200	16940	23000	15875
Maximum linear density (BPI)	29540	51000	25000	50000	30600
Rotational speed (RPM)	4200/3000	3000	600	3600	1000
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)	32	35	150	24	73
Average rotational delay (msec)	10/7	10	50	8.3	30
Average access time (msec)	42/39	45	200	32.3	103
Spin-up/Spin-down times (sec)		2.5		3.5/2.9	
Data transfer rate (MBytes/sec) Internal External	1.94	1.69-3.38	.900	2.0/4.0 10.0	1.77/2.01
Buffer/cache size (Kbytes)	1000	4000		4000	256
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	42 x 148 x 295.2		41.3 x 146 x 208.3	400 x 630 x 170
FIRST CUSTOMER SHIPMENT	3Q93	1Q96	6/90	1Q97	1Q94
COMMENTS	*37600 logical tracks. ODD-155 is external package.	Direct overwrite, 2 beam head.		*LIM-DOW. **Logical tracks.	*Sector size 512B/1024B. AJ model is for optical library

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
DRIVE	230MO Plus* 230MO Turbo	640MO Turbo	MOS330E MOS330S MOS331E* MOS331S*	MOS332S 230MO Turbo Black PowerMO 230 III	MOS341E
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	PCM	OEM	PCM	OEM
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	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	CAV	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 230/128	F: 540/640	F: 230/128	F: 230/128	F: 540/640
Capacity per track (Bytes)	F: 12800	F: 34816	F: 12800	F: 12800	F: 34816
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11500	18480	11500**	11500*	18480
Track density (TPI)	18273	23090	18273	18273	23090
Maximum linear density (BPI)	29300	52900	29300	29300	52900
Rotational speed (RPM)	4200	3600	4200	4200	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)	28	28	27	27	28
Average rotational delay (msec)	7.1	8.3	7.1	7.1	8.3
Average access time (msec)	35.1	36.3	34.1	34.1	36.3
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	1.075-1.72/.896	1.8-3.0 5.5 synch.	1.075-1.72/.896 5.0 synch.	1.075-1.72/.896 2.4	1.8-3.0 5.5 synch.
Buffer/cache size (Kbytes)	1000*	2000	256, 1000*	256	2000
SIZE (mm: H x W x D)		35 x 123 x 218	25.4 x 101.6 x 153.5	40 x 133 x 202	25.4 x 101.6 x 153.5
FIRST CUSTOMER SHIPMENT	10/94	1997	2Q96	2Q97	2Q96
COMMENTS	*Includes cache	Direct overwrite.	*1 MB optional. **37600 logical tracks.	*37600 logical tracks. Not sold in U.S.	Direct overwrite.

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
DRIVE	MOS520E MOS520S	MOS525E	MOS540E	PowerMO 2600	SYS.230
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM	OEM, PCM	PCM	PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2,Prt.Port
Speed control & zones	CAV/ZCAV	ZCAV	CAV/ZCAV	CAV/ZCAV**	CAV/ZCAV**
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 650/325	F: 595/650*	F: 327/654/1300 F:654/1308/2600	F: 325/680/1300 F:650/1300/2600	F: 128/230 F: 128/230
Capacity per track (Bytes)	F: 17408	F: 17408	F: 17836	F: 17836**	F:10000/12800**
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18750*	21600**	26040*	26040*	11500*
Track density (TPI)	18273/15875	18273	22030	22030	18273
Maximum linear density (BPI)	31005/27597	29540	31500	31500	29300
Rotational speed (RPM)	3000/4500	3500	3600	3600	4200
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)	56/54	29	26	26	27
Average rotational delay (msec)	10/6.67	8.57	8.3	8.3	7.1
Average access time (msec)	66/60.67	37.57	34.3	34.3	34.1
Spin-up/Spin-down times (sec)			2.5/2.2	2.5/2.2	
Data transfer rate (MBytes/sec) Internal External	1.2-2.3/1.0	1.750	1.78-4.06 5.0 synch.	1/2.4/4.1 5.0 synch.	2.4
Buffer/cache size (Kbytes)	1000**	1000***	4000	4000	256
SIZE (mm: H x W x D)	82.6 x 146.1 x 205	41.3 x 146.1 x 205	41.3 x 146 x 203	119.4 x 173 x 274.3	50.4 x 152.4 x 203.2
FIRST CUSTOMER SHIPMENT	11/93	5/94	1Q96		
COMMENTS	*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.	*73080 logical tracks.	*73030 logical tracks. **At highest capacity. External mount.	*37600 logical tracks. **At highest capacity. External mount.

MANUFACTURER	PHILIPS LMS	PINNACLE MICRO	PINNACLE MICRO	PINNACLE MICRO	PIONEER
DRIVE	LD 6100	Vertex	Apex	Apex (A/V)	DE-SH2200 DE-UH2200
DISK/TREND GROUP	23	22	23	23	22
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	300 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Ablative	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Write Once	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2/HPAC	SCSI-2/HPAC	SCSI
Speed control & zones	CAV	ZCAV	ZCAV	CLV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 12000	F: 1020/1315 F: 2040/2630	F: 1304/2286** F: 1607/4571**	F: 2697 F: 5394	F: 1100 F: 2200
Capacity per track (Bytes)	F: NS	F:	F: 38912/88064	F: 45600/103300	F:
Data surfaces per spindle	2	1	1	1	1
Tracks per surface	63000		36300 (user)	36300 (user)	
Track density (TPI)	NS	22087	25400	25400	
Maximum linear density (BPI)	NS		63342*	63342*	
Rotational speed (RPM)	858	3755	3755/2400**	3755-5000	3000
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Sampled	Continuous	Continuous	Continuous	Sampled
Average positioning time (msec)	65	19	19/21**	17	42
Average rotational delay (msec)	35	8	8/12.5**	7	10
Average access time (msec)	100	27	27/33.5**	24	52
Spin-up/Spin-down times (sec)	3/1.5	3/2	3/2	3/2	
Data transfer rate (MBytes/sec) Internal External	2.7 RD/1.3 WR 10.0 synch.	4.3 10.0 synch.	4.3/3.5** 10.0 synch.	3.8-5.121	5.3 1.4-2.6
Buffer/cache size (Kbytes)	2000	1000	1000	1000	
SIZE (mm: H x W x D)	178 x 475 x 683	74 x 213 x 270	41 x 146 x 210.3	41.3 x 146 x 211.3	41.3 x 147 x 203
FIRST CUSTOMER SHIPMENT	2Q95	6/96	4Q96	--	1Q95
COMMENTS	Dual head drive	1,7 RLL Code.	*1,7 RLL Code. Direct overwrite. **At highest capacity.	*1,7 RLL Code. Direct overwrite. Prelim. spec.	DE-SH2200 is external mount.

MANUFACTURER	PIONEER	PIONEER	RICOH	SHARP	SHARP
DRIVE	DE-SH7101 DE-UH7101	DE-SH9101 DE-UH9101	RO-5060E RS-5060E	JY-800 JY-8000***	MD-PS1
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM, PCM	Captive, OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	64 mm
Recording technology	MO/Dye Polymer	MO/Dye Polymer	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunction	Multifunction	Multifunct-(MO)	Multifunct-(MO)	Rewritable
Interface	SCSI	SCSI	SCSI-2	SCSI, SCSI-2	Parallel Port
Speed control & zones	CAV	CAV	CAV/ZCAV	CAV/ZCAV	CLV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 327 F: 654	F: 850/327 F: 1700/654	F: 326.2/652.3	F: 595/652*	F: 140
Capacity per track (Bytes)	F: 16384	F: 26624/48128*	F: 17408	F: 17408	F: NA
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	19958		18751/21600*	21600**	10000
Track density (TPI)	15875		15900/18273	18273	15875
Maximum linear density (BPI)	15875		24900/29540	29540	39827
Rotational speed (RPM)	2400	2700	4500/3000	3000	940-422
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	
Servo type	Sampled	Sampled	Continuous	Continuous	Continuous
Average positioning time (msec)	53	43	29	39	
Average rotational delay (msec)	12.5	11.1	6.7/10	10	
Average access time (msec)	65.5	54.1	35.4/39	49	300
Spin-up/Spin-down times (sec)				5.5/4	
Data transfer rate (MBytes/sec) Internal External	.635 2.4	1.2-2.2 5.3	5.0 synch. 3.3 asynch.	2.0 max. 5.0 synch.	.150
Buffer/cache size (Kbytes)	64	1000	512	1000	128
SIZE (mm: H x W x D)	41.3 x 146 x 203.2	42 x 147 x 210	82.6 x 146.1 x 203.2	41.3 x 146 x 203	41.3 x 101.6 x 123
FIRST CUSTOMER SHIPMENT	2Q93	2Q96	1Q94	1Q94	3/97
COMMENTS	DE-SH7101 is external mount.	DE-SH9101 is external mount. *16384 for 654 MB media.	*37600 logical tracks.	*512/1024 bytes per sector. **37600 logical tracks. ***External mnt Write cache.	Used with video camera.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	CMO-N540-10 CMO-R540-10	HS-1	HS-D650	MDH-10	RMO-S330
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	PCM	OEM	PCM	PCM
MEDIA: Disk diameter	130 mm	86 mm	86 mm	64 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Rewritable	Rewritable	Rd.Only,Rewrit.	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	ZCAV	ZCAV	ZCAV	CLV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 650/1300 F: 1300/2600	F: 650 F: 650	F: 650 F: 650	F: 140 F: 140	F: 128 F: 128
Capacity per track (Bytes)	F: N/A	N/A	N/A	NA	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	26010	17665	17665	10000	10000
Track density (TPI)	22100	21200	21200	15875	15875
Maximum linear density (BPI)	51000	60500	60500	39827	24420
Rotational speed (RPM)	3600	2400	2400	940-422	1800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, DC Motor	Linear, Voice Coil
Servo type	Continuous	Sampled	Sampled	Continuous	Continuous
Average positioning time (msec)	25	33	33	455	120
Average rotational delay (msec)	8.3	12.5	12.5	45	16.6
Average access time (msec)	33.3	45.5	45.5	500	136.6
Spin-up/Spin-down times (sec)	2.5/2.2	8/5*	8/5*		
Data transfer rate (MBytes/sec) Internal External	2.0-4.0 5.0 synch.	1.0-2.0 10.0	1.0-2.0 5.0	.150 2.5 asynch.	.375 4.0 synch.
Buffer/cache size (Kbytes)	1000	512	512		128
SIZE (mm: H x W x D)	70 x 211 x 293	177 x 60 x 250	24.5 x 101.6 x 149	30 x 80 x 131	52.4 x 160 x 240
FIRST CUSTOMER SHIPMENT	4Q96	2/96	11/95	3Q94	7/94
COMMENTS	R series is Sony brand.	External subsystem of HS-D650. *Loading/eject time included.	*Loading/eject time included.		External mount.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	RMO-S580	RMO-S591 RMO-S594	SMO-531/81 SMO-F531	SMO-F541 SMO-F544	SMO-F541DW SMO-F544DW
DISK/TREND GROUP	22	22	22	22	22
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Rewritable	Multifunct-(MO)	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	CAV/ZCAV	ZCAV	CAV/ZCAV	ZCAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 650 F: 1300	F: 1300 F: 2600	F: 650 F: 1300	F: 1300 F: 2600	F: 650/1300 F: 1300/2600
Capacity per track (Bytes)	F: 17408	N/A	F: 17408	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21600*	26010*	21600*	26010*	26010*
Track density (TPI)	18273	22100	18273	22100	22100
Maximum linear density (BPI)	29540	51000	29540	51000	51000
Rotational speed (RPM)	3600	3600	3600	3600	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)	39	25	39	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	47.3	33.3	47.3	33.3	33.3
Spin-up/Spin-down times (sec)		2.5/2.2	2.5/2.2	2.5/2.2	2.5/2.2
Data transfer rate (MBytes/sec) Internal External	1.2-2.4 5.0 synch.	2.0-4.2 5.0 synch.	1.2-2.4 5.0 synch.	2.0-4.2 5.0 synch.	2.0-4.0 10.0 synch.
Buffer/cache size (Kbytes)	4000	1000, 4000	4000	1000, 4000	1000, 4000
SIZE (mm: H x W x D)	70 x 211 x 293	70 x 211 x 293	41.4 x 146 x 203.2	41.4 x 146 x 203	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	4/95	1Q96	3/95	1Q96	2Q97
COMMENTS	*37600 logical tracks. External mount.	*75735 logical tracks.	*37600 logical tracks. 531/81 used for optical library	*75735 logical tracks. F544 has 4 MB buffer.	Direct overwrite. *75735 logical tracks. F544 has 4 MB buffer.

MANUFACTURER	SONY				
DRIVE	CMO-N540-40 CMO-R540-40				
DISK/TREND GROUP	23				
MARKET	OEM, PCM				
MEDIA: Disk diameter	130 mm				
Recording technology	Magneto-Optic				
DRIVE: Operating mode	Multifunct-(MO)				
Interface	SCSI-2				
Speed control & zones	ZCAV				
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 650/1300				
Capacity per disk (Mbytes)	F: 1300/2600				
Capacity per track (Bytes)	F: N/A				
Data surfaces per spindle	1				
Tracks per surface	26010				
Track density (TPI)	22100				
Maximum linear density (BPI)	51000				
Rotational speed (RPM)	3600				
PERFORMANCE					
Positioner type	Linear, Voice Coil				
Servo type	Continuous				
Average positioning time (msec)	25				
Average rotational delay (msec)	8.3				
Average access time (msec)	33.3				
Spin-up/Spin-down times (sec)	2.5/2.2				
Data transfer rate (MBytes/sec)					
Internal	2.0-4.0				
External	5.0 synch.				
Buffer/cache size (Kbytes)	4000				
SIZE (mm: H x W x D)	70 x 211 x 293				
FIRST CUSTOMER SHIPMENT	4Q96				
COMMENTS	R series is Sony brand.				

CD FORMAT DISK TOWER SPECIFICATIONS

1997 DISK/TREND REPORT

CD FORMAT DISK TOWER SPECIFICATIONS

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

Drive type: Drives are indicated as CD-ROM, DVD-ROM, CD-R, CD-RW, DVD-R, or DVD-RAM, as appropriate.

Relative speed: The data transfer rate relative to the original CD-ROM drives, which operated at "1X" speed, expressed as 4X, 8X, etc. The fastest rate is given. Most drives operate at several rates, falling back to a lower speed when reading poorly replicated disks or otherwise limited. For CAV drives maximum relative speed is given.

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

E'net = Ethernet
TR = Token ring

Processor type: For network attached towers, the type of internal processor and standard RAM memory used, in megabytes. Example: 486: 4 MB

Tower HDD buffer: Where a rigid disk drive is used as a buffer, the capacity of the drive is given in gigabytes.

Other features: The presence of other features is noted as "Yes", "No", or "Option" as the case may be.

Data transfer rate: The data rate on the interface channel to the host or network. Throughput will be lower due to write verify or other delays and latencies. For drives, the internal data transfer rate is given. Most drives used in towers have SCSI or fast SCSI controller interfaces.

Average positioning time: The average time required to position the head over the proper track. Usually measured as an average of all possible seeks or approximated as 1/3 of the full seek stroke.

Average access time: The average time required for the requested data to be available under the drive pickup. Includes average access time plus average latency.

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.

1997 DISK/TREND optical disk product groups

For the 1997 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.

Read/write optical disk drives:

Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

CD format disk towers:

Group 51: CD format disk towers

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 52: Optical disk libraries with 1 to 39 cartridge capacity.
Group 53: Optical disk libraries with 40 to 69 cartridge capacity.
Group 54: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES
CD FORMAT TOWER	Compact Storage	MAX Tower	Standard Series	Compact Net Storage	Multi-Protocol CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Net	Net
Drive type	Minichanger	CD-ROM	CD-ROM	Minichanger	CD-ROM
Relative speed	16X	12X, 15X, 16X	12X, 15X, 16X	16X	12X, 15X, 16X
Tower host/net and software environment	SCSI host Various	SCSI host Various	SCSI host Various	Ethernet, TR NetWare, NT	Ethernet Various
Tower capacity (Gbytes) MIN	3	4.6	4.6	3	4.6
MAX	21	31.9	18.2	21	9.1
Minimum drives per tower	1	7	7	1	7
Maximum drives per tower	7	49	28	7	14
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2	Ethernet, TR	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--		--	--	32 bit RISC
Tower HDD buffer, if used (GB)	--		--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply		Option	Option	No	Option
Minichangers	Yes	No		Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	10.0	5.0	1.2/2.0/12.0	1.2/2.0/12.0
drive (MB/sec)	2.4	Drive dependent	Drive dependent	2.4	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 3000	F: 650	F: 650	F: 3000	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent		Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent		Drive dependent
Drive models	Nakamichi	Toshiba	Toshiba	Nakamichi	Toshiba
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	2Q96	2Q95	1Q95	2Q96	4Q96
COMMENTS		1 SCSI ID per 7 drives.			Axis server.

MANUFACTURER	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ALLION COMPUTER	ALLION COMPUTER	ATRONICS
CD FORMAT TOWER	Network Ready CD Tower	CD Server	CD-Serv/Mate CD-ROM Server	CD-Serv/Tower	IDEal CDServer
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X, 15X, 16X	12X, 15X, 16X	Drive dependent	Drive dependent	Various
Tower host/net and software environment	Ethernet NetWare, NT	Ethernet Various	Ethernet Various	Ethernet Various	Ethernet NetWare, other
Tower capacity (Gbytes) MIN	4.6	4.6	.65	.65	4.2
MAX	9.1	31.9	9.1	9.1	4.2
Minimum drives per tower	7	7	1	1	7
Maximum drives per tower	14	49	14	14	7
Tower interface to host/net	Ethernet, TR	Ethernet, TR	E'net 10BT,10B2	E'net 10BT,10B2	E'net 10BT,10B2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2, EIDE
Cache size (min, max: MB)	.256	.256			2, 16
Features:					
Processor type & memory (MB)	Intel	Pentium	--	--	--
Tower HDD buffer, if used (GB)	--	1	--	--	--
Hot swap drives	No	Yes	No	No	No
Redundant power supply	Option	Yes	No	No	No
Minichangers	Yes	No	No	No	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0/12.0	1.2/2.0/12.0	1.2	1.2	1.2
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Toshiba	Toshiba	Various	Various	Various
TOWER SIZE: Inches: H x W x D			2.55 x 8.27 x 6.5	17 x 6.9 x 15.7	17 x 8 x 25
POWER: (Watts or KVA)					230
FIRST CUSTOMER SHIPMENT	2Q95	2Q95	1997	1997	4Q96
COMMENTS	Microtest server.				Token Ring option.

MANUFACTURER	AXIS COMMUNICATIONS	AXIS COMMUNICATIONS	AXIS COMMUNICATIONS	AXONIX	BOFFIN
CD FORMAT TOWER	StorPoint CD/E Miniserver	StorPoint CD/TE Miniserver	StorPoint CD/T StorPoint CD/TR Miniserver	CD-Sharer ProLinQ	JB321
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Minichanger
Relative speed				Drive dependent	4X
Tower host/net and software environment	Ethernet Windows, OS/2, UNIX,NetW.,Web	Ethernet Windows, OS/2, UNIX,NetW.,Web	Token Ring Windows, OS/2, UNIX,NetW.,Web	Windows,OS/2,NT NetW., DOS, Web	PC compatible DOS, Windows, NT
Tower capacity (Gbytes) MIN	6.5	4.6	6.5	.65	4.55
MAX	4.6	9.2	4.6	9.1	13.7
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	7	14	7	14	3
Tower interface to host/net	E'net 10BT,10B2	E'net 10BT, AUI	TR STP, UTP	Ethernet, TR	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 32	2, 32	2, 32	.256	
Features:					
Processor type & memory (MB)	32 bit RISC	32 bit RISC	32 bit RISC	X86:8-128	--
Tower HDD buffer, if used (GB)	No	No	No	Option	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	Yes	Yes	Option	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2/2.0	2.0	1.2	10.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	.6
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 4550
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
Drive models	Various	Various	Various	Various	Nakamichi
TOWER SIZE: Inches: H x W x D	1.7 x 5.9 x 8.8	1.7 x 5.9 x 8.2	1.7 x 5.9 x 8.8		20 x 10 x 18
POWER: (Watts or KVA)	15 watts	19 watts	18 watts	.12 KVA	
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96	1996	
COMMENTS	Supports 56 disks in library with LUN addressing.	Supports up to 112 disks in library with LUN addressing. 1 or 2 SCSI channels.	Supports 56 disks in library with LUN addressing.	Custom configurations available.	Drives are 7 disk changers.

MANUFACTURER	BOFFIN	BOFFIN	BOFFIN	BOFFIN	BOFFIN
CD FORMAT TOWER	JB749	JB828	Tower 14	Tower 7	P1407 P2807
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Net
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X	8X	Drive dependent	Drive dependent	Drive dependent
Tower host/net and software environment	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT	Ethernet Novell, NT, VINES, other
Tower capacity (Gbytes) MIN	4.55	2.6	2.6	2.6	4.55
MAX	31.9	18.2	9.1	4.55	4.55
Minimum drives per tower	1	1	4	4	7
Maximum drives per tower	7	7	7	7	7
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	--	--			Pentium 100: 16
Tower HDD buffer, if used (GB)	--	--	--	Option	1
Hot swap drives	No	No	--	--	--
Redundant power supply	No	No			Option
Minichangers	Yes	Yes	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	10.0	5.0	5.0	1.2
drive (MB/sec)	.6	1.2	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 4550	F: 2600	F: 650	F: 650	F: 650
Average positioning time (msec)			Drive dependent	Drive dependent	Drive dependent
Average access time (msec)			Drive dependent	Drive dependent	Drive dependent
Drive models	Nakamichi	Nakamichi	Various	Various	Various
TOWER SIZE: Inches: H x W x D	31 x 10 x 18		17 x 7 x 21	17 x 7 x 21	
POWER: (Watts or KVA)			500 watts	250 watts	300 watts
FIRST CUSTOMER SHIPMENT					
COMMENTS	Drives are 7 disk changers.	Drives are 4 disk changers.			

MANUFACTURER	BOFFIN	BOFFIN	BOFFIN	BOFFIN	BOFFIN
CD FORMAT TOWER	CDV14/100	CDV21/100	P1414 P2814	P2821	SS-14/100
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Tower host/net and software environment	Ethernet NetWare	Ethernet NetWare	Novell, NT, VINES, other	Ethernet Novell, NT, VINES	Ethernet VINES, DOS, NT, OS/2, Windows
Tower capacity (Gbytes) MIN			4.55	4.55	
MAX	9.1	13.6	9.1	13.65	9.2
Minimum drives per tower	14	21	7	7	14
Maximum drives per tower	14	21	14	21	14
Tower interface to host/net	Ethernet	Ethernet	SCSI-2	Ethernet	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	Pentium 100: 16	Pentium 100: 16	Pentium 100: 16	Pentium 100: 16	Pentium 100: 16
Tower HDD buffer, if used (GB)	.545	.545	1	1	.545
Hot swap drives	--	--	--	--	--
Redundant power supply	Option	Option	Option	Option	Option
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2	1.2	1.2	1.2
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)	300 watts	600 watts	300 watts	500 watts	300 watts
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	BOFFIN	BOFFIN	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL
CD FORMAT TOWER	SS-21/100	P2828	CDJ2800 CDJ2801	CDT1200 CDT1600	CDT3200
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Host	Host	Host
Drive type	CD-ROM	CD-ROM	Minichanger	Minichanger	Minichanger
Relative speed	Drive dependent	Drive dependent		8X	8X
Tower host/net and software environment	Ethernet VINES, DOS, NT, OS/2, Windows	Ethernet Novell, NT, VINES	SCSI host Windows, Novell NT, UNIX, Mac	SCSI host Windows, Novell NT, UNIX, Mac	SCSI host Windows, Novell NT, UNIX, Mac
Tower capacity (Gbytes) MIN		4.55	18.8	2.6	2.6
MAX	13.6	18.2	18.8	10.4	20.8
Minimum drives per tower	21	7	5	1	1
Maximum drives per tower	21	28	5	4	8
Tower interface to host/net	Ethernet	Ethernet	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	Pentium 100: 16	Pentium 100: 16	--	--	--
Tower HDD buffer, if used (GB)	.545	1	1, 4	--	Option:1-4
Hot swap drives	--	--	No	No	No
Redundant power supply	Option	Option	Yes	No	No
Minichangers	No	No	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2	10.0	10.0	10.0
drive (MB/sec)	Drive dependent	Drive dependent	1.2	1.2	1.2
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 4550	F: 2600	F: 2600
Average positioning time (msec)	Drive dependent	Drive dependent			
Average access time (msec)	Drive dependent	Drive dependent	350	150	150
Drive models	Various	Various	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)	600 watts	500 watts			
FIRST CUSTOMER SHIPMENT			1996	1997	1997
COMMENTS			2801 has 2 rigid drives.		

MANUFACTURER	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL
CD FORMAT TOWER	SQ2100	CDT4000	CDS2800	CDS4900	CDS8400
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Net	Net	Net
Drive type	Minichanger	Minichanger	Minichanger	Minichanger	Minichanger
Relative speed		8X			
Tower host/net and software environment	SCSI host Windows, Novell NT, UNIX, Mac	SCSI host Windows, Novell NT, UNIX, Mac	Ethernet Windows, Novell NT, UNIX, Web	Ethernet Windows, Novell NT, UNIX, Web	Ethernet Windows, Novell NT, UNIX, Web
Tower capacity (Gbytes) MIN	13.6		18.2	31.8	4.55
MAX	13.6		18.2	31.8	54.6
Minimum drives per tower	3	1	4	7	1
Maximum drives per tower	3	10	4	7	21
Tower interface to host/net	SCSI-2	SCSI-2	Ethernet	Ethernet	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	--	--	32bit RISC:2-32	32bit RISC:2-32	32bit RISC:2-32
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives		No	No	No	No
Redundant power supply	Yes	Yes	Yes	Yes	Yes
Minichangers	Yes	Yes	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	10.0	1.2	1.2	1.2
drive (MB/sec)	1.2	1.2	.6	.6	.6
DRIVES: Nominal capacity/drive (MB)	F: 4550	F: 2650	F: 4550	F: 4550	F: 2660
Average positioning time (msec)					
Average access time (msec)	350	350	350	350	150
Drive models	Nakamichi	Nakamichi	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D			17.2 x 9.45 x 17.2	17.8 x 9.45 x 17.2	30 x 14.75 x 17.75
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	1996	1997	1996	1996	1997
COMMENTS					

MANUFACTURER	CMS ENHANCEMENTS	CMS ENHANCEMENTS	COMPACT DEVICES	COMPACT DEVICES	COMPACT DEVICES
CD FORMAT TOWER	Eclipse-E	Eclipse-T	TopSpin 210 Miniserver	Twister Web Server	TopSpin 220 Miniserver
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM*	CD-ROM
Relative speed	12X, 16X	12X, 16X	Drive dependent	Drive dependent	Drive dependent
Tower host/net and software environment	Ethernet NetWare, UNIX, Windows	Token Ring NetWare, UNIX, Windows	Ethernet NT, NetWare, NFS,TCP/IP,HTTP	Ethernet TCP/IP, HTTP	Ethernet NT, NetWare, NFS,TCP/IP,HTTP
Tower capacity (Gbytes) MIN	.65	.65	.65		.65
MAX	9/36*	9/36*	4.6		4.6
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	14	7	5	14
Tower interface to host/net	Ethernet	STP, UTP	E'net 10BT,10B2	E'net 10BT,10B2	E'net 10BT,10B2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256			
Features:					
Processor type & memory (MB)	32 bit RISC	32 bit RISC	186	--	186
Tower HDD buffer, if used (GB)	--	--	--	1.2	--
Hot swap drives	No	No	--	--	--
Redundant power supply	No	No	--	--	--
Minichangers	Option	Option	Option		Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	2.0	1.2	1.2	1.2
drive (MB/sec)	.6/.9/1.2	.6/.9/1.2	Drive dependent	Drive dependent	
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650*	F: 650
Average positioning time (msec)	110	110	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	120, 150	120, 150	Drive dependent	Drive dependent	Drive dependent
Drive models	TEAC, Toshiba	TEAC, Toshiba	Various	Various	Various
TOWER SIZE: Inches: H x W x D	15.5 x 8.4 x 17**	15.5 x 8.4 x 17**	1.5 x 6 x 4*	2.25 x 7 x 8.125	1.5 x 6 x 4*
POWER: (Watts or KVA)	300-400 watts	300-400 watts		10 watts	
FIRST CUSTOMER SHIPMENT	1997	1997	1/97	4/97	1/97
COMMENTS	*With minichanger. **27.5" high for 14 drives. Multiple protocol supp.	*With minichanger. **27.5" high for 14 drives. Multiple protocol supp.	*Also available as board. LUN support for 56 devices.	*Complete Web server:supports 5 CD-ROM, 2 HDD or 1 HDD and 1 Zip.	*Also available as board. LUN support for 56 devices.

MANUFACTURER	CUTTING EDGE	CUTTING EDGE	CUTTING EDGE	DTS COMPUTER	DYNATEK AUTOMATION
CD FORMAT TOWER	CDPowerShare	CDPowerAccess	CDPowerServ	DP300	CDT658PD/ETH
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Net	Net	Net	Net
Drive type	CD-ROM/DVD-ROM	Minichanger	CD-ROM/DVD-ROM	CD-ROM	CD-ROM
Relative speed	4X, 6X, 8X	12X-16X	10X-16X/1X	Various	8X
Tower host/net and software environment	SCSI host	Ethernet, other NetWare, NT, UNIX, other	Ethernet, TR ATM, FDDI	UNIX, NetWare, Windows, NT	Ethernet Various
Tower capacity (Gbytes) MIN	2.6	3	4.6	4.6	.650
MAX	36.8	168	36.8	4.6	4.55
Minimum drives per tower	4	1	7	7	1
Maximum drives per tower	56	56	56	7	7
Tower interface to host/net	SCSI-2	E'net,TR,other	E'net,TR, other	Ethernet, TR	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256		.256
Features:					
Processor type & memory (MB)		32 bit RISC	Pentium,PowerPC	--	32 bit RISC
Tower HDD buffer, if used (GB)		--	1.6-3.2	--	--
Hot swap drives	Option	Option	Option	No	No
Redundant power supply	Option	Option	Option	No	No
Minichangers	Option	Yes	Option	--	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0/20.0/40.0	1.2/2.0/12.0	1.2/2.0/12.0/20	1.2/2.0	1.2
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	1.2
DRIVES: Nominal capacity/drive (MB)	F: 650/4700	F: 3000	F: 650/4700	F: 650	F: 650
Average positioning time (msec)				Drive dependent	
Average access time (msec)	190	190	190	Drive dependent	
Drive models	Various	Nakamichi, Matsushita	Various	TEAC	Nakamichi, Pioneer,Toshiba
TOWER SIZE: Inches: H x W x D	Configuration dependent	Configuration dependent	Configuration dependent	21.3 x 8.7 x 13	19 x 7.5 x 11.9
POWER: (Watts or KVA)	300-600 watts	300-600 watts	300-600 watts	200 watts	250 watts
FIRST CUSTOMER SHIPMENT	1Q93	3Q95	3Q95		1995
COMMENTS		Axis controller	24 MB RAM. Custom configuration.	Sold in Europe	Host attach option.

MANUFACTURER	DYNATEK AUTOMATION	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER
CD FORMAT TOWER	CDT662PD/ETH	CD-4	CD-7	CDD-7	RM-7
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Host	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	4X-20X	4X-20X	4X-20X	4X-20X
Tower host/net and software environment	Ethernet Various	DOS, Windows, OS/2, UNIX DOS, Windows	OS/2, UNIX DOS, Windows	OS/2, UNIX DOS, Windows	DOS, Windows, OS/2, UNIX
Tower capacity (Gbytes) MIN	.650	.65	.65	.65	.65
MAX	4.55	2.6	4.55	4.55	4.55
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	7	4	7	7	7
Tower interface to host/net	Ethernet	SCSI, other	SCSI, other	SCSI, other	SCSI, other
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Features:					
Processor type & memory (MB)	32 bit RISC	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Option	Option	Option	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	5.0	5.0	5.0	5.0
drive (MB/sec)	1.8	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)		Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)		Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Nakamichi, Pioneer,Toshiba	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	19 x 7.5 x 11.9	9 x 6.5 x 15	13 x 7 x 15.25	18.75 x 8.75 x 13	7 x 19 x 27
POWER: (Watts or KVA)	250 watts	230 watts	230 watts	300 watts	230 watts
FIRST CUSTOMER SHIPMENT	1995	1993	1993	1993	1993
COMMENTS	Host attach option.				

MANUFACTURER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER
CD FORMAT TOWER	CD-14	CDD-14	CDSS-14	RM-5	EX-7
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X-20X	4X-20X	4X-20X	4X-20X	4X-20X
Tower host/net and software environment	OS/2, UNIX, DOS, Windows	OS/2, UNIX, DOS, Windows	OS/2, UNIX, DOS, Windows	OS/2, UNIX, DOS, Windows	Ethernet, TR, NetWare, NT, NFS, Web
Tower capacity (Gbytes) MIN	.65	.65	.65	.65	.65
MAX	9.1	9.1	9.1	36.4	4.55
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	14	14	56	7
Tower interface to host/net	SCSI, other	SCSI, other	SCSI, other	SCSI, other	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Features:					
Processor type & memory (MB)	--	--	--	--	
Tower HDD buffer, if used (GB)	--	--	--	--	
Hot swap drives	No	No	No		No
Redundant power supply	No	No	No		No
Minichangers	Option	Option	Option	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	5.0	5.0	1.2/2.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	26 x 9 x 16	28.75 x 9 x 16.75	14 x 14.75 x 16.75	Configuration dependent	22 x 7 x 15.25
POWER: (Watts or KVA)	460 watts	600 watts	300 watts	300-600 watts	300 watts
FIRST CUSTOMER SHIPMENT	1993	1993	1994	1994	3Q96
COMMENTS				Rack mount series.	

MANUFACTURER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER
CD FORMAT TOWER	JB-7	CDS-14	EX-14	JB-14	JB-28
DISK/TREND GROUP	51	51	51	51	51
MARKET		PCM	PCM		
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	Minichanger	CD-ROM	CD-ROM	Minichanger	Minichanger
Relative speed	16X	4X-20X	4X-20X	16X	16X
Tower host/net and software environment	NFS, Web, NT, NetWare	NT, VINES, NetWare	Ethernet, TR, NetWare, NT, NFS, Web	NetWare, NT, NFS, Web	NFS, Web, NT, NetWare
Tower capacity (Gbytes) MIN	3	4.55	.65	3	3
MAX	21	9.1	9.1	42	63
Minimum drives per tower	1	7	1	1	1
Maximum drives per tower	7	14	14	14	28
Tower interface to host/net	Ethernet, TR	Ethernet, TR	Ethernet, TR	Ethernet, TR	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)		Drive dependent	Drive dependent		
Features:					
Processor type & memory (MB)	32 bit RISC	Pentium:16-128		32 bit RISC	32 bit RISC
Tower HDD buffer, if used (GB)	--	1.2-4		--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	Option	Option	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	1.2/2.0	1.2/2.0	1.2/2.0	1.2/2.0
drive (MB/sec)	2.4	Drive dependent	Drive dependent	2.4	2.4
DRIVES: Nominal capacity/drive (MB)	F:3000(5 disks)	F: 650	F: 650	F:3000(5 disks)	F:3000(5 disks)
Average positioning time (msec)		Drive dependent	Drive dependent		
Average access time (msec)		Drive dependent	Drive dependent		
Drive models	Nakamichi	Various	Various	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	13 x 7 x 15.25	32.6 x 14.2 x 25	26 x 9 x 16	26 x 9 x 16	32.6 x 22 x 25
POWER: (Watts or KVA)	300 watts	600 watts	600 watts	600 watts	600 watts
FIRST CUSTOMER SHIPMENT	3Q96	1993	3Q96	3Q96	3Q96
COMMENTS	Host attach option. Axis controller 5 disk changer.	Complete server.		Host attach option. Axis controller 5 disk changer.	Host attach option. Axis controller 5 disk changer.

MANUFACTURER	EXCEL COMPUTER	EXCEL COMPUTER	KINTRONICS	KINTRONICS	KINTRONICS
CD FORMAT TOWER	CDS-28	EX-28	CD-ROM Tower	CD-ROM TowerC	CD-ROM Server
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Host	Host	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X-20X	4X-20X	14X-16X	8X, 16X	4X, 15X
Tower host/net and software environment	NT, VINES, NetWare	Ethernet, TR, NetWare, NT, NFS, Web	SCSI host Novell, Windows NT	SCSI host Novell, Windows NT	Ethernet Novell, Windows NT
Tower capacity (Gbytes) MIN	4.55	.65	.65	2.6, 3.0	.65
MAX	18.2	18.2	18.2	72.8, 84	18.2
Minimum drives per tower	7	1	1	7	1
Maximum drives per tower	28	28	28	28	28
Tower interface to host/net	Ethernet, TR	Ethernet, TR	SCSI-2	SCSI-2	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	Drive dependent	Drive dependent	.256	.256	
Features:					
Processor type & memory (MB)	Pentium:16-128		--	--	32 bit RISC
Tower HDD buffer, if used (GB)	1.2-4		--	--	--
Hot swap drives		No	Option	Option	Option
Redundant power supply		No	No	No	No
Minichangers	Option	Option	Option	Yes	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	1.2/2.0	10.0	10.0	1.2
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 2600, 3000	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Toshiba	Nakamichi	Toshiba
TOWER SIZE: Inches: H x W x D	32.6 x 22 x 25	32.6 x 22 x 25	18.75 x 8.75 x 13	18.75 x 8.75 x 13	18.75 x 8.75 x 13
POWER: (Watts or KVA)	600 watts	600 watts	300 watts	300 watts	300 watts
FIRST CUSTOMER SHIPMENT	1993	3Q96			
COMMENTS	Complete server.		ATTO SCSI expander.	Nakamichi changer.	Axis server.

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
CD FORMAT TOWER	CD7000	LVA07N10X	LCR04M01E	LCR04M01T	LCR07M01E
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X, 6X	16X	16X	16X	16X
Tower host/net and software environment	SCSI host Various	SCSI host DOS, Windows, NT, OS/2, UNIX	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows
Tower capacity (Gbytes) MIN	4.6	.65	2.6	2.6	2.6
MAX	4.6	4.55	10.4	10.4	18.2
Minimum drives per tower	7	1	1	1	1
Maximum drives per tower	7	7	4	4	7
Tower interface to host/net	SCSI-2	SCSI-2	Ethernet	Token Ring	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.512	2, 32	2, 32	2, 32
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	Yes	Yes	Yes
Minichangers	No	No	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	1.2	2.0	1.2
drive (MB/sec)	Drive dependent	2.4	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Sony, Toshiba Plextor	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	19 x 7 x 15.75	21.4 x 8.4 x 20.6			
POWER: (Watts or KVA)	250 watts	250 watts	250 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT		1997	3Q97	3Q97	3Q97
COMMENTS			Rack mount.	Rack mount.	Rack mount.

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
CD FORMAT TOWER	LCR07M01T	LCS04M01E	LCS04M01T	LCS07M01E	LCS07M01T
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	16X	16X	16X	16X
Tower host/net and software environment	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows
Tower capacity (Gbytes) MIN	2.6	2.6	2.6	2.6	2.6
MAX	18.2	10.4	10.4	18.2	18.2
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	7	4	4	7	7
Tower interface to host/net	Token Ring	Ethernet	Token Ring	Ethernet	Token Ring
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 32	2, 32	2, 32	2, 32	2, 32
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	Yes	Yes	Yes	Yes	Yes
Minichangers	Yes	Option	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	2.0	1.2	2.0	1.2	2.0
drive (MB/sec)	2.4	2.4	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)	250 watts	250 watts	250 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT	3Q97	3Q97	3Q97	3Q97	3Q97
COMMENTS	Rack mount.	Rack mount.			

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
CD FORMAT TOWER	LVA07N10E	LVA07N10T	LCX12M01E	LCX12M01T	SmartARRAY CD
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	OEM, PCM	OEM, PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Minichanger
Relative speed	16X	16X	16X	16X	8X
Tower host/net and software environment	Ethernet DOS, Windows, NT, OS/2, UNIX	Token Ring DOS, Windows, NT, OS/2, UNIX	NT, OS/2, UNIX DOS, Windows	NT, OS/2, UNIX DOS, Windows	Ethernet Windows, NT MaCOS,UNIX,oth.
Tower capacity (Gbytes) MIN	.65	.65	2.6	2.6	4.55
MAX	4.55	4.55	31.2	31.2	18.2
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	7	7	12	12	7
Tower interface to host/net	E'net 10BT,10B5	Token Ring	Ethernet	Token Ring	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 32	2, 32	2, 32	2, 32	.256
Features:					
Processor type & memory (MB)	--	--	--	--	
Tower HDD buffer, if used (GB)	--	--	--	--	
Hot swap drives	No	No	No	No	
Redundant power supply	No	No	Yes	Yes	
Minichangers	No	No	No	No	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	2.0	1.2	2.0	1.2/2.0
drive (MB/sec)	2.4	2.4	2.4	2.4	1.2
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 2600
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	150
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	165
Drive models	Various	Various	Various	Various	Nakamichi
TOWER SIZE: Inches: H x W x D	21.4 x 8.4 x 20.6	21.4 x 8.4 x 20.6			
POWER: (Watts or KVA)	250 watts	250 watts	250 watts	250 watts	
FIRST CUSTOMER SHIPMENT	1997	1997	3Q97	3Q97	
COMMENTS					Nakamichi minichangers.

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA
CD FORMAT TOWER	Vantage	Vantage 850 Vantage 950*	CD NetROM 7/7	CD Net Ultimate Storage	CD NetROM 14/14
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	Various	Various	12X	8X	12X
Tower host/net and software environment	Ethernet NetWare, UNIX, Windows, other	Ethernet NetWare, UNIX, Windows, other	SCSI host NetWare,NT,DOS, OS/2,UNIX,other	SCSI host NetWare, UNIX, NT, NFS, TCP/IP	SCSI host NetWare,NT,DOS, OS/2,UNIX,other
Tower capacity (Gbytes) MIN	4.6	4.6		4.6	
MAX	36.4	36.4	4.2	5.2	8.4
Minimum drives per tower	7	7	7	1	14
Maximum drives per tower	56	56	7	14	14
Tower interface to host/net	E'net,TR,ATM*	Ethernet, TR	SCSI-2	SCSI-2	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256		Host dependent	
Features:					
Processor type & memory (MB)	Pentium 90:64MB		--	Host dependent	--
Tower HDD buffer, if used (GB)	--		--	4	--
Hot swap drives	No	--	Option	Option	Option
Redundant power supply	No	--	Option	Option	Option
Minichangers	No	--	No	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	1.2/2.0	10.0	Host dependent	10.0
drive (MB/sec)	Drive dependent	Drive dependent	1.8	1.2	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	115		115
Average access time (msec)	Drive dependent	Drive dependent	125	10*	125
Drive models	Sony, Toshiba Plextor	Sony, Toshiba Various	Toshiba, other	Nakamichi	Toshiba, other
TOWER SIZE: Inches: H x W x D	77.3 x 23 x 31.5	1.3 x 7.7 x 5.2	34 x 18 x 41	26 x 9 x 18	67 x 37 x 38
POWER: (Watts or KVA)	250 watts	12 watts	250 watts	500 watts	300 watts
FIRST CUSTOMER SHIPMENT				2Q97	3Q96
COMMENTS	*Also FDDI, CDDI.	Direct network attached server *Token Ring interface.	Expandable to 56 drives. Rack mount option. DVD-ROM option.	*53 with HDD buffer.	Expandable to 56 drives. DVD-ROM option.

MANUFACTURER	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA
CD FORMAT TOWER	CD Net 100	CD Net Universal Server	CD Net Ultimate Server	CD NetROM Remote	CD Net 314
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	12X	8X	12X	6X
Tower host/net and software environment	Ethernet, TR NetWare, NT, VINES	Ethernet NetWare, UNIX, NT, NFS, TCP/IP	Ethernet NetWare, UNIX, NT, NFS, TCP/IP	Ethernet Novell NetWare	Ethernet, TR NetWare, NT, VINES
Tower capacity (Gbytes) MIN		4.6	4.6	4.6	
MAX	4.2	5.2	5.2	5.2	8.4
Minimum drives per tower	--	1	1	1	--
Maximum drives per tower	7	14	14	14	14
Tower interface to host/net	Ethernet, TR	Ethernet	Fast Ethernet	Ethernet	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	8, 128	.512	64, 128	.512	32, 128
Features:					
Processor type & memory (MB)	Pentium: 8 MB	Embedded	Pentium: 64 MB	Embedded	Pentium: 32 MB
Tower HDD buffer, if used (GB)	--	--	4 GB	--	--
Hot swap drives	No	Option	Option	Yes	No
Redundant power supply	No	Option	Option	Yes	No
Minichangers	No	Option	Yes	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	1.2	12.0	1.2	1.2/2.0
drive (MB/sec)	.6/.9	1.8	1.2	1.8	.6/.9
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)			10*		
Average access time (msec)					
Drive models	TEAC, other	Toshiba	Nakamichi	Toshiba	TEAC, other
TOWER SIZE: Inches: H x W x D	16.14 x 15.75 x 14.96	16 x 9 x 16	16 x 28 x 17	16 x 9 x 16	14.56 x 15.75 x 26.37
POWER: (Watts or KVA)	220 watts	300 watts	500 watts	300 watts	300 watts
FIRST CUSTOMER SHIPMENT		2Q97	2Q97	1Q97	
COMMENTS		7 drive rack mount option. Purchased controller.	*53 with HDD buffer.		

MANUFACTURER	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA	MICRO DESIGN INTERNATIONAL
CD FORMAT TOWER	CD Net 556	CD Net 914	CD Net 956	CD Net Remote	SE4CD8XST
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	12X	12X	Drive dependent	8X
Tower host/net and software environment	Ethernet, TR NetWare, NT, VINES	Ethernet, TR NetWare, NT, VINES	Ethernet, TR NetWare, NT, VINES	Ethernet Novell NetWare	SCSI host NetWare, NT, Mac, OS/2
Tower capacity (Gbytes) MIN				4.6	2.6
MAX	33.6	8.4	33.6	5.2	18.2
Minimum drives per tower	--	--	--	1	1
Maximum drives per tower	56	14	56*	14	7
Tower interface to host/net	Ethernet, TR	E'net,V Fast,TR	Ethernet, TR	Ethernet	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	32, 128	32, 128	64, 128	.512	.256
Features:					
Processor type & memory (MB)	Pentium: 32 MB	Pentium: 32 MB	Pentium: 64 MB	Embedded	--
Tower HDD buffer, if used (GB)	--	1	1	--	--
Hot swap drives	No	No	No	--	No
Redundant power supply	No	No	No	--	No
Minichangers	No	No	No	No	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	12.0/1.2/2.0	12/1.2/2.0	1.2	5.0
drive (MB/sec)	.9	1.8	1.8	Drive dependent	1.2
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	115	115	115	Drive dependent	130
Average access time (msec)	125	125	125	Drive dependent	140
Drive models	TEAC, other	Toshiba, other	Toshiba, other	Various	Nakamichi
TOWER SIZE: Inches: H x W x D	46.06 x 16.53 x 28.34	14.56 x 15.75 x 26.37	46.06 x 16.53 x 28.34	--	16.1 x 6.5 x 16.5
POWER: (Watts or KVA)	800 watts	400 watts	800 watts	12 watts	109 watts
FIRST CUSTOMER SHIPMENT		3Q96	3Q96	1Q97	11/96
COMMENTS		Rack mount option. DVD-ROM option.	*28 with VINES. Rack mount option. DVD-ROM option.	Shipped without drives.	

MANUFACTURER	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL
CD FORMAT TOWER	SECD12XET8	SECD12XST	SECD16XDE16	SECD16XET8	SECD16XST
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	12X	16X	16X	16X
Tower host/net and software environment	SCSI host NetWare, NT, Mac, OS/2	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, OS/2, Mac
Tower capacity (Gbytes) MIN	1.3	.65	.65	1.3	.65
MAX	5.2	4.55	10.4	5.2	4.55
Minimum drives per tower	2	1	1	1	1
Maximum drives per tower	8	7	16	8	7
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	No	No	No
Hot swap drives	No	No	Option	Option	Option
Redundant power supply	No	No	Option	Option	Option
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	5.0	5.0	5.0
drive (MB/sec)	1.8	1.8	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	115	115	120	120	120
Average access time (msec)	125	125	160	160	160
Drive models	Various	Various	NEC	NEC	NEC
TOWER SIZE: Inches: H x W x D	16.1 x 6.5 x 16.5	16.1 x 6.5 x 16.5	16.1 x 14.38 x 16	16.1 x 6.5 x 16.5	16.1 x 6.5 x 16.5
POWER: (Watts or KVA)	141 watts	70-109 watts	350 watts	125-141 watts	73-125 watts
FIRST CUSTOMER SHIPMENT	11/96	11/96	6/97	6/97	6/97
COMMENTS			Expandable to 56 drives.	Expandable to 56 drives.	Expandable to 56 drives.

MANUFACTURER	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL
CD FORMAT TOWER	SECD8XET8	SECD8XST	SECD8XSTE	SE4CD8XDT	SECD12XDE16
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X, 12X	8X	8X	8X	12X
Tower host/net and software environment	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, Mac, OS/2	SCSI host NetWare, NT, Mac, OS/2
Tower capacity (Gbytes) MIN	1.3	.65	.65	2.6	.65
MAX	5.2	4.55	4.55	36.4	10.4
Minimum drives per tower	2	1	1	1	1
Maximum drives per tower	8	7	7	14	16
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	No	No	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	5.0	5.0	5.0
drive (MB/sec)	1.2/1.8	1.2	1.2	1.2	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	130	130	130	130	115
Average access time (msec)	140	140	140	140	125
Drive models	Various	Various	Various	Nakamichi	Various
TOWER SIZE: Inches: H x W x D	16.1 x 6.5 x 16.5	16.1 x 6.5 x 16.5	16.1 x 6.5 x 16.5	16.1 x 14.38 x 16	16.1 x 14.38 x 16
POWER: (Watts or KVA)	125-141 watts	70-109 watts	73-125 watts	350 watts	350 watts
FIRST CUSTOMER SHIPMENT	4/96	4/96	4/96	11/96	11/96
COMMENTS	Expandable to 56 drives.			Double tower.	Double tower.

MANUFACTURER	MICRO DESIGN INTERNATIONAL	MICROTEST	MICROTEST	MICROTEST	MICROTEST
CD FORMAT TOWER	CD-Express Connect	DiscPort Tower	DiscPort Enterprise Server	DiscPort PRO	DiscPort XL
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X, 16X	4X, 8X, 12X	12X	Drive dependent	Drive dependent
Tower host/net and software environment	Ethernet NetWare, NFS, UNIX, Web	Ethernet, TR NetWare, NT	Ethernet, TR NetWare, NT	Ethernet NetWare, NT	Ethernet NetWare, NT
Tower capacity (Gbytes) MIN	.65	4.6	4.6	.65	.65
MAX	4.55	9.2	41/82	9.2	4.6
Minimum drives per tower	1	7	7	1	1
Maximum drives per tower	7	14	63/112	14	7
Tower interface to host/net	Ethernet	Ethernet, TR	E'net, TR	Ethernet	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	1				
Features:					
Processor type & memory (MB)	1.86	N/A	PentPro166:69MB		
Tower HDD buffer, if used (GB)	--	N/A	2.3-9.1	N/A	N/A
Hot swap drives	No	N/A	Yes	N/A	N/A
Redundant power supply	No	N/A	No	N/A	N/A
Minichangers	No	Option	Option	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	1.2/2.0	1.2/12.0/2.0	1.2	1.2
drive (MB/sec)	1.8/2.4	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	115	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	125	Drive dependent	Drive dependent
Drive models	Various	Various	Toshiba	Various	Various
TOWER SIZE: Inches: H x W x D	16.1 x 6.5 x 16.5	12 x 20 x 25	Configuration dependent	12 x 12 x 5.5	12 x 12 x 5.5
POWER: (Watts or KVA)	300 watts	400 watts	300 watts	35 watts	35 watts
FIRST CUSTOMER SHIPMENT	10/96	4Q95	4Q96	2Q95	3Q96
COMMENTS		Available without drives.	Hard disk can emulate CD-ROMS	Server controller.	Server controller.

MANUFACTURER	NETWORK STORAGE SOLUTIONS	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL
CD FORMAT TOWER	SPANStor-CD	Maxtet/CD Mini	Maxtet/CD	Netserve/CD Mini 40	Maxtet 53X
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Host	Host	Net	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	16X	4X, 8X, 12X	16X	8X
Tower host/net and software environment	Ethernet Windows, NT NetWare, UNIX	SCSI host Windows, Apple NT, Novell, oth	SCSI host Windows, Apple NT, Novell, oth	Ethernet Windows, Apple DOS, OS/2, oth.	SCSI host Windows, DOS, OS/2,Apple,oth.
Tower capacity (Gbytes) MIN	.65	24	5.5	27	5.5
MAX	4.55	24	44	27	44
Minimum drives per tower	1	8	8	8	8
Maximum drives per tower	7	8	64*	8	64*
Tower interface to host/net	Ethernet	SCSI-2	SCSI-2	Ethernet	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256				5.5, 44
Features:					
Processor type & memory (MB)	M68030:4	--	--	Inteli960:16-64	--
Tower HDD buffer, if used (GB)	--	--	--	--	Yes
Hot swap drives	No	Yes	Yes	Yes	Yes
Redundant power supply	No	--	--	--	--
Minichangers	No	Yes	No	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0	1.2	5.0	1.2	8.5
drive (MB/sec)	1.8	1.5-2.4	.6/1.2/1.8	2.4	1.2
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 3000	F: 650	F: 650	F: 650
Average positioning time (msec)	115				
Average access time (msec)	125	120	115-130	120	8**
Drive models	Toshiba	Nakamichi MJ5.16SI	Various	Nakamichi MJ5.16SI	Various
TOWER SIZE: Inches: H x W x D	13.6 x 7.5 x 16.4	18 x 14 x 13	Configuration dependent	18 x 14 x 13	Configuration dependent
POWER: (Watts or KVA)	200 watts	300 watts	300-1800 watts	300 watts	300 watts
FIRST CUSTOMER SHIPMENT	1995	1997	1994	1997	1997
COMMENTS			*Rack mount.		*Rack mount. **With HDD caching.

MANUFACTURER	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	ORNETIX	PLEXTEC	PLEXTEC
CD FORMAT TOWER	Netserve/53X	Netserve/CD	HyperLinQ	CDT-7XX	IDMAX-7XX
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	OEM, PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM, other	CD-ROM	CD-ROM
Relative speed	8X	4X, 8X, 12X	55X*	12X, 16X	12X, 16X
Tower host/net and software environment	Ethernet Windows, DOS, OS/2,Apple,oth.	Ethernet Windows, DOS, OS/2,Apple,oth.	Ethernet, other Novell, Windows DOS, OS/2, Web	SCSI host Various	SCSI host Various
Tower capacity (Gbytes) MIN	5.5	5.5	Drive dependent	.65	.65
MAX	44	44	Drive dependent	4.55	4.55
Minimum drives per tower	8	8	7	1	1
Maximum drives per tower	64*	64*	14	7	7
Tower interface to host/net	Ethernet	Ethernet	Ethernet, TR	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	5.5, 44				
Features:					
Processor type & memory (MB)	Inteli960:16-64	Inteli960:16-64		--	--
Tower HDD buffer, if used (GB)	Yes	--		--	--
Hot swap drives	Yes	Yes	--	No	No
Redundant power supply	--	--	--	No	No
Minichangers	No	No	--	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2	.1.2/12.0/2.0	10.0	10.0
drive (MB/sec)	1.2	.6/1.2/1.8		1.8/2.4	1.8/2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	Drive dependent	F: 650	F: 650
Average positioning time (msec)			Drive dependent		
Average access time (msec)	8**	115-130	Drive dependent		
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	Configuration dependent	Configuration dependent	1.61 x 5.75 x 8.53		
POWER: (Watts or KVA)	300-1800 watts	300 watts	25 watts		
FIRST CUSTOMER SHIPMENT	1997	1997	2Q97	1996	1996
COMMENTS	*Rack mount. **With HDD caching.	*Rack mount.	Miniserver. *HDD buffered.		Rack mount option.

MANUFACTURER	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC
CD FORMAT TOWER	CDT-14XX CDT-E-14XX	IDMAX-14XX IDMAX-E-14XX	CDJA-7XX	CD-LAN-14XX CD-LAN-E-14XX	CD-LAN-21XX
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Net	Net	Net
Drive type	CD-ROM	CD-ROM	Minichanger	CD-ROM	CD-ROM
Relative speed	12X, 16X	12X, 16X	8X, 16X	12X, 16X	12X, 16X
Tower host/net and software environment	SCSI host Various	SCSI host Various	Ethernet, TR Various	Ethernet, TR Various	Ethernet, TR Various
Tower capacity (Gbytes) MIN	.65	.65	2.6/3	.65	.65
MAX	9.1	9.1	18.2/21	9.1	21.7
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	14	7	14	21
Tower interface to host/net	SCSI-2	SCSI-2	Ethernet, TR	Ethernet, TR	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	No	Yes	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	10.0	1.2/12.0/2.0	1.2/12.0/2.0	1.2/12.0/2.0
drive (MB/sec)	1.8/2.4	1.8/2.4	1.2/2.4	1.2/2.4	1.2/2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 2600/3000	F: 650	F: 650
Average positioning time (msec)					
Average access time (msec)					
Drive models	Various	Various	Nakamichi	Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	1996	1996	1996	1996	1996
COMMENTS			Rack mount option.		

MANUFACTURER	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC
CD FORMAT TOWER	CD-LAN-JA-14XX	CD-LAN-JA-21XX	CD-LAN-R	CDJA-14XX	CD-LAN-E-28XX
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	Minichanger	Minichanger	CD-ROM	Minichanger	CD-ROM
Relative speed	8X, 16X	8X, 16X	12X, 16X	8X, 16X	12X, 16X
Tower host/net and software environment	Ethernet Various	Ethernet Various		Ethernet, TR Various	Ethernet, TR Various
Tower capacity (Gbytes) MIN	2.6/3	2.6/3		2.6/3	.65
MAX	36.4/42	54.6/63		36.4/42	18.2
Minimum drives per tower	1	1	7	1	1
Maximum drives per tower	14	21	56	14	28
Tower interface to host/net	Ethernet, TR	Ethernet, TR	Ethernet, TR	Ethernet, TR	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	Yes	No	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0/2.0	1.2/12.0/2.0	1.2/12.0/2.0	1.2/12.0/2.0	1.2/12.0/2.0
drive (MB/sec)	1.2/2.4	1.2/2.4	1.8/2.4	1.2/2.4	1.2/2.4
DRIVES: Nominal capacity/drive (MB)	F: 2600/3000	F: 2600/3000	F: 650	F: 2600/3000	F: 650
Average positioning time (msec)					
Average access time (msec)					
Drive models	Nakamichi	Nakamichi	Various	Nakamichi	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	1996	1996	1996	1996	1996
COMMENTS			Rack mount.	Rack mount option.	

MANUFACTURER	PLEXTEC	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	CD-LAN-JA-28XX	CD-12X4	CD-12X7	CD-6X4	CD-6X7
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Host	Host	Host	Host
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X, 16X	12X	12X	6X	6X
Tower host/net and software environment	Ethernet Various	SCSI host DOS, Windows NT UNIX, other	SCSI host DOS, Windows NT UNIX, other	SCSI host DOS, Windows, NT, UNIX, other	SCSI host DOS, Windows, NT, UNIX, other
Tower capacity (Gbytes) MIN	2.6/3	2.6	4.55	2.6	4.55
MAX	72.8/84	2.6	4.55	2.6	4.55
Minimum drives per tower	1	4	7	4	7
Maximum drives per tower	28	4	7	4	7
Tower interface to host/net	Ethernet, TR	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)		.512	.512	.256	.256
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	Yes	Yes	Yes	Yes
Redundant power supply	No	No	No	No	No
Minichangers	Yes	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0/2.0	10.0	10.0	5.0	5.0
drive (MB/sec)	1.2/2.4	1.8	1.8	.9	.9
DRIVES: Nominal capacity/drive (MB)	F: 2600/3000	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)		95	95	115	115
Average access time (msec)		105	105	145	145
Drive models	Nakamichi	Plextor PX-12CSi	Plextor PX-12CSi	Plextor PX-63CS	Plextor PX-63CS
TOWER SIZE: Inches: H x W x D		12 x 8.5 x 17	12 x 8.5 x 17	12 x 8.5 x 17	12 x 8.5 x 17
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	1996	4Q96	4Q96	2Q95	2Q95
COMMENTS					

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	ORN-12X4	ORN-12X7	ORN-6X4	ORN-6X7	NP-12CS-7
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	12X	6X	6X	12X
Tower host/net and software environment	SCSI host NetWare	SCSI host NetWare	SCSI host NetWare	SCSI host NetWare	Ethernet NT, UNIX, NetWare, Web
Tower capacity (Gbytes) MIN	2.6	4.55	2.6	4.55	4.55
MAX	4.55	4.55	4.55	4.55	4.55
Minimum drives per tower	4	7	4	7	7
Maximum drives per tower	7	7	7	7	7
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2	SCSI-2	E'net 10BT,10B2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.512	.512	.256	.256	2, 32
Features:					
Processor type & memory (MB)	--	--	--	--	
Tower HDD buffer, if used (GB)	--	--	--	--	
Hot swap drives	Yes	Yes	Yes	Yes	Option
Redundant power supply	No	No	No	No	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	10.0	5.0	5.0	1.2
drive (MB/sec)	1.8	1.8	.9	.9	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	95		127	127	95
Average access time (msec)	105		145	145	105
Drive models	Plextor PX-12CSi	Plextor PX-12CSi	Plextor PX-63CS	Plextor PX-63CS	Plextor PX-12CSi
TOWER SIZE: Inches: H x W x D	12 x 8.5 x 17	12 x 8.5 x 17	12 x 8.5 x 17	12 x 8.5 x 17	
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	2Q95	2Q95	4/97
COMMENTS	ORNETIX software.	ORNETIX software.	ORNETIX software.	ORNETIX software.	Axis network server.

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	NP-63CS-7	PS-12CS-2WNT	PS-12CS-NNW	PS-12CS-ORN	PS-12CS-OTG
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	12X	12X	12X	12X
Tower host/net and software environment	Ethernet	Ethernet Windows NT	Ethernet Windows NT	Ethernet NetWare	Ethernet NetWare
Tower capacity (Gbytes) MIN	4.55	4.55	4.55	4.55	4.55
MAX	4.55	36.4	36.4	18.2	18.2
Minimum drives per tower	7	7	7	7	7
Maximum drives per tower	7	56	56	28	28
Tower interface to host/net	E'net 10BT,10B2	Ethernet	Ethernet	Ethernet	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 32	.512	.512	.512	.512
Features:					
Processor type & memory (MB)		Pentium	Pentium	486 DX2	486 DX2
Tower HDD buffer, if used (GB)		1	1		
Hot swap drives	Option	Yes	Yes	Yes	Yes
Redundant power supply	No	Yes	Yes	Yes	Yes
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2/12.0	1.2	1.2	1.2
drive (MB/sec)	5.0	1.8	1.8	1.8	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	127	95	95	105	105
Average access time (msec)	145	105	105	125	125
Drive models	Plextor PX-63CS	Plextor PX-12CSi	Plextor PX-12CSi	Plextor PX-12CSi	Plextor PX-12CSi
TOWER SIZE: Inches: H x W x D		13 x 17 x 15.25	13 x 17.5 x 15.25	13 x 17.5 x 15.25	13 x 17.5 x 15.25
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	2Q95	4Q96	4Q96	2Q96	2Q96
COMMENTS	Axis network server.	NT server and OTG or IXOS CD sharing software.	ORNETIX software.		

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PROCOM TECHNOLOGY
CD FORMAT TOWER	PS-63CS-2WNT	PS-63CS-NNW	PS-63CS-ORN	PS-63CS-OTG	7 Mac CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	6X	6X	6X	4X, 12X, 16X
Tower host/net and software environment	Ethernet Windows NT	Ethernet Windows NT	Ethernet NetWare, Windows	Ethernet Windows NT	Apple System 7
Tower capacity (Gbytes) MIN	4.55	4.55	4.55	4.55	1.3
MAX	18.2	18.2	18.2	18.2	4.5
Minimum drives per tower	7	7	7	7	2
Maximum drives per tower	28	28	28	28	7
Tower interface to host/net	Ethernet	Ethernet	Ethernet	Ethernet	SCSI
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256				.256
Features:					
Processor type & memory (MB)	Pentium	Pentium	486/66: 4 MB	486/66: 16 MB	--
Tower HDD buffer, if used (GB)	1	1	1	1	No
Hot swap drives	Yes	Yes	Yes	Yes	No
Redundant power supply	Yes	Yes	Yes	Yes	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0	1.2	1.2	1.2	4.2/5.0
drive (MB/sec)	1.8	.9	.9	.9	.6/1.8/2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	127	105	115	115	150/115/99
Average access time (msec)	145	125	145	145	
Drive models	Plextor PX-63CS	Plextor PX-63CS	Plextor PX-63CS	Plextor PX-63CS	
TOWER SIZE: Inches: H x W x D	13 x 17 x 15.25	13 x 17.5 x 15.25	15.25 x 17.5 x 13	15.25 x 17.5 x 13	18.75 x 8.75 x 13
POWER: (Watts or KVA)					106 watts
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	2Q96	2Q96	6/94
COMMENTS					

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	7 Plus CD Tower	7 Subsystem CD Tower	14 Plus CD Tower	28 Plus CD Tower	7 Ethernet CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X, 12X, 16X	4X, 12X, 16X	4X, 12X, 16X	4X, 12X, 16X	4X, 12X, 16X
Tower host/net and software environment	SCSI host Win., NT, OS/2, NetWare, UNIX	SCSI host Win., NT, OS/2, NetWare, UNIX	PC NetWare, DOS, NT, OS/2, Wind.	PC NetWare, DOS, OS/2, NT, UNIX	Win., NT, OS/2, NetWare, UNIX
Tower capacity (Gbytes) MIN	1.3	1.3	4.5	4.5	.65
MAX	4.5	4.5	9.1	18.2	4.5
Minimum drives per tower	2	2	7	7	1
Maximum drives per tower	7	7	14	28	7
Tower interface to host/net	SCSI	SCSI	SCSI-2	SCSI-2	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	No	No	--	--	No
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	Yes	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	--	--	10.0	10.0	1.2
drive (MB/sec)	.6/1.8/2.4	.6/1.8/2.4	.6/.9	.6/1.8/2.4	.6/1.8/2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	150/115/99	150/115/99	150/115/99	150/115/99	150/115/99
Average access time (msec)	150/115/99				
Drive models					
TOWER SIZE: Inches: H x W x D	18.75 x 8.75 x 13	18.75 x 8.75 x 13	22.4 x 15.5 x 17.8	33.5 x 17.5 x 26	18.75 x 8.75 x 13
POWER: (Watts or KVA)	106 watts	106 watts	369 watts	400 watts	106 watts
FIRST CUSTOMER SHIPMENT	6/94	10/93	4/96	7/97	8/94
COMMENTS					

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	7 Token Ring CD Tower	14 Ethernet-2 CD Tower	14 Token Ring-2 CD Tower	28 Server CD Tower	CCA28-E1
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Minichanger
Relative speed	4X, 8X	4X, 12X, 16X	4X, 12X, 16X	12X, 16X	8X
Tower host/net and software environment	Win., NT, OS/2, NetWare, UNIX	PC NetWare,DOS,NT OS/2,UNIX,Wind.	PC NetWare,DOS,NT OS/2,UNIX,Wind.	PC NetWare, DOS, OS/2, NT, UNIX	Ethernet NT, Novell
Tower capacity (Gbytes) MIN	.65	4.5	4.5	4.5	18.2
MAX	4.5	9.1	9.1	18.2	18.2
Minimum drives per tower	1	7	7	7	7
Maximum drives per tower	7	14	14	28	7
Tower interface to host/net	Token Ring	Ethernet	Token Ring	Enet,TR,other	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	Proprietary	Proprietary	Pent. 200:16-64	--
Tower HDD buffer, if used (GB)	No			--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	Yes	Yes	Yes	No
Minichangers	No	Option	Option	No	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	2.0	1.2	2.0	1.2/2.0/12.0	1.2
drive (MB/sec)	.6/.9	.6/1.8/2.4	.6/1.8/2.4	.6/1.8/2.4	1.2
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 2600
Average positioning time (msec)	100/115/150	150/115/99	150/115/99	150/115/99	220
Average access time (msec)					
Drive models					Nakamichi
TOWER SIZE: Inches: H x W x D	18.75 x 8.75 x 13	18.75 x 8.75 x 13	22.4 x 15.5 x 17.8	33.5 x 17.5 x 26	18.75 x 8.75 x 13
POWER: (Watts or KVA)	106 watts	369 watts	369 watts	400 watts	106 watts
FIRST CUSTOMER SHIPMENT	1/95	2/96	4/96	7/97	12/96
COMMENTS					

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	CCA56-E1	CD FORCE 14	CD FORCE 21	CD Server 14	CD Server 21
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	12X, 16X	12X, 16X	12X, 16X	12X, 16X
Tower host/net and software environment	Ethernet NT, Novell	PC NetWare,DOS,NT OS/2, UNIX	PC NetWare,DOS,NT OS/2, UNIX	PC NetWare,DOS,NT OS/2, UNIX	PC NetWare,DOS,NT OS/2, UNIX
Tower capacity (Gbytes) MIN	36.4	4.5	4.5		
MAX	36.4	9	13.6		
Minimum drives per tower	14	7	7	7	7
Maximum drives per tower	14	14	21	14	21
Tower interface to host/net	Ethernet	E'net,TR,C/FDDI	E'net,TR,C/FDDI	E'net,TR,C/FDDI	E'net,TR,C/FDDI
Drive interface	SCSI-2	SCSI	SCSI	SCSI	SCSI
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	Pent.133:16-128	Pent.133:16-128	Pent.100:16-128	Pent.166:16-128
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	Yes	Yes	No	Yes
Minichangers	Yes	Yes	Yes	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2				
drive (MB/sec)	1.2	1.8/2.4	1.8/2.4	1.8/2.4	1.8/2.4
DRIVES: Nominal capacity/drive (MB)	F: 2600	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	220	115/99	115/99	10/9	115/99
Average access time (msec)					
Drive models	Nakamichi	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	22.4 x 15.5 x 17.8	22.4 x 15.5 x 17.8	30.2 x 20 x 20	22.4 x 15.5 x 17.8	30.2 x 20 x 20
POWER: (Watts or KVA)	369 watts	369 watts	487 watts	369 watts	487 watts
FIRST CUSTOMER SHIPMENT	12/96	7/96	6/96	6/96	3/95
COMMENTS				Third party software.	Third party software.

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	CD FORCE 28	CD FORCE Rax	CD Server 28	CD Tower Rax	DVD/CD FORCE 14
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	DVD-ROM
Relative speed	12X, 16X	12X, 16X	12X, 16X	12X, 16X	1X
Tower host/net and software environment	PC NetWare,DOS,NT OS/2, UNIX	PC Windows, NT, NetWare, OS/2	PC NetWare,DOS,NT OS/2, UNIX	PC NetWare, DOS, OS/2, NT, UNIX	PC NetWare, OS/2, Win., NT, UNIX
Tower capacity (Gbytes) MIN	4.5	4.5		4.6	32.9
MAX	18.2	40.9		38.4	65.8
Minimum drives per tower	7	7	7	7	7
Maximum drives per tower	28	63	28	56	14
Tower interface to host/net	E'net,TR,C/FDDI	E'net,TR,C/FDDI	E'net,TR,C/FDDI	Enet,TR,other	E'net,TR,C/FDDI
Drive interface	SCSI	SCSI-2	SCSI	SCSI-2	
Cache size (min, max: MB)	.256	.256	.256	.256	
Features:					
Processor type & memory (MB)	Pent.200:16-128	Pent.200:16-128	Pent.200:16-128	Pentium: 64-128	No
Tower HDD buffer, if used (GB)	--	--	--	Yes	No
Hot swap drives	No	--	No	No	No
Redundant power supply	Yes	--	Yes	Yes	No
Minichangers	Yes	Option	Option	No	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)		1.2/12.0		1.2/2.0/12.0	1.2/2.0/12.0
drive (MB/sec)	1.8/2.4	1.8/2.4	1.8/2.4	1.8/2.4	1.38
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 4700
Average positioning time (msec)	10/9	115/99	115/99	115	200
Average access time (msec)					
Drive models	Various	Various	Various	Various	
TOWER SIZE: Inches: H x W x D	33.5 x 17.5 x 26	84 x 22 x 34	33.5 x 17.5 x 26		22.4 x 15.5 x 17.8
POWER: (Watts or KVA)	400 watts	1400 watts	400 watts	1400 watts	369 watts
FIRST CUSTOMER SHIPMENT	7/97	4/96	7/97	5/95	6/97
COMMENTS		Rack mount.	Third party software.		Can mix CD-ROM and DVD-ROM.

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	REXAS
CD FORMAT TOWER	Hyper CD FORCE Rax	Hyper CD FORCE 12	Hyper CD FORCE 28	Hyper CD FORCE 18	CDRS100
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	36X, 53X*	36X, 53X*	12X, 16X	36X, 53X*	16X and up
Tower host/net and software environment	PC NetWare, OS/2, Win., NT, UNIX	PC NetWare, OS/2, Win., NT, UNIX	PC NetWare,DOS,NT OS/2, UNIX	PC NetWare, OS/2, Win., NT, UNIX	SCSI host Windows, UNIX
Tower capacity (Gbytes) MIN	4.6	3.9	4.5	7.8	.65
MAX	40.9	7.8	18.2	11.7	4.55
Minimum drives per tower	7	6	7	12	1
Maximum drives per tower	63	12	28	18	7
Tower interface to host/net	E'net,TR,C/FDDI	E'net,TR,C/FDDI	E'net,TR,C/FDDI	E'net,TR,C/FDDI	SCSI-2
Drive interface	SCSI-2		SCSI		SCSI-2
Cache size (min, max: MB)	.256		.256		
Features:					
Processor type & memory (MB)	Pent.200:16-128	No	Pent.200:16-128	No	--
Tower HDD buffer, if used (GB)	5	No	4	No	--
Hot swap drives	Yes	No	No	No	No
Redundant power supply	Yes	No	Yes	No	Option
Minichangers	Option	Option	Yes	Option	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0	1.2/2.0/12.0		5.4/7.9	10.0
drive (MB/sec)	.6/1.2/1.8	5400/7950*	5.4/7.9	5400/7950*	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	10/9	10/9	10/9	10/9	Drive dependent
Average access time (msec)					Drive dependent
Drive models	Various		Various		Various
TOWER SIZE: Inches: H x W x D	84 x 22 x 34	22.4 x 15.5 x 17.8	33.5 x 17.5 x 26	30.2 x 20 x 20	13.3 x 7.1 x 16.7
POWER: (Watts or KVA)	1400 watts	369 watts	400 watts	487 watts	.3 KVA
FIRST CUSTOMER SHIPMENT	9/96	10/96	7/97	12/96	
COMMENTS	*Rigid disk drive buffering Rack mount.	*Rigid disk drive buffering	Rigid disk drive buffering	*Rigid disk drive buffering	

MANUFACTURER	REXAS	SCINET	SCINET	SCINET	SMART AND FRIENDLY
CD FORMAT TOWER	CDRS200	LS Series CD-Server	Series 2000 Cd-Server	Series 700 CD-Server	CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Net	Net	Net	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X and up	Drive dependent	Drive dependent	Drive dependent	8X, 16X
Tower host/net and software environment	SCSI host Windows, UNIX	Ethernet, other NetWare, NT	Ethernet, other NetWare, NT	Ethernet, other NetWare, NT	SCSI host Various
Tower capacity (Gbytes) MIN	.65	2.6	4.55	4.55	3.25
MAX	4.55	4.55	Drive dependent	Drive dependent	9.1
Minimum drives per tower	1	4	7	7	5
Maximum drives per tower	7	7	56	42	14
Tower interface to host/net	SCSI-2	Ethernet, TR	Ethernet, TR	Ethernet, TR	SCSI-2
Drive interface	SCSI-2	SCSI-2/EIDE	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)		63	128	128	
Features:					
Processor type & memory (MB)	--	486-66: 4-6	Pentium: 32-128	Pentium: 4-128	--
Tower HDD buffer, if used (GB)	--	Option	Yes	Yes	--
Hot swap drives	Yes	No	Yes	No	No
Redundant power supply	Yes	No	No	No	No
Minichangers	No	Option	Option	Option	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	1.2/12.0/2.0	1.2/12.0/2.0	1.2/12.0/2.0	5.0
drive (MB/sec)	Drive dependent				1.2/2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Matsushita	Matsushita	Matsushita	Various
TOWER SIZE: Inches: H x W x D	23.2 x 8.3 x 17.1	26.4 x 8.3 x 17.3	37 x 21.1 x 29		
POWER: (Watts or KVA)	.3 KVA	250 watts	600 watts	300 watts	
FIRST CUSTOMER SHIPMENT		3/97	4/97	3/96	1996
COMMENTS		Expandable to 28 drives.		Up to 254 disks with mini-changers installed.	

MANUFACTURER	SMART AND FRIENDLY	SMART AND FRIENDLY	SMART AND FRIENDLY	SMS DATA PRODUCTS	SMS DATA PRODUCTS
CD FORMAT TOWER	CDJ 16008	CDJ 28008	CDJ 4008	1070 Tower	10700P Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Drive type	Minichanger	Minichanger	Minichanger	CD-ROM	CD-ROM
Relative speed	8X	8X	8X	12X	12X
Tower host/net and software environment	SCSI host Various	SCSI host Various	SCSI host Various	SCSI host	SCSI host Novell, NT
Tower capacity (Gbytes) MIN				1.3	2.6
MAX	10.4	18.4	2.6	4.6	4.6
Minimum drives per tower	4	7	1	2	4
Maximum drives per tower	4	7	1	7	7
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2*	SCSI-2	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)				--	
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	Yes	Yes	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	5.0	5.0	5.0
drive (MB/sec)	1.2	1.2	1.2	1.8	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)				Drive dependent	Drive dependent
Average access time (msec)				Drive dependent	Drive dependent
Drive models	Nakamichi	Nakamichi	Nakamichi	Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96		
COMMENTS			*SCSI adapter bundled in. Nakamichi minichangers.		

MANUFACTURER	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS
CD FORMAT TOWER	CDR43	S70070PT	SCSI Pro7	S70014	S70021
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Drive type	CD-R/CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed		8X, 12X	8X, 12X	8X, 12X	8X, 12X
Tower host/net and software environment	SCSI UNIX, Macintosh other	SCSI host	SCSI host	SCSI host	SCSI host
Tower capacity (Gbytes) MIN	5.2	4.55	4.55	9.2	13.8
MAX	5.2	4.55	4.55		
Minimum drives per tower	4	7	7	14	21
Maximum drives per tower	4	7	7	14	21
Tower interface to host/net	Ethernet	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	10.0	5.0	5.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models		Various		Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS	1 CD-R, 3 CD-ROM				

MANUFACTURER	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS
CD FORMAT TOWER	S70028	Series 3000 Millenia	Series 5000 Millenia	1070 Tower 2/5	1070DP Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	PCM	PCM	PCM	PCM
TOWER CONFIGURATION: Attachment	Host	Host	Host	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X, 12X	12X	12X	12X	12X
Tower host/net and software environment	SCSI host	SCSI host Novell, UNIX, VINES, DOS	SCSI host Novell, UNIX, VINES, DOS	Ethernet	Ethernet, Novell, NT
Tower capacity (Gbytes) MIN		13.65	13.65	1.3	2.6
MAX		40.95	127.4	1.3	4.6
Minimum drives per tower	28	21	63	2	4
Maximum drives per tower	21	63	196	2	7
Tower interface to host/net	SCSI-2	Ethernet, TR	Ethernet, TR	Ethernet	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	No	No	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	10.0	10.0	1.2	1.2/2.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	1.8	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent			Drive dependent	Drive dependent
Average access time (msec)	Drive dependent			Drive dependent	Drive dependent
Drive models	Various	Toshiba	Toshiba	Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	TAC SYSTEMS	TAC SYSTEMS
CD FORMAT TOWER	Pro7 Direct	S7007NOV/NOVTR	S7007NT	CD MiniTower	CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X, 12X	8X, 12X	8X, 12X	12X, other	12X, other
Tower host/net and software environment	Ethernet UNIX, NetWare, NT	Ethernet, TR Novell	Ethernet Windows NT	SCSI host	SCSI host
Tower capacity (Gbytes) MIN		4.6	4.55	4.55	4.55
MAX			4.55	4.55	41
Minimum drives per tower	7	7	7	7	7
Maximum drives per tower	7	7	7	7	63
Tower interface to host/net	Ethernet	Ethernet, TR	Ethernet	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)				.256	.256
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	Option	No
Redundant power supply	No	No	No	Option	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2/2.0	1.2	10.0	10.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	1.8	1.8
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D				15 x 6 x 15.5	30 x 6 x 15.5
POWER: (Watts or KVA)				250 watts	500 watts
FIRST CUSTOMER SHIPMENT				1996	1996
COMMENTS	Axis server module.			Rack mount option.	

MANUFACTURER	TAC SYSTEMS	TAC SYSTEMS	TAC SYSTEMS	TAC SYSTEMS	TEKRAM TECHNOLOGY
CD FORMAT TOWER	MiniTower LANRedi	TowerDrive LANRedi	LANRedi DataMart	TwinTower LANRedi	CS700
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
TOWER CONFIGURATION: Attachment	Net	Net	Net	Net	Net
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X, other	12X, other	12X, other	12X, other	12X, 16X
Tower host/net and software environment	Ethernet Novell, NT NFS, UNIX, Web	Ethernet Novell, NT, NFS, UNIX	Ethernet Novell, NT, NFS, UNIX	Ethernet Novell, NT NFS, UNIX, Web	Ethernet Windows, NT, Novell
Tower capacity (Gbytes) MIN	4.55	9.1	13.7	4.55	.65
MAX	4.55	9.1	41	18.2	5.2
Minimum drives per tower	7	14	21	7	1
Maximum drives per tower	7	14	63	28	8
Tower interface to host/net	Ethernet 10BT	Ethernet 10BT	Ethernet, TR	E'net 10BT, TR	E'net 10BT,10B2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI
Cache size (min, max: MB)	.256	.26	.256	.256	.128
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	Yes	No	No
Redundant power supply	No	No	Yes	No	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	1.2/2.0	1.2/2.0	1./2.0	1.2
drive (MB/sec)	1.8	1.8	1.8	1.8	1.8/2.4
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	15 x 6 x 15.5	30 x 6 x 15.5	52 x 24 x 30	36 x 13 x 16	17.3 x 7.1 x 16.5
POWER: (Watts or KVA)	250 watts	250 watts	500 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT	1997	1997	1997	1997	2Q97
COMMENTS	Rack mount option.		Host attach option.		

MANUFACTURER	TEN X TECHNOLOGY	TODD ENTERPRISES	TODD ENTERPRISES	TODD ENTERPRISES	TODD ENTERPRISES
CD FORMAT TOWER	TenXpert-1/24P	T-8050	T-8050-AD	VL14	VL4
DISK/TREND GROUP	51	51	51	51	51
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
TOWER CONFIGURATION: Attachment	Net	Host	Net	Host	Host
Drive type	CD Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X, 8X	6X, 8X, 12X	6X, 8X, 12X	6X, 8X, 12X	6X, 8X, 12X
Tower host/net and software environment	Ethernet DOS, Windows, NT, UNIX	SCSI host Various	Net Various	SCSI host Various	SCSI host Various
Tower capacity (Gbytes) MIN	15.6/19.5	.65	.65	.65	.65
MAX	15.6/19.5	4.55	4.55	9.2	2.6
Minimum drives per tower	6	1	1	1	1
Maximum drives per tower	6	7	7	14	4
Tower interface to host/net	Ethernet 10BT	SCSI-2	Ethernet	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	--	.256/.512	.256/.512	.256/5.2	.256/.512
Features:					
Processor type & memory (MB)	Intel 386EX: 4	--	--	--	--
Tower HDD buffer, if used (GB)	1	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	5.0/10.0/10.0	1.2	5.0/10.0/10.0	5.0/10.0/10.0
drive (MB/sec)	1.2/2.4	.6/.9/1.2	.6/.9/1.2	.6/.9/1.2	.6/.9/1.2
DRIVES: Nominal capacity/drive (MB)	F: 2600/3250	F: 650	F: 650	F: 650	F: 650
Average positioning time (msec)	Drive dependent	145/115/110	145/115/110	145/115/110	
Average access time (msec)	Drive dependent				
Drive models	Nakamichi				
TOWER SIZE: Inches: H x W x D	18.75 x 8.75 x 13			28.5 x 8.75 x 17	9.25 x 6.75 x 5.2
POWER: (Watts or KVA)	85 watts				
FIRST CUSTOMER SHIPMENT	1Q96				
COMMENTS	Complete server				

MANUFACTURER	TODD ENTERPRISES	VISION COMPUTERS	VISION COMPUTERS		
CD FORMAT TOWER	VL7	NOVUS	STRADUS		
DISK/TREND GROUP	51	51	51		
MARKET	OEM, PCM	PCM	PCM		
TOWER CONFIGURATION: Attachment	Host	Net	Host		
Drive type	CD-ROM	CD-ROM	CD-ROM		
Relative speed	6X, 8X, 12X	Various	Various		
Tower host/net and software environment	SCSI host Various	Ethernet	SCSI host		
Tower capacity (Gbytes) MIN	.65	4.6	4.6		
MAX	4.55	19.5	19.5		
Minimum drives per tower	1	7	7		
Maximum drives per tower	7	30	30		
Tower interface to host/net	SCSI-2	Ethernet	SCSI-2		
Drive interface	SCSI-2	SCSI-2	SCSI-2		
Cache size (min, max: MB)	.256/.512				
Features:					
Processor type & memory (MB)	--	Pentium100:16MB	--		
Tower HDD buffer, if used (GB)	--	1	--		
Hot swap drives	No	No	No		
Redundant power supply	No	No	No		
Minichangers	No	No	No		
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0/10.0/10.0	1.2	5.0		
drive (MB/sec)	.6/.9/1.2	Drive dependent	Drive dependent		
DRIVES: Nominal capacity/drive (MB)	F: 650	F: 650	F: 650		
Average positioning time (msec)	145/115/110	Drive dependent	Drive dependent		
Average access time (msec)		Drive dependent	Drive dependent		
Drive models		Various	Various		
TOWER SIZE: Inches: H x W x D	15.2 x 6.75 x 15.2				
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS					

1997 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 concurrently.

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.

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.

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.

1997 DISK/TREND optical disk product groups

For the 1997 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.

Read/write optical disk drives:

Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

CD format disk towers:

Group 51: CD format disk towers

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 52: Optical disk libraries with 1 to 39 cartridge capacity.
Group 53: Optical disk libraries with 40 to 69 cartridge capacity.
Group 54: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER		ADAPTIVE INFORMATION SYSTEMS	ADAPTIVE INFORMATION SYSTEMS	ADAPTIVE INFORMATION SYSTEMS	ADAPTIVE INFORMATION SYSTEMS	ADAPTIVE INFORMATION SYSTEMS
OPTICAL LIBRARY		A6970-S48/2	A6970-S48/4	A6970-S60/2	A6900-500	A6900-502
DISK/TREND GROUP		53	53	53	54	54
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (MB)	2600	2600	2600	2600	2600
	Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE:	Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
	Drive models	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)		48		270	228
	Maximum disk capacity (units)	48	60	60	306*	264*
	Number of drives: Maximum	2	4	2	2	8
	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)		156		797	688
	Import/export module (disks)	1	1	1	1	1
PERFORMANCE						
	Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	Dual X-Y axis
	Pickers per positioner	1	1	1	1	1
	Average media exchange time (sec)	6	6	6	8	8
	Spin-up + drive ready time (sec)	39	5	39	5	5
	Spin-down time (sec)	10	2.5	10	2.5	2.5
	Average drive access time (msec)	49	49	49	49	49
	Drive data transfer rate (MB/s)	1.7-3.4	2.3-4.6	1.7-3.4	2.3-4.6	2.3-4.6
FIRST CUSTOMER SHIPMENT					1997	1997
COMMENTS		HSM subsystem. Hitachi Library	HSM subsystem. Hitachi Library	HSM subsystem. Hitachi Library	*With 2 drives. Hitachi Library	*With 2 drives. Hitachi Library

MANUFACTURER	ADAPTIVE INFORMATION SYSTEMS	ADAPTIVE INFORMATION SYSTEMS	ADAPTIVE INFORMATION SYSTEMS	ASM	ASM
OPTICAL LIBRARY	A6970-S180/2	A6970-S180/4	A6970-S192/2	CDR 40	CDR 80
DISK/TREND GROUP	54	54	54	50	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	2600	2600	2600	540	540
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	Caddy	Caddy
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)				40	72
Maximum disk capacity (units)	180	180	192	44	84
Number of drives: Maximum	2	4	2	2	4
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2, RS232	SCSI-2, RS232
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)				23.8	45.4
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	6	6		
Spin-up + drive ready time (sec)	39	39	39	Drive dependent	Drive dependent
Spin-down time (sec)	10	10	10	Drive dependent	Drive dependent
Average drive access time (msec)	49	49	49	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	1.7-3.4	1.7-3.4	1.7-3.4	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT					
COMMENTS	HSM subsystem. Hitachi Library	HSM subsystem. Hitachi Library	HSM subsystem. Hitachi Library		

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY	CDR 100	CDR 200	CDR 300	CDR 500	CDR 900
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 CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	100	200	300	500	72
Maximum disk capacity (units)	100	200	300	500	80
Number of drives: Maximum	2	4	6	10	4
Interface: Library Drive	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	54	108	166	270	43.2
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)					
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
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER		ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY		CDR 1000	CDR 1100	CDR 1200	CDR 1300	CDR 1400
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 CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	152	212	643	965	1394
	Maximum disk capacity (units)	168	228	667	1037	1514
	Number of drives: Maximum	6	8	16	27	42
	Interface: Library Drive	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2
	Library capacity (Gbytes) (with maximum disk capacity)	90.7	123	360	560	818
	Import/export module (disks)	1	1	1	1	1
PERFORMANCE						
	Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
	Pickers per positioner	2	2	2	2	2
	Average media exchange time (sec)	6				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
	Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT						
COMMENTS						

MANUFACTURER		ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY		ASM 21	ASM 21SL	ASM 22	ASM 22SL	ASM 54
DISK/TREND GROUP		52	52	52	52	52
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE:	Type	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once
	Drive models					
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)					
	Maximum disk capacity (units)	26	26	20	20	38
	Number of drives: Maximum	1	2	2	4	4
	Interface: Library Drive	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2
	Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Import/export module (disks)	1	1	1	1	1
PERFORMANCE						
	Positioner type					
	Pickers per positioner	2	2	2	2	2
	Average media exchange time (sec)	6	6	6	6	
	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
	Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT						
COMMENTS						

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY	ASM 54SL	ASM 52	ASM 52SL	ASM 1000	ASM 102
DISK/TREND GROUP	52	53	53	54	54
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once
Drive models					
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)				200	
Maximum disk capacity (units)	38	50	50	1000	112
Number of drives: Maximum	8	2	4	24	2
Interface: Library	SCSI-2, RS232C	SCSI-2, RS232C	SCSI-2, RS232C	SCSI-2, RS232C	SCSI-2, RS232C
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type					
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)					
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
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT					
COMMENTS				Customized.	

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY	ASM 102SL	ASM 104	ASM 104SL	ASM 106	ASM 152
DISK/TREND GROUP	54	54	54	54	54
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once
Drive models					
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)					
Maximum disk capacity (units)	112	100	100	88	162
Number of drives: Maximum	4	4	8	6	2
Interface: Library	SCSI-2, RS232C	SCSI-2, RS232C	SCSI-2, RS232C	SCSI-2, RS232C	SCSI-2, RS232C
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type					
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)					8
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER		ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY		ASM 152SL	ASM 154	ASM 154SL	ASM 156	ASM 158
DISK/TREND GROUP		54	54	54	54	54
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE:	Type	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once	Rewrit.,Wr.Once
	Drive models					
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)					
	Maximum disk capacity (units)	162	150	150	138	126
	Number of drives: Maximum	4	4	8	6	8
	Interface: Library Drive	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2
	Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Import/export module (disks)	1	1	1	1	1
PERFORMANCE						
	Positioner type					
	Pickers per positioner	2	2	2	2	2
	Average media exchange time (sec)	8	8	8	8	8
	Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT						
COMMENTS						

MANUFACTURER	ATG	ATG	CHERUB	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY	AC 16000	GF 6910	2000	INF250/2 Infinidisc	INF250/4 Infinidisc
DISK/TREND GROUP	52	52	50	50	50
MARKET	OEM	OEM	PCM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	10200	10200	650	650	650
Cartridge type	ATG Cygnet	Proprietary	None	None	None
DRIVE: Type	Write Once	Write Once	Minichanger	CD-ROM	CD-ROM
Drive models	GD 16000	GD 6001 GD 9001 GD 9001S	Nakamichi MJ4.8S (8X)	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	1	6	240	250	250
Maximum disk capacity (units)	6	6	240	250	250
Number of drives: Maximum	1	1	6	2	4
Interface: Library Drive	SCSI-1 SCSI-2	SCSI SCSI-2	SCSI-2 SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	96	30.6	156	162.5	162.5
Import/export module (disks)	1 or 6	1	7	1/250	1/250
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	Rotary/ Y axis	Rotary/ Y axis
Pickers per positioner	1	1	2	1	1
Average media exchange time (sec)	2.5	2.5	3	12-20	12-20
Spin-up + drive ready time (sec)	2.4	3		Drive dependent	Drive dependent
Spin-down time (sec)	1.8	2		Drive dependent	Drive dependent
Average drive access time (msec)	119	Drive dependent	150	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	3.3	1.0	1.2	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	3Q96	1992	8/97		
COMMENTS					

MANUFACTURER		CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY		INF250/6 Infinidisc	INF250/8 Infinidisc	INF500/2 Infinidisc	INF500/4 Infinidisc	1602
DISK/TREND GROUP		50	50	50	50	52
MARKET		OEM	OEM	OEM	OEM	OEM
MEDIA:	Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	12"
	Nominal disk capacity (MB)	650	650	650	650	Drive dependent
	Cartridge type	None	None	None	None	Drive dependent
DRIVE:	Type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Wr.Once,Rewrit.
	Drive models	Various	Various	Various	Various	ATG, LMS, Sony, Nikon
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	250	250	500	500	29
	Maximum disk capacity (units)	250	250	500	500	29
	Number of drives: Maximum	6	8	2	4	2
	Interface: Library Drive	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI
	Library capacity (Gbytes) (with maximum disk capacity)	162.5	162.5	325	325	295*/232**
	Import/export module (disks)	1/250	1/250	1/250	1/250	1
PERFORMANCE						
	Positioner type	Rotary/ Y axis	Rotary/ Y axis	Rotary/ Y axis	Rotary/ Y axis	Y axis
	Pickers per positioner	1	1	1	1	2
	Average media exchange time (sec)	12-20	12-20	12-20	12-20	6.5
	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
	Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT						10/91
COMMENTS						*With ATG drive **With Nikon drive.

MANUFACTURER	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY	ASM-123W	ASM-149M	ASM-176M	ASM-224W	1800/A2
DISK/TREND GROUP	52	52	52	52	54
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	5600/12000	6800	8000	10200	10200
Cartridge type	Philips LMS	Nikon	Nikon	ATG Cygnet	ATG
DRIVE: Type	Write Once	Rewritable	Rewritable	Write Once	Write Once
Drive models	LD 4100	DD121-1AJ	DD121-1AJ	GD 9001/S	ATG GD 9001S
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	22	22	22	22	61
Maximum disk capacity (units)	22	22	22	22	141
Number of drives: Maximum	2	2	2	2	5
Interface: Library Drive	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	SCSI-2, RS232C SCSI
Library capacity (Gbytes) (with maximum disk capacity)	123.2	149	176	224.4	1438
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7.2	8	8	7.2	7.2
Spin-up + drive ready time (sec)	3.5	4	4	2.6	2.6
Spin-down time (sec)	1.5	2.2	2.2	2	2.0
Average drive access time (msec)	115	76	76	116	116
Drive data transfer rate (MB/s)	1.0	1.1	1.1	1.5	1.5
FIRST CUSTOMER SHIPMENT	2Q94	1994	2Q94	2Q94	10/91
COMMENTS					Includes model 1802 and 1803 assemblies.

MANUFACTURER		CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY		1800/H1	1800/L2	1800/N1	1800/S2	1800/SA
DISK/TREND GROUP		54	54	54	54	54
MARKET		OEM	OEM	OEM	OEM	OEM
MEDIA:	Nominal disk diameter	12"	12"	12"	12"	12"
	Nominal disk capacity (MB)	7000	5600/12000	8000	6550/15000	48 min.(analog)
	Cartridge type	Hitachi	LMSI	Nikon	Sony	Sony Analog
DRIVE:	Type	Write Once	Write Once	Rewritable	Write Once	Analog Video
	Drive models	Hitachi OD 321	Philips LMS4100 Philips LMS6100	Nikon DD121-1AJ	Sony WDD 930 Sony WDD 531	Sony LVR 5000A LVA 7000
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	61	61	61	61	48
	Maximum disk capacity (units)	141	141	141	141	128
	Number of drives: Maximum	5	5	5	5	5
	Interface: Library Drive	RS232C SCSI-2	SCSI, RS232C SCSI	RS-232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
	Library capacity (Gbytes) (with maximum disk capacity)	987	789.6/1692	1128	923/2115	6144 minutes
	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)	8	7.2	9	8	8
	Spin-up + drive ready time (sec)	3.5	3.5	5.8	2.4	N/A
	Spin-down time (sec)	3.5	1.5	3.2	1.2	N/A
	Average drive access time (msec)	150	115	137	207	500 (max.)
	Drive data transfer rate (MB/s)	1.116-2.220	1.0	1.5	.900	4.5/6.7 MHz
FIRST CUSTOMER SHIPMENT		3Q93	7/91	1Q94	3Q93	1Q94
COMMENTS		Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.

MANUFACTURER	CYGNET STORAGE SOLUTIONS	DISC	DISC	DISC	DISC
OPTICAL LIBRARY	CASS	D1260	D210U	D300	D600
DISK/TREND GROUP	54	50	50	50	50
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	10200	640	640	640	640
Cartridge type	ATG Cygnet	Caddy	Caddy	Caddy	Caddy
DRIVE: Type	Write Once	CD-ROM, CD-R*	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R*
Drive models	ATG GD 9001S	Various	Various	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	111	1170	140	249	498
Maximum disk capacity (units)	131	1478	238	361	722
Number of drives: Maximum	4	32	16	16	32
Interface: Library	IBM channel	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	--	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1132	961	152	235	469
Import/export module (disks)		2	1	1	2
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7.2	7	7	7	7
Spin-up + drive ready time (sec)	2.6	1-3	1-3	1-3	1-3
Spin-down time (sec)	2	2-3	2-3	2-3	2-3
Average drive access time (msec)	116	150	150	150	150
Drive data transfer rate (MB/s)	1.5	.6	.6	.6	.6
FIRST CUSTOMER SHIPMENT	1995	7/94	9/95	7/94	7/94
COMMENTS	ESCON option.	*Can mix CD ROM and 5.25" drives plus media in library.			*Can mix CD ROM and 5.25" drives plus media in library.

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
OPTICAL LIBRARY	D630	DA100	DA200	D50	D60
DISK/TREND GROUP	50	50	50	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Nominal disk capacity (MB)	640	650	650	2600	2600
Cartridge type	Caddy	None	None	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	Rewritable-(MO)	Rewritable-(MO)
Drive models	Various	Sony	Sony	Sony, H-P	Sony, H-P
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	585				
Maximum disk capacity (units)	739	125	225	50	60
Number of drives: Maximum	16	6	6	4	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)	480	81.3	146.3	130	156
Import/export module (disks)	1	1	1	1/10	1/10
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	7	4	4	4	4
Spin-up + drive ready time (sec)	1-3	4	4	Drive dependent	Drive dependent
Spin-down time (sec)	2-3	2	2	Drive dependent	Drive dependent
Average drive access time (msec)	150	250	250	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	.6	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	7/94	2/97	2/97	2Q97	2Q97
COMMENTS		Purchased mechanism.	Purchased mechanism.	Purchased mechanism.	Purchased mechanism.

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
OPTICAL LIBRARY	D1050-2	D150U	D245	D255U	D280U
DISK/TREND GROUP	54	54	54	54	54
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300/2600	1300/2600	1300/2600	1300/2600	1300/2600
Cartridge type	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVE: Type	Wr.Once,Rewrit.	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	Various	H-P, Sony, Pinnacle	H-P, Sony Pinnacle	H-P, Sony, Pinnacle	H-P, Sony, Pinnacle
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	914	170	247	247	290
Maximum disk capacity (units)	1054	170	247	247	290
Number of drives: Maximum	16	8	8	8	8
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)	2376-2740	4420	6422	6422	7540
Import/export module (disks)	2	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7	7	7	7	7
Spin-up + drive ready time (sec)	2-3	1-3	1-3	1-3	1-3
Spin-down time (sec)	2-3	2-3	2-3	2-3	2-3
Average drive access time (msec)	19-35	19-35	19-35	19-35	19-35
Drive data transfer rate (MB/s)	1.8	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	5/92	4Q95	4Q95	4Q95	4Q95
COMMENTS	Custom configurations available.	Custom configurations available.	Custom configurations available.	Custom configurations available.	Custom configurations available.

MANUFACTURER	DISC	DISC	DISC	DSM GMBH & CO.	DSM GMBH & CO.
OPTICAL LIBRARY	D350-1 D350U	D510-2	D525-1 D525U	CD60 TERADISC	CD61 TERADISC
DISK/TREND GROUP	54	54	54	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)	1300/2600	1300/2600	1300/2600	650	650
Cartridge type	Drive dependent	Drive dependent	Drive dependent	Magazine	Magazine
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 CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	300	454	457	130	250
Maximum disk capacity (units)	350	514	527	170	290
Number of drives: Maximum	6	8	8	4	6
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)	390-455	590-668	594-685	115.6	197.2
Import/export module (disks)	1	2	1	1/5	1/5
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	1	1
Average media exchange time (sec)	7	7	7		
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
Drive data transfer rate (MB/s)	1.8	1.8	1.8	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	5/92	5/92	5/92	8/96	8/96
COMMENTS	Custom configurations available.	Custom configurations available.	Custom configurations available.	Preliminary specification.	Preliminary specification.

MANUFACTURER		DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
OPTICAL LIBRARY		CD62 TERADISC	CDR 40 CDR 51 TERASTORE	CDR 53 CDR 55 TERASTORE	CDR 71 CDR 72 CDR 73 CDR 74 TERASTORE	28 28-U TERASTORE
DISK/TREND GROUP		50	50	50	50	52
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	12"
	Nominal disk capacity (MB)	650	600 (Mode 1)	600 (Mode 1)	600 (Mode 1)	Drive dependent
	Cartridge type	Magazine	Caddy	Caddy	Caddy	Proprietary
DRIVE:	Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	Write Once
	Drive models	Various	Various	Various	Various	ATG, Toshiba, Sony, LMS 4100
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	350	28 (CDR 40)	142 (CDR 53)	273 (CDR 71)	10
	Maximum disk capacity (units)	430	63 (CDR 51)	179 (CDR 55)	7435 (CDR 74)	28
	Number of drives: Maximum	10	5	6	2*	2
	Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
	Library capacity (Gbytes) (with maximum disk capacity)	292.4	42.8	121.7	1070	Drive dependent
	Import/export module (disks)	1/5	1	1	1	1
PERFORMANCE						
	Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	Y axis
	Pickers per positioner	1	2	2	2	2
	Average media exchange time (sec)		3	6.5	4-6	6
	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
	Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT		8/96	1/94	7/94	2/95	11/89
COMMENTS		Preliminary specification.			*Field upgradable to 42 drives.	Model 28-U is field upgradable to model 48.

MANUFACTURER		DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
OPTICAL LIBRARY		4000 5100 TERASTORE	48 TERASTORE	100-2000 TERASTORE	5300 5500 TERASTORE	7100 7200 7300 7400 TERASTORE
DISK/TREND GROUP		53	53	54	54	54
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA:	Nominal disk diameter	130 mm	12"	12"	130 mm	130 mm
	Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	Cartridge type	ANSI/ISO	Proprietary	Proprietary	ANSI/ISO	ANSI/ISO
DRIVE:	Type	Wr.Once,Rewrit.	Write Once	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.
	Drive models	Various	ATG, LMS 4100, Sony WDD600	ATG, Toshiba, Sony, Hitachi, LMS	Various	Various
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	24 (4000)	28	54	96 (5300)	234 (7700)
	Maximum disk capacity (units)	63 (5100)	48*	2380*	179 (5500)	1645 (7400)
	Number of drives: Maximum	2*	3	120	6	42
	Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
	Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
	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)	3	7	8-12	6.5	4-6
	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
	Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT		4/92	11/89	9/87	11/89	3/93
COMMENTS		*Option up to 5 drives.	*Field upgradable.	*Field upgradable.		

MANUFACTURER	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	ELMS SYSTEMS
OPTICAL LIBRARY	CD ADL-150 CD ADL-150R	CD Library 144	2000 ADL+	2000E	DVL-1000
DISK/TREND GROUP	50	50	54	54	50
MARKET	OEM	Captive,OEM,PCM	Captive, OEM	Captive, OEM	PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	14"	14"	120 mm
Nominal disk capacity (MB)	600	650	14824	25000	650
Cartridge type	None	None	ANSI/ISO	ANSI/ISO	Magazine
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	Write Once	Write Once	CD/DVD-ROM,CD-R
Drive models	Toshiba	TEAC CD-516S TEAC CD-R50S	2000	ODW25	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	50	108	25	50	20
Maximum disk capacity (units)	150	162	134	134, 100	100
Number of drives: Maximum	4	4	2	2, 4	4
Interface: Library Drive	RS232 SCSI	SCSI-2 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	90	105.3	1983	3350	65/470
Import/export module (disks)	1/50	1/18	1	1	20
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	2	2	1
Average media exchange time (sec)	2	8	6.5	6.5	8
Spin-up + drive ready time (sec)	2		2.4	2.3	Drive dependent
Spin-down time (sec)	1		1.4	1.2	Drive dependent
Average drive access time (msec)		150	170	170	Drive dependent
Drive data transfer rate (MB/s)	.6 (4X)	2.4 (16X)	1.0	1.8	Drive dependent
FIRST CUSTOMER SHIPMENT	4Q95	3Q97	3Q94	2Q97	10/96
COMMENTS	NSM mechanism. -150R model has CDR drive.	4X CD-R.	Expandable in modules of 25 disks. Depopulated versions available.		Bar coded magazine. HDD cache option. Various configurations.

MANUFACTURER	EMASS	FILENET	FILENET	FUJITSU	FUJITSU
OPTICAL LIBRARY	AML/J	OSAR 50 GTL	Model 0150 OSAR 107/144 GT	F6448/JX M2522/JX M2522/LX	M2522/AX
DISK/TREND GROUP	54	53	54	52	52
MARKET	OEM, PCM	Captive	Captive, OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	130 mm	12"	12"	130 mm	130 mm
Nominal disk capacity (MB)	2600	12000	12000	2600	1300
Cartridge type	ANSI/ISO	LMSI	LMSI	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Write Once	Write Once	Rewritable	Rewritable
Drive models	Various	LMSI 6100	LMSI LD 6100	M2508B	M2504B
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	396	40	107	28	28
Maximum disk capacity (units)	396	50	144	28	28
Number of drives: Maximum	4	3	6	2	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI, RS232 SCSI-2	RS232, RS422 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1030	600	1728	72	36
Import/export module (disks)	1/10	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	1	2	2	1	1
Average media exchange time (sec)		4	4.0	8	8
Spin-up + drive ready time (sec)	Drive dependent	3	3.0	3.7	5.5
Spin-down time (sec)	Drive dependent	1.5	1.5	3.3	3.5
Average drive access time (msec)	Drive dependent	120	130	32.3	40
Drive data transfer rate (MB/s)	Drive dependent	10.0	4.0	2.0-4.0	1.0-2.0
FIRST CUSTOMER SHIPMENT		10/95	3/91	2Q97	2Q95
COMMENTS	Library can store multiple media types.		Maximum capacity with 2 drives.		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
OPTICAL LIBRARY	M2531A	M2531B	M2532B1	M2532B2	F6445/A1 M255X/A1
DISK/TREND GROUP	52	52	52	52	54
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	86 mm	86 mm	86 mm	86 mm	130 mm
Nominal disk capacity (MB)	230	230	640	640	644
Cartridge type	ISO	ISO	ISO	ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	M2512	M2512	Fujitsu M2513B	Fujitsu M2513B	M2507L
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	35	35	35	35	390
Maximum disk capacity (units)	35	35	35	35	390
Number of drives: Maximum	2	2	1	2	6
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, Prop.* SCSI-2, Prop.*
Library capacity (Gbytes) (with maximum disk capacity)	8.1	8.1	22	22	251.2
Import/export module (disks)	35	35	1/35	1/35	10/10
PERFORMANCE					
Positioner type	X axis	X axis	X axis	X axis	Rotary Drum Y axis picker
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	5	6.5	6.5	10
Spin-up + drive ready time (sec)	5	5	7	7	5.5
Spin-down time (sec)	4	4	4	4	4.5
Average drive access time (msec)	43.3	43.3	43.3	43.3	40.6
Drive data transfer rate (MB/s)	1.3-2.1	1.3-2.1	2.3-3.9	2.3-3.9	2.08
FIRST CUSTOMER SHIPMENT	3Q95	1Q95	2Q96	2Q96	4Q91
COMMENTS	Includes 532 MB rigid disk drive.				Single pass write. *With DIR (M109X/F1785).

MANUFACTURER		FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
OPTICAL LIBRARY		F6445/A2 M255X/A2	F6445/A2X2 M255X/A2X2	F6448/KX M2522/KX M2522/MX	M2522/BX	M2522/CX
DISK/TREND GROUP		54	54	54	54	54
MARKET		Captive, OEM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (MB)	644	644	2600	1300	644
	Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE:	Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
	Drive models	M2507L	M2507L	M2508B	M2504B	M2507B
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	780	1560	78	78	78
	Maximum disk capacity (units)	780	1560	78	78	78
	Number of drives: Maximum	11	10	4	4	2
	Interface: Library Drive	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
	Library capacity (Gbytes) (with maximum disk capacity)	502.3	1004.6	202	101	50
	Import/export module (disks)	10/10	10/10	1*	1*	1
PERFORMANCE						
	Positioner type	Rotary Drum (2) 2 Y axis picker	Rotary Drum (4) 4 Y axis picker	Rotary Drum Y axis picker	Rotary Drum Y axis picker	Rotary Drum Y axis picker
	Pickers per positioner	1	1	1	1	1
	Average media exchange time (sec)	10	10	9	9	9
	Spin-up + drive ready time (sec)	5.5	5.5	3.7	5.5	5.5
	Spin-down time (sec)	4.5	4.5	3.3	3.5	4.5
	Average drive access time (msec)	40.6	40.6	32.3	40	40.6
	Drive data transfer rate (MB/s)	2.08	2.08	2.0-4.0	1.0-2.0	2.08
FIRST CUSTOMER SHIPMENT		4Q91	4Q91	2Q97	4Q94	3Q95
COMMENTS		Single pass write. *With DIR (M109X/F1785).	Single pass write. *With DIR (M109X/F1785).	*20 cartridges. Available with DEE option.	*20 cartridges. Available with DEE option.	

MANUFACTURER	GRUNDIG (K&S)	GRUNDIG (K&S)	GRUNDIG (K&S)	GRUNDIG (K&S)	GRUNDIG (K&S)
OPTICAL LIBRARY	CDJ-30	CDJ-M200	MCD-10	MCD-35	Megastore 1000
DISK/TREND GROUP	50	50	50	50	52
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (MB)	540/600	540/600	650	540/600	654/1024
Cartridge type	Caddy	Tray	Caddy	Tray	ISO
DRIVE: Type	CD-R	CD-ROM, CD-R	CD-R	CD-ROM, CD-R	Rewritable
Drive models	Philips, other	Various	Yamaha, Philips (option)	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	30	25	10	35	10
Maximum disk capacity (units)	30	200	10	35	10
Number of drives: Maximum	1	4	1	2	1
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	18	120	6.5	21	6.5/10.2
Import/export module (disks)	1/15	25	1	35	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)	30	2.5	7-9*	2*	18
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
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	1994	4Q94		9/94	9/91
COMMENTS		Expandable to 1600 disks. Label printer option.	*Includes spin-up and spin-down time.	*Includes spin-up and spin-down time.	

MANUFACTURER	GRUNDIG (K&S)	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
OPTICAL LIBRARY	Megastore 1000/M	C1100F C1101F C1115F C1116F 40fx	C1150F 80fx	C1100A/B C1101A C1102A* C1103 Model 20xt	C1152C* 40st
DISK/TREND GROUP	54	52	52	52	52
MARKET	OEM	OEM, PCM	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)	650/1500*	2600	2600	1300	1300
Cartridge type	ANSI	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	Sony, Maxoptix, Matsushita LF7300Z, Ricoh	H-P C1113F	H-P C1113F	H-P C1716T	H-P C1716T
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host, Net	Host, Net
Minimum disk capacity (units)	10	16	32	16	32
Maximum disk capacity (units)	80	16	32	16	32
Number of drives: Maximum	4	2	2	1	2
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2**	SCSI-2, LAN
Drive	SCSI, SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	120*	41.6	83.2	20.8	41.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)	18	12	10	8	6
Spin-up + drive ready time (sec)	Drive dependent	5.5	5.5	2.5	2.5
Spin-down time (sec)	Drive dependent	3.0	3.0	2.0	2
Average drive access time (msec)	Drive dependent	35	35	36	36
Drive data transfer rate (MB/s)	Drive dependent	3.4	3.4	1.6	1.6
FIRST CUSTOMER SHIPMENT	1994	2/96	2/96	4/94	1Q95
COMMENTS	*With LF7300Z. Available with 10, 20, 40 or 80 cartridges.	C1100 and 1101 have single drive. C1101 and C1116 are differential.		**C1100A is single ended. C1101A is differential. C1103 is OEM version. *Dir. LAN conn.	*Direct LAN connect. Upgradable to 80st.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
OPTICAL LIBRARY	C1700T C1710T Model 40T	C1713T Model 20T	C1160F 160fx	C1162C* 80st	C1170F 200fx
DISK/TREND GROUP	52	52	53	53	54
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	2600	1300	2600
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/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 C1113F	H-P C1716T	H-P C1113F
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host, Net	Host
Minimum disk capacity (units)	32	16	64	64	76
Maximum disk capacity (units)	32	16	64	64	76
Number of drives: Maximum	2	1	4	4	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	41.6	20.8	166.4	83.2	197.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	X-Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	2	1
Average media exchange time (sec)	7	7	10	6	10
Spin-up + drive ready time (sec)	2.5	2.5	5.5	2.5	5.5
Spin-down time (sec)	2.0	2.0	3.0	2	3.0
Average drive access time (msec)	36	36	35	36	35
Drive data transfer rate (MB/s)	1.6	1.6	3.4	1.6	3.4
FIRST CUSTOMER SHIPMENT	5/93	5/93	2/96	1Q95	2/96
COMMENTS		Upgradable to 40T.		*Direct LAN connect.	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
OPTICAL LIBRARY	300st	C1104F* C1105F 330fx	C1107F* C1108F C1110F C1112F 600fx	C1104A/B 165st	C1172C* 100st
DISK/TREND GROUP	54	54	54	54	54
MARKET	Captive,OEM,PCM	OEM, PCM	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)	1300/2600*	2600	2600	1300	1300
Cartridge type	ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	H-P C1716T	H-P C1113F	H-P C1113F	H-P C1716T	H-P C1716T
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host, Net
Minimum disk capacity (units)	238	128	238	128	76
Maximum disk capacity (units)	238	128	238	128	76
Number of drives: Maximum	6	6	12	4	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, LAN SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	309.4/618.8	332.8	618.8	166.4	98.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	2			2	2
Average media exchange time (sec)	3.5	10	10	6	6
Spin-up + drive ready time (sec)	2.5	5.5	5.5	2.5	2.5
Spin-down time (sec)	2	3	3	2	2
Average drive access time (msec)	36	35	35	36	36
Drive data transfer rate (MB/s)	1.6	3.4	3.4	1.6	1.6
FIRST CUSTOMER SHIPMENT	9/95	3/96	3/96	3Q95	1Q95
COMMENTS	*When 2600 MB drives avail. Drives can be hot swapped.	Expandable to 600fx. *4 drives.	*6, 8, 10, 12 drives respectively.	Upgradable to 300st.	*Direct LAN connect.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI
OPTICAL LIBRARY	C1704T C1714T Model 120T	C1705T C1715T Model 200T	OL172S-20A	OL172-48	OL172-180
DISK/TREND GROUP	54	54	52	53	54
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	2600	1300	2607
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	H-P C1716T	H-P C1716T	Hitachi OD-172S	Hitachi OL-F172 OL-F172S/D21	Hitachi OL-F172S/D21
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	88	144	20	48*	180
Maximum disk capacity (units)	88	144	20	60	192*
Number of drives: Maximum	4	4	2	4	4
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)	114	187	52	156	500
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1		1	1
Average media exchange time (sec)	8	8	5	6	6
Spin-up + drive ready time (sec)	2.5	2.5	7.5	5	5
Spin-down time (sec)	2.0	2.0	4.5	2.5	2.5
Average drive access time (msec)	36	36	49	49	49
Drive data transfer rate (MB/s)	1.6	1.6	2.3-4.6	2.3-4.6	2.3-4.6
FIRST CUSTOMER SHIPMENT	5/93	5/93	3Q96	4Q95	1997
COMMENTS	Upgradable to 200T.		Available only with single-ended SCSI.	*With 4 drives. Available with single-ended or differential SCSI.	*With 2 drives. Available with single-ended or differential SCSI.

MANUFACTURER	HITACHI	HITACHI	IBM	IBM	IBM
OPTICAL LIBRARY	OL500-270	OL502-228	3395-C20	3395-C40	3995-023
DISK/TREND GROUP	54	54	52	52	52
MARKET	Captive, OEM	Captive, OEM	Captive, PCM	Captive, PCM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2600	2600	650/1300/2600	650/1300/2600	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunction	Multifunction	Multifunction
Drive models	Hitachi OL-F172S/D21	Hitachi OL-F172S/D21	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC
LIBRARY CONFIGURATION: Attachment	Host	Host	Net	Host	Net
Minimum disk capacity (units)	270	228	20	20	32
Maximum disk capacity (units)	306*	264*	20	20	32
Number of drives: Maximum	8	8	2	2	2
Interface: Library	SCSI-2	SCSI-2	Ethernet, TR	SCSI-2	Ethernet, TR
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	797	688	52	52	40
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Dual X-Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	8	5.6	5.6	7
Spin-up + drive ready time (sec)	5	5	3	3	3
Spin-down time (sec)	2.5	2.5	1.3	1.3	1.3
Average drive access time (msec)	49	49	41.5	41.5	41.5
Drive data transfer rate (MB/s)	2.3-4.6	2.3-4.6	1.272	1.272	1.561
FIRST CUSTOMER SHIPMENT	1997	1997	4Q96	4Q96	8/93
COMMENTS	*With 2 drives. Available only with differential SCSI.	*With 2 drives. Available only with differential SCSI.	Plasmon mechanism. Rewritable and WORM media.	Plasmon mechanism. Attaches to AS/400.	Hewlett-Packard mechanism. Rewritable and WORM media.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	3995-063	3995-A23	3995-A63	3995-C60	3395-C22
DISK/TREND GROUP	52	52	52	52	53
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, PCM	Captive, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	1300	650/1300/2600	650/1300/2600
Cartridge type	ISO	ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	IMB 0632-CHC	IBM 0632-CHC
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Net
Minimum disk capacity (units)	32	16	16	20	52
Maximum disk capacity (units)	32	16	16	20	52
Number of drives: Maximum	2	1	1	1	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	Ethernet, TR SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	40	20	20	52	135
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)	7	7	7	5.2	5.2
Spin-up + drive ready time (sec)	3	3	3	5.5	3
Spin-down time (sec)	1.3	1.3	1.3	3.5	1.3
Average drive access time (msec)	41.5	41.5	41.5	33.3	41.5
Drive data transfer rate (MB/s)	1.561	1.561	1.561	2.0-4.0	1.272
FIRST CUSTOMER SHIPMENT	8/93	10/93	6/94		4Q96
COMMENTS	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.	For RS/6000. Hewlett-Packard mechanism. Rewritable and WORM media.	Plasmon mechanism.	Plasmon mechanism. Rewritable and WORM media.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	3395-C42	3995-C12 3995-C32	3995-C62	3395-C24	3395-C26
DISK/TREND GROUP	53	53	53	54	54
MARKET	Captive, PCM	Captive, PCM	Captive, PCM	Captive, PCM	Captive, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650/1300/2600	650/1300/2600	650/1300/2600	650/1300/2600	650/1300/2600
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/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 CONFIGURATION: Attachment	Host	Host	Host	Net	Net
Minimum disk capacity (units)	52	52	52	104	156
Maximum disk capacity (units)	52	52	52	104	156
Number of drives: Maximum	2	3 (2 for C12)	2	4	6
Interface: Library Drive	SCSI-2 SCSI-2	S/390 SCSI-2	SCSI-2 SCSI-2	Ethernet, TR SCSI-2	Ethernet, TR SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	135	135	135	270	405
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	5.2	5.2	5.2	5.6	5.6
Spin-up + drive ready time (sec)	3	3	5.5	3	3
Spin-down time (sec)	1.3	1.3	3.5	1.3	1.3
Average drive access time (msec)	41.5	41.5	33.3	41.5	41.5
Drive data transfer rate (MB/s)	1.272	1.272	2.0-4.0	1.272	1.272
FIRST CUSTOMER SHIPMENT	4Q96	4Q96		4Q96	4Q96
COMMENTS		Plasmon mechanism. C12 is expansion unit. For DFSMS/MVS systems.	Plasmon mechanism.	Plasmon mechanism. Rewritable and WORM media.	Plasmon mechanism. Rewritable and WORM media.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	3395-C28	3995-113	3995-123	3995-133	3995-163
DISK/TREND GROUP	54	54	54	54	54
MARKET	Captive, PCM	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)	650/1300/2600	1300	1300	1300	1300
Cartridge type	ANSI/ISO	ISO	ANSI/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 CONFIGURATION: Attachment	Net	Host	Net	Host	Host
Minimum disk capacity (units)	258	144	144	144	144
Maximum disk capacity (units)	258	144	144	144	144
Number of drives: Maximum	6	4	5	5	4
Interface: Library Drive	Ethernet, TR SCSI-2	SCSI SCSI	Ethernet, TR SCSI	S/370* SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	671	188	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	2	1	1	1	1
Average media exchange time (sec)	6.2	8	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
Drive data transfer rate (MB/s)	1.272	1.272	1.561	1.561	1.561
FIRST CUSTOMER SHIPMENT	4Q96	6/93	8/93	1Q94	1Q94
COMMENTS	Plasmon mechanism. Rewritable and WORM media.	Expansion unit for libraries. Hewlett-Packard mechanism. Rewritable and WORM media.	Hewlett-Packard mechanism. Rewritable and WORM media.	For MVS/ES systems. Hewlett-Packard mechanism. *OEMI channel, ESCON channel.	For RS/6000. Hewlett-Packard mechanism. Rewritable and WORM media.

MANUFACTURER		IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY		3995-C16 3995-C36	3995-C18 3995-C38	3995-C34	3995-C44	3995-C46
DISK/TREND GROUP		54	54	54	54	54
MARKET		Captive, PCM	Captive, PCM	Captive, PCM	Captive	Captive
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (MB)	650/1300/2600	650/1300/2600	650/1300/2600	2600	2600
	Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/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	IBM 0632
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	156	258	104	104	104
	Maximum disk capacity (units)	156	258	104	104	104
	Number of drives: Maximum	7 (6 for C16)	7 (6 for C18)	5	2	4
	Interface: Library Drive	S/390 SCSI-2	S/390 SCSI-2	S/390 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
	Library capacity (Gbytes) (with maximum disk capacity)	405	671	270	270	270
	Import/export module (disks)	1	1	1	1	1
PERFORMANCE						
	Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
	Pickers per positioner	2	2	2	2	2
	Average media exchange time (sec)	5.6	6.2	5.6	5.4	5.4
	Spin-up + drive ready time (sec)	3	3	3	5.5	5.5
	Spin-down time (sec)	1.3	1.3	1.3	3.5	3.5
	Average drive access time (msec)	41.5	41.5	41.5	33.3	33.3
	Drive data transfer rate (MB/s)	1.272	1.272	1.272	2-4	2-4
FIRST CUSTOMER SHIPMENT		4Q96	4Q96	4Q96	2/97	5/97
COMMENTS		Plasmon mechanism. C16 is expansion unit. For DFSMS/MVS systems.	Plasmon mechanism. C18 is expansion unit. For DFSMS/MVS systems.	Plasmon mechanism. For DFSMS/MVS systems.	Plasmon mechanism. For AS/400.	Plasmon mechanism. For AS/400. Upgrade from C44.

MANUFACTURER	IBM	IBM	IBM	IBM	JVC
OPTICAL LIBRARY	3995-C48	3995-C64	3995-C66	3995-C68	MC-1200
DISK/TREND GROUP	54	54	54	54	50
MARKET	Captive	Captive, PCM	Captive, PCM	Captive, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	120 mm
Nominal disk capacity (MB)	2600	650/1300/2600	650/1300/2600	650/1300/2600	650
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	None
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	CD-ROM, CD-R
Drive models	IBM 0632	IBM 0632	IBM 0632	IBM 0632	Plextor
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	258	104	156	258	50
Maximum disk capacity (units)	258	104	156	258	200
Number of drives: Maximum	4	2	4	4	6
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)	671	270	405	671	130
Import/export module (disks)	1	1	1	1	1/50
PERFORMANCE					
Positioner type	X-Y axis with pivot	X-Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	2	2	2	2	1
Average media exchange time (sec)	6	5.4	5.8	6	8
Spin-up + drive ready time (sec)	5.5	5.5	5.5	5.5	
Spin-down time (sec)	3.5	3.5	3.5	3.5	
Average drive access time (msec)	33.3	33.3	33.3	33.3	150/400
Drive data transfer rate (MB/s)	2-4	2.0-4.0	2.0-4.0	2.0-4.0	1.2*
FIRST CUSTOMER SHIPMENT	2/97				2Q97
COMMENTS	Plasmon mechanism. For AS/400.	Plasmon mechanism.	Plasmon mechanism.	Plasmon mechanism.	*CD-R drives are 4X Read, 2X Write. CD-ROM drives are 8X.

MANUFACTURER	JVC	KUBIK ENTERPRISES	KUBIK ENTERPRISES	KUBIK ENTERPRISES	KUBOTA
OPTICAL LIBRARY	MC-1600	CD Tower	CDR240M CDR240MA	MO-120	K2020
DISK/TREND GROUP	50	50	50	54	52
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	650	650	2600	2600
Cartridge type	None	N/A	N/A	N/A	ANSI/ISO
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	Rewritable	Multifunct-(MO)
Drive models	Plextor	Toshiba, Plextor	Toshiba, Plextor	Sony	Kubota
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	50	480	240	120	20
Maximum disk capacity (units)	600	1680	240	120	20
Number of drives: Maximum	6	28	4	4	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI, RS232C SCSI	SCSI, RS232C SCSI	SCSI, RS232C SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	390	1092	156	312	52
Import/export module (disks)	1/50	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Rotary	Rotary	Rotary	Y axis
Pickers per positioner	1	1-4	1-4	1-4	1
Average media exchange time (sec)	8	7	7	8	4
Spin-up + drive ready time (sec)		1	1	2	4.5
Spin-down time (sec)		1	1	2	2.5
Average drive access time (msec)	150/400	Drive dependent	Drive dependent	Drive dependent	19
Drive data transfer rate (MB/s)	1.2*	.614/1.8	.614/1.8	Drive dependent	4.65
FIRST CUSTOMER SHIPMENT	2Q97	1995	1992	4Q97	1996
COMMENTS	*CD-R drives are 4X Read, 2X Write. CD-ROM drives are 8X.	Contains 2 to 7 CDR240.	CDR240MA is rack mount version.	Rack mount available. No cartridge required.	Sold in Japan

MANUFACTURER	KUBOTA	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
OPTICAL LIBRARY	K4020	SQ-TC510N	SQ-TC512F	SQ-TC512N	LF-J100A2
DISK/TREND GROUP	53	50	50	50	50
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	2600	656	650	650	650/668*
Cartridge type	ANSI/ISO	None	Magazine	Magazine	Magazine
DRIVE: Type	Multifunct-(MO)	CD-ROM	CD-ROM	CD-ROM	PD
Drive models	Kubota	MEI (10X)	MEI (12X)	MEI (12X)	MEI LF1004 (4X)
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	40	5	5	5	100
Maximum disk capacity (units)	40	5	5	5	100
Number of drives: Maximum	2	1	1	1	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	104	3.2	3.25	3.25	66.8
Import/export module (disks)	1	5	1/5	1/5	1/10
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1			2
Average media exchange time (sec)	4	5			6
Spin-up + drive ready time (sec)	4.5				6
Spin-down time (sec)	2.5				3
Average drive access time (msec)	19	130	130	130	179.8
Drive data transfer rate (MB/s)	4.65	1.5	1.8	1.8	0.518-1.141
FIRST CUSTOMER SHIPMENT	1997	11/96	6/97	5/97	7/96
COMMENTS	Sold in Japan	1.625" high.	128K buffer.	128K buffer.	10 disk magazine. *CD-ROM mode.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MAXOPTIX	MAXOPTIX	MAXOPTIX	MAXOPTIX
OPTICAL LIBRARY	LF-J50A2	MX520	PX520	MX335	MX540
DISK/TREND GROUP	50	52	52	53	53
MARKET	PCM	OEM, PCM	OEM	PCM	PCM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	86 mm	130 mm
Nominal disk capacity (MB)	650/668*	2600	2600	640	2600
Cartridge type	Magazine	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	PD	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)	Rewritable-(MO)
Drive models	MEI LF1004 (4X)	Maxoptix T4-2600	Maxoptix T4-2600	Fujitsu	Maxoptix T4-2600
LIBRARY CONFIGURATION: Attachment	Host	--	Net	Host	Host
Minimum disk capacity (units)	50	20	20		40
Maximum disk capacity (units)	50	20	20		40
Number of drives: Maximum	2	2	2		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)	33.4				
Import/export module (disks)	1/10				
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	X axis	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	6	4	2.6		4
Spin-up + drive ready time (sec)	6	4.5	4.5	4.5	4.5
Spin-down time (sec)	3	2.5	2.5	2.5	2.5
Average drive access time (msec)	179.8	19			19
Drive data transfer rate (MB/s)	0.518-1.41	4.65	4.65		4.65
FIRST CUSTOMER SHIPMENT	7/96				
COMMENTS	10 disk magazine. *CD-ROM mode.	Kubota mechanism.	Kubota mechanism.	Fujitsu mechanism.	Kubota mechanism.

MANUFACTURER	MAXOPTIX	NAKAMICHI	NAKAMICHI	NAKAMICHI	NEC
OPTICAL LIBRARY	PX552	MJ-4.8S	MJ5.16	MJ5.16S	N1137-58
DISK/TREND GROUP	53	50	50	50	52
MARKET	OEM	PCM	OEM	OEM, PCM	Captive
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (MB)	2600	650	650	650	1300
Cartridge type	ANSI/ISO	None	None	None	ANSI/ISO
DRIVE: Type	Rewritable-(MO)	CD-ROM	CD-ROM (16X)	CD-ROM (16X)	Rewritable
Drive models	Maxoptix T4-2600	Nakamichi			NEC N1137-57
LIBRARY CONFIGURATION: Attachment	Net	Host	Host	Host	Host
Minimum disk capacity (units)	52	4	5	5	4
Maximum disk capacity (units)	52	4	5	5	4
Number of drives: Maximum	2	1	1	1	1
Interface: Library	SCSI-2	SCSI	IDE/ATAPI	SCSI-2	SCSI
Drive	SCSI-2		IDE/ATAPI	SCSI-2	SCSI
Library capacity (Gbytes) (with maximum disk capacity)		2.6	3.25	3.25	5.2
Import/export module (disks)		1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	2.6	4			6
Spin-up + drive ready time (sec)					8
Spin-down time (sec)					5
Average drive access time (msec)		150			42
Drive data transfer rate (MB/s)	4.65	1.2	1.8-2.4	1.8-2.4	3.0
FIRST CUSTOMER SHIPMENT		6/96	2Q97	2Q97	1993
COMMENTS	Plasmon mechanism.	43 mm high.	128K buffer.	256K buffer.	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
OPTICAL LIBRARY	OL5120	OL5220	N7925-84	OL5260	OL5453
DISK/TREND GROUP	52	52	53	53	53
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	1300	1300	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO	ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	NEC	NEC	NEC	NEC	NEC
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	20	20	60	60	53
Maximum disk capacity (units)	20	20	60	60	53
Number of drives: Maximum	1	2	2	2	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	26	26	78	78	69
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	2	2	2
Average media exchange time (sec)	5.5	5.5	8	8	8
Spin-up + drive ready time (sec)	8	8	8	8	8
Spin-down time (sec)	5	5	5	5	5
Average drive access time (msec)	29	29	42	39	39
Drive data transfer rate (MB/s)	5.0	5.0	3.0	5.0	5.0
FIRST CUSTOMER SHIPMENT	10/95	10/95	1995	1995	1995
COMMENTS					

MANUFACTURER	NEC	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS
OPTICAL LIBRARY	N3661-XX	CDR-4300	CDR-4400	CDR-C251 MultiSpin 4X4	CDR-C302 MultiSpin 4Xc CD Jukebox
DISK/TREND GROUP	54	50	50	50	50
MARKET	Captive	OEM, PCM	PCM	OEM, PCM	PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm/80 mm
Nominal disk capacity (MB)	2600	680	680	650	680
Cartridge type	ANSI/ISO	None	None	None	None
DRIVE: Type	Rewritable-(MO)	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Drive models	NEC ODD160	NEC	NEC	NEC	NEC MultiSpin 4
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	193	4	4	4	7
Maximum disk capacity (units)	889	4	4	4	7
Number of drives: Maximum	10	1	1	1	1
Interface: Library Drive	NEC Proprietary SCSI-2	IDE/ATAPI IDE/ATAPI	IDE/ATAPI	IDE/ATAPI IDE/ATAPI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	2300	2.6	2.6	2.6	4.8
Import/export module (disks)	2	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)		4	4	4	2.5
Spin-up + drive ready time (sec)	2.5	2	2	2	2
Spin-down time (sec)	5	1	1	1	1
Average drive access time (msec)	45	165	150	250	380
Drive data transfer rate (MB/s)	1.69-3.38	.9	1.2	.6	.6
FIRST CUSTOMER SHIPMENT	9/96	2Q96	4Q96		2Q95
COMMENTS		Slot loading.	Slot loading.	MS, XA, CD-I compatibility. Nakamichi mechanism. Slot loading.	128K buffer. Nakamichi mechanism. Slot loading.

MANUFACTURER	NIPPON COLUMBIA (DENON)	NIPPON COLUMBIA (DENON)	NISTEC	NSM	NSM
OPTICAL LIBRARY	DRD-1400	DRD-1408	ALW-501	CDR 100 Recordable	CDR 100 XA
DISK/TREND GROUP	50	50	50	50	50
MARKET	PCM	OEM, PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650	650	650	650	650
Cartridge type	None	None	None	Magazine	Magazine
DRIVE: Type	CD-ROM	CD-ROM	CD-R	CD-R	CD-ROM
Drive models		Plextor 8X	Philips CDD 2000	Yamaha CDR-400*	TEAC*
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	200	200	--	100	100
Maximum disk capacity (units)	200	200	50	100	100
Number of drives: Maximum	2	2	1	1	1
Interface: Library Drive	SCSI-2, RS232 SCSI-2	SCSI-2 SCSI-2	RS232C SCSI-2	RS232 SCSI-2	RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	130	130	N/A	65	65
Import/export module (disks)	1/100	1/100	1/50	1/50	1/50
PERFORMANCE					
Positioner type	X axis	X axis	Y axis,	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	25	19.5	NS	4.5	4.5
Spin-up + drive ready time (sec)	2		NS	1.5	1.5
Spin-down time (sec)	2		NS	1.0	1.0
Average drive access time (msec)	.3	150	300	250	150
Drive data transfer rate (MB/s)	.3	1.2	.6	.6 WR/.9 RD	2.4*
FIRST CUSTOMER SHIPMENT	2096	1996	1996	3/94	1/94
COMMENTS			Recorder/ transport.	*After 6/97.	*After 5/97.

MANUFACTURER	NSM	NSM	NSM	NSM	NSM
OPTICAL LIBRARY	Mercury Net	Mercury-20	Mercury-31	Mercury-40 Mercury-40 Net	Satellite
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)	650	650	650	650	650
Cartridge type	Magazine	Magazine	Magazine	Magazine	Magazine
DRIVE: Type	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R
Drive models	Plextor*	Plextor*	Plextor (3)* Yamaha (1)*	Plextor	Plextor, Yamaha
LIBRARY CONFIGURATION: Attachment	Net	Host	Host	Host, Net	Host
Minimum disk capacity (units)	150	150	150	150	60
Maximum disk capacity (units)	150	150	150	150	135*
Number of drives: Maximum	4	2	4	4	5
Interface: Library Drive	Ethernet, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232* SCSI-2	SCSI-2, RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	100	100	100	100	90
Import/export module (disks)	1/50	1/50	1/50	1/50	1/15
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)	>3	>3	>3	>3	2.5
Spin-up + drive ready time (sec)	.150	1.5	.150/.500	1.5	1.5
Spin-down time (sec)		1.5		1.5	1.5
Average drive access time (msec)	110	110	110/250	110	110/250
Drive data transfer rate (MB/s)	1.8	1.8	1.8/.6	1.8	1.8/.6
FIRST CUSTOMER SHIPMENT	1/96	4Q94	4/95	4Q94	5/97
COMMENTS	Novell network ready. *After 4/97.	*After 5/97.	*After 4/97.	*Net version interfaces Ethernet.	*With 1 drive.

MANUFACTURER		PFU	PFU	PHILIPS LMS	PHILIPS LMS	PIONEER
OPTICAL LIBRARY		MC700A	MC700B	LF 6600	LF 6602	DRJ-5004X
DISK/TREND GROUP		52	52	52	52	50
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	86 mm	86 mm	12"	12"	120 mm
	Nominal disk capacity (MB)	230	230	12000	12000	650
	Cartridge type	ISO	ISO	Philips LMS	Philips LMS	N/A
DRIVE:	Type	Rewritable	Rewritable	Write Once	Write Once	CD-ROM, CD-R
	Drive models	Fujitsu	Fujitsu	Philips LMS LD 6100	Philips LMS LD 6100	Pioneer D504X Pioneer R504X
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	32	32	6	12	100
	Maximum disk capacity (units)	32	32	6	12	500
	Number of drives: Maximum	1	2	1	2	4
	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)	7.4	7.4	72	144	325
	Import/export module (disks)	32	32	6	6	100
PERFORMANCE						
	Positioner type	X axis	X axis	Moving Magazine	Moving Magazine	Y axis
	Pickers per positioner	1	1	N/A	N/A	1
	Average media exchange time (sec)	3	6	2.5	2.5	18
	Spin-up + drive ready time (sec)	2	2	3	3	3
	Spin-down time (sec)	1	1	1.5	1.5	2
	Average drive access time (msec)	30	30	100	100	300
	Drive data transfer rate (MB/s)	1.3-2.1	1.3-2.1	2.7	2.7	.614
FIRST CUSTOMER SHIPMENT		1994	1994	2Q95	2Q95	3Q94
COMMENTS		Purchased mechanism.	Purchased mechanism.	Dual head drive	Dual head drive	

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
OPTICAL LIBRARY	DRM-1004X40 DRM-1004XR21	DRM-1804X	DRM-5002R2W	DRM-5003R1W	DRM-5004X4R
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)	650	650	650	650	650
Cartridge type	Magazine	N/A	N/A	N/A	N/A
DRIVE: Type	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM
Drive models	Pioneer	Pioneer (integrated with drive)	Pioneer	Pioneer	Pioneer 4X
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	50	18	100	100	100
Maximum disk capacity (units)	100	18	500	500	500
Number of drives: Maximum	4*	1	4*	4*	4
Interface: Library Drive	SCSI-2	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	65	11.7	325	325	325
Import/export module (disks)	1/50	18	100	100	100
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)	5	5	29	29	29
Spin-up + drive ready time (sec)	3 RD/4 WR	3	2	2	2
Spin-down time (sec)	2 RD/1.5 WR	2	1	1	1
Average drive access time (msec)	110 RD/650 WR	300			300
Drive data transfer rate (MB/s)	.614 WR/.673 RD	.614/.154			.614
FIRST CUSTOMER SHIPMENT	9/96	4Q93			4Q94
COMMENTS	*4 CD-ROM (X40) 2 CD-ROM plus 1 CD-R (XR21). DVD-ROM option.		*2 CD-ROM, 2 CD-R.	*3 CD-ROM, 1 CD-R.	

MANUFACTURER		PIONEER	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY		DRM-624X	C120-22	C120-40	C240-42	C240-60
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)	650	650	650	650	650
	Cartridge type	N/A	None	None	None	None
DRIVE:	Type	CD-ROM	CD-ROM, CD-R	CD-ROM (8X)	CD-ROM, CD-R	CD-ROM (8X)
	Drive models	Pioneer 24X (integrated with drive)	Various	Various	Various	Various
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	6	120	120	240	240
	Maximum disk capacity (units)	6	120	120	240	240
	Number of drives: Maximum	1	4*	4	6*	6*
	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)	3.9	78	78	156	156
	Import/export module (disks)	6	1/10	1/10	1/10	1/10
PERFORMANCE						
	Positioner type	NS	Y axis	Y axis	Y axis	Y axis
	Pickers per positioner	1	2	2	2	2
	Average media exchange time (sec)	5	3	3	3	3
	Spin-up + drive ready time (sec)	NS				
	Spin-down time (sec)	NS				
	Average drive access time (msec)	90	160/260	160	160/260	160
	Drive data transfer rate (MB/s)	1.8-3.6	1.2/6.0	1.2	1.2/6.0	1.2
FIRST CUSTOMER SHIPMENT		3Q97	1Q97		1Q97	1Q97
COMMENTS		128K buffer.	*2 CD-ROM (8X), 2 CD-R (2X/4X).		*4 CD-ROM, 2 CD-R.	*4 CD-ROM, 2 CD-R.

MANUFACTURER		PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY		C480-42	C480-60	D120	C120-P4	C240-P6
DISK/TREND GROUP		50	50	50	50	50
MARKET		PCM	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)	650	650	650	650	650
	Cartridge type	None		None	None	None
DRIVE:	Type	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R	PD	PD
	Drive models	Various	Various	Matsushita, other	Matsushita	Matsushita
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)			120	120	240
	Maximum disk capacity (units)	480	480	120	120	240
	Number of drives: Maximum	6*	6*	4	4	6
	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)	312	312		78	156
	Import/export module (disks)	1/10	1/10	1/10	1/10	1/10
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)	3	3	3	3	3
	Spin-up + drive ready time (sec)			Drive dependent		
	Spin-down time (sec)			Drive dependent		
	Average drive access time (msec)			Drive dependent	177/207	177/207
	Drive data transfer rate (MB/s)			1.25	9.0/1.441	9.0/1.441
FIRST CUSTOMER SHIPMENT		1Q97	1Q97	2Q97	1Q97	1Q97
COMMENTS		*4 CD-ROM, 2 CD-R.	*6 CD-ROM drives.		Reads CD-ROM at 6X.	

MANUFACTURER		PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY		C480-P6	D240	D480	M20-260-X	M20J-695
DISK/TREND GROUP		50	50	50	52	52
MARKET		PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
MEDIA:	Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
	Nominal disk capacity (MB)	650	650	650	2600	2600
	Cartridge type		None	None	ANSI/ISO	ANSI/ISO/Panas.
DRIVE:	Type	PD	PD	PD	Wr.Once,Rewrit.	Wr.Once,Rewrit.
	Drive models	Matsushita	Matsushita, other	Matsushita, other		
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)		240	480	20	20
	Maximum disk capacity (units)	480	240	480	20	20
	Number of drives: Maximum	6*	6	6	2	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)	312			52	52
	Import/export module (disks)	1/10	1/10	1/10	1	1
PERFORMANCE						
	Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
	Pickers per positioner	2	2	2	1	1
	Average media exchange time (sec)	3	3	3	5.4	5.4
	Spin-up + drive ready time (sec)		Drive dependent	Drive dependent	3.6	2.5
	Spin-down time (sec)		Drive dependent	Drive dependent		2.2
	Average drive access time (msec)		Drive dependent	Drive dependent		25
	Drive data transfer rate (MB/s)		1.25	1.25		5.0 synch.
FIRST CUSTOMER SHIPMENT			2Q97	2Q97		
COMMENTS		*6 PD drives.			4 MB buffer. Direct overwrite.	

MANUFACTURER		PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY		M32-260-X	M32J-695	M52-260-X	M104-260-X	M104J-695
DISK/TREND GROUP		52	52	53	54	54
MARKET		OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (MB)	2600	2600	2600	2600	1300/1500/2600
	Cartridge type	ANSI/ISO	ANSI/ISO/Panas.	ANSI/ISO	ANSI/ISO	ANSI/ISO/Panas.
DRIVE:	Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
	Drive models					Various
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	32		52	104	104
	Maximum disk capacity (units)	32	32	52	104	120*
	Number of drives: Maximum	2	2	2	4	4
	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)	83	83	135	270	270
	Import/export module (disks)					1
PERFORMANCE						
	Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
	Pickers per positioner	1	1	2	2	1
	Average media exchange time (sec)	5.8	6	1.85	2	4
	Spin-up + drive ready time (sec)	3.6	2.5	3.6	3.6	Drive dependent
	Spin-down time (sec)		2.2			Drive dependent
	Average drive access time (msec)		25			Drive dependent
	Drive data transfer rate (MB/s)		5.0 synch.			Drive dependent
FIRST CUSTOMER SHIPMENT						4/94
COMMENTS						*Depends upon drive height.

MANUFACTURER		PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	REGAL ELECTRONICS
OPTICAL LIBRARY		M156-260-X	M156J-695	M258-260-X	M285J-695E	CDC-4Xi
DISK/TREND GROUP		54	54	54	54	50
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	120 mm/80 mm
	Nominal disk capacity (MB)	2600	1300/1500/2600	2600	1300/1500/2600	540/630
	Cartridge type	ANSI/ISO	ANSI/ISO/Panas.	ANSI/ISO	ANSI/ISO/Panas.	Magazine
DRIVE:	Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	CD-ROM (4X)
	Drive models		Various		Various	
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	156	156	258	258	5
	Maximum disk capacity (units)	156	180*	258	300*	5
	Number of drives: Maximum	6	6	6	6	1
	Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI
	Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	
	Library capacity (Gbytes) (with maximum disk capacity)	406	405	671	670	2.7/3.1
	Import/export module (disks)		1		1	5
PERFORMANCE						
	Positioner type	Y axis	Y axis	Y axis with pivot	Y axis	Y axis
	Pickers per positioner	2	1	2		1
	Average media exchange time (sec)	2.45	4	2.65	4	5
	Spin-up + drive ready time (sec)	3.6	Drive dependent	3.6	Drive dependent	
	Spin-down time (sec)		Drive dependent		Drive dependent	
	Average drive access time (msec)		Drive dependent		Drive dependent	220
	Drive data transfer rate (MB/s)		Drive dependent		Drive dependent	.614
FIRST CUSTOMER SHIPMENT			4/94		6/94	2Q96
COMMENTS			*Depends upon drive height.		*Depends on drive height.	256K buffer. Fits half 5.25" height slot.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
OPTICAL LIBRARY	CDL 1100-20	CDL 2100-22 Fyla	CDL 2100-40 Fyla	CDL 2200-04 Fyla	CDL 2200-22 Fyla
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)	650	650	650	650	650
Cartridge type	None	None	None	None	None
DRIVE: Type	CD-ROM 12X	CD-ROM, CD-R	CD-ROM	CD-R	CD-ROM, CD-R
Drive models	Sony	Sony 6X RD/4X WR	Sony 12X	Sony 6X RD, 4X WR	Sony 6X RD, 4X WR
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)		125	125	225	225
Maximum disk capacity (units)	100	125	125	250	250
Number of drives: Maximum	2	6*	6*	6*	6*
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)	65	81.25	81.25	146.25	146.25
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	12.2	4	4	4	4
Spin-up + drive ready time (sec)	4	4	4	4	4
Spin-down time (sec)	2	2	2	2	2
Average drive access time (msec)	130	250			250
Drive data transfer rate (MB/s)	1.2-1.8	.6 RD/.3 WR	.6	.6 RD/.3 WR	.6 RD/.3 WR
FIRST CUSTOMER SHIPMENT	6/97	6/97	2Q97	6/97	6/97
COMMENTS		*4 standard.	*4 standard.	*4 standard.	*4 standard.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
OPTICAL LIBRARY	CDL 2200-40 Fyla	OSL 2001-11	OSL 2001-12 OSL 2001-22	OSL 2001-21	OSL 2500-12
DISK/TREND GROUP	50	52	52	52	52
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	1300	2600	1300	2600
Cartridge type	None	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	Sony 12X	Sony SMO-F531	Sony SMO-F541	Sony SMO-F531	Sony SMO-F541
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	225	20	20	20	25
Maximum disk capacity (units)	250	20	20	20	25
Number of drives: Maximum	6*	1	2	2	1
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	146.25	26	52	26	65
Import/export module (disks)	1	1/10	1/10	1/10	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)	4	5	5	5	5
Spin-up + drive ready time (sec)	4	2.5	2.5	2.5	2.5
Spin-down time (sec)	2	2	2.2	2	2.2
Average drive access time (msec)		47	29	47	33
Drive data transfer rate (MB/s)	.6	2.4	4.06	2.4	4.0, 5.0 synch.
FIRST CUSTOMER SHIPMENT	2Q97	1994	3/96	1994	2Q97
COMMENTS	*4 standard.				

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
OPTICAL LIBRARY	OSL 2500-22	OSL 6000-21	OSL 6000-22 OSL 6000-42	OSL 6000-41	OSL 10000
DISK/TREND GROUP	52	53	53	53	54
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2600	1300	2600	1300	2600
Cartridge type	ANSI/ISO	ISO/ANSI	ISO/ANSI	ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	Sony SMO-F541	Sony SMO-F541	Sony SMO-F541	Sony SMO-F531	Sony 540
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	25	60	50	50	
Maximum disk capacity (units)	25	60	60	50	104
Number of drives: Maximum	2	2	4	4	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2	SCSI-2 SCSI-2	SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	65	78	156	65	270
Import/export module (disks)	1		1/10	1/10	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)	5	4	5	4	4
Spin-up + drive ready time (sec)	2.5	2.5	2.5	2.5	2.5
Spin-down time (sec)	2.2	2	2.2	2	2.2
Average drive access time (msec)	33	47	29	47	33
Drive data transfer rate (MB/s)	4.0, 5.0 synch.	2.4	4.06	2.4	4.0/5.0 synch.
FIRST CUSTOMER SHIPMENT	2Q97	4Q95	3/96	4Q95	4Q96
COMMENTS					Purchased mechanism.

MANUFACTURER	SONY	SONY	TEAC	TILTRAC	TILTRAC
OPTICAL LIBRARY	OSL 15000	OSL 25000	CD-C68E	M3T CDMultiServer	M3T14-200
DISK/TREND GROUP	54	54	50	50	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	2600	2600	650	650	650
Cartridge type	ANSI/ISO	ANSI/ISO	None	None	None
DRIVE: Type	Multifunction	Multifunction	CD-ROM 8X	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Sony 540	Sony 540	TEAC	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)			6	100	200
Maximum disk capacity (units)	156	258	6	250	200
Number of drives: Maximum	6	6	1	28*	14
Interface: Library			IDE/ATAPI	RS232C	RS232C
Drive			IDE/ATAPI	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	405	670	3.9	162.5	130
Import/export module (disks)	1	1	1	1	1/50
PERFORMANCE					
Positioner type	Y axis	Y axis with pivot	Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	1	1	1
Average media exchange time (sec)	4	4	6	6	6
Spin-up + drive ready time (sec)	2.5	2.5	2	Drive dependent	Drive dependent
Spin-down time (sec)	2.2	2.2	2	Drive dependent	Drive dependent
Average drive access time (msec)	33	33	190	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	4.0/5.0 synch.	4.0/5.0 synch.	1.2	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	9/96	2Q96	1Q97
COMMENTS	Purchased mechanism.	Purchased mechanism.	128K buffer.	*7 drives minimum.	

MANUFACTURER	TILTRAC	TILTRAC	TILTRAC	TILTRAC	TILTRAC
OPTICAL LIBRARY	M3T21-150	M3T28-100	M3T7-250	M6T CDMultiServer	M6T14-500
DISK/TREND GROUP	50	50	50	50	50
MARKET	PCM	PCM	PCM	OEM, PCM	PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650	650	650	650	650
Cartridge type	None	None	None	None	None
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 CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	150	100	250	300	500
Maximum disk capacity (units)	150	100	250	550	500
Number of drives: Maximum	21	28	7	42*	14
Interface: Library Drive	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	97.5	65	162.5	357.5	325
Import/export module (disks)	1/50	1/50	1/50	1	1/50
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	10 X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	6	6	10	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
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	1Q97	1Q97	1Q97	2Q96	1Q97
COMMENTS				*7 drives minimum.	

MANUFACTURER	TILTRAC	TILTRAC	TILTRAC	TILTRAC	TILTRAC
OPTICAL LIBRARY	M6T21-450	M6T28-400	M6T35-350	M6T42-300	M6T7-550
DISK/TREND GROUP	50	50	50	50	50
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650	650	650	650	650
Cartridge type	None	None	None	None	None
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 CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	450	400	350	300	550
Maximum disk capacity (units)	450	400	350	300	550
Number of drives: Maximum	21	28	35	42	7
Interface: Library Drive	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	292.5	260	227.5	195	357.5
Import/export module (disks)	1/50	1/50	1/50	1/50	1/50
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)	10	10	10	10	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
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	1Q97	1Q97	1Q97	1Q97	1Q97
COMMENTS					

MANUFACTURER	TODD ENTERPRISES				
OPTICAL LIBRARY	TAJ-2000				
DISK/TREND GROUP	50				
MARKET	OEM, PCM				
MEDIA: Nominal disk diameter	120 mm				
Nominal disk capacity (MB)	680				
Cartridge type	Caddy				
DRIVE: Type	CD-ROM				
Drive models	Hitachi CDR-6750				
LIBRARY CONFIGURATION: Attachment	Net				
Minimum disk capacity (units)	174				
Maximum disk capacity (units)	203				
Number of drives: Maximum	14				
Interface: Library	Ethernet				
Drive	SCSI				
Library capacity (Gbytes) (with maximum disk capacity)	132				
Import/export module (disks)	--				
PERFORMANCE					
Positioner type	X-Y axis				
Pickers per positioner	1				
Average media exchange time (sec)	12				
Spin-up + drive ready time (sec)	8-9				
Spin-down time (sec)	2				
Average drive access time (msec)	235				
Drive data transfer rate (MB/s)	.307				
FIRST CUSTOMER SHIPMENT	1994				
COMMENTS	UNIX server.				

1997 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing optical disk drives or optical disk libraries, or those which are expected to 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 1996, this figure is reported explicitly only for firms with major 1996 optical disk drive or library sales. "1996 total net sales" covers the fiscal year ending in 1996 for each manufacturer unless noted otherwise, or for the parent company if the manufacturer is a subsidiary. All fiscal years end on December 31, 1996, 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 rates for 1996 are used, as reported by the U.S. Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
Canada	Canadian dollar	1.36
France	French franc	5.12
Germany	Deutschmark	1.50
Hong Kong	Hong Kong dollar	7.73
Japan	Yen	108.8
Malaysia	Ringgit	2.52
Netherlands	Guilder	1.69
Singapore	Singapore dollar	1.41
South Korea	Won	805.0
Taiwan	Taiwan dollar	27.5
United Kingdom	Pound	0.64

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

U.S. Manufacturers

ABANTE CORPORATION
2045 Calmwater Court
Suwanee GA 30174

Abante, founded in 1995, offers a CD tower capable of interfacing up to 64 personal computers using a proprietary interconnect method licensed from Rexas, a Japanese company. The basic model handles up to 7 drives, but can be expanded to include 19 drives. The company also designs CD-R duplication systems and offers a variety of engineering services related to CD format drives.

ADVANCED MEDIA SERVICES
10 Upton Drive
Wilmington, MA 01887

AMS, founded in 1991, integrates storage subsystems, including disk drive arrays and CD-ROM towers. Both host attached and network attached towers are available, as are towers with Nakamichi minichangers instead of standard CD-ROM drives.

ATRONICS INTERNATIONAL
44700-B Industrial Drive
Fremont, CA 94086

ATronics, established in 1984, has concentrated on mother boards, chips and controllers for the IBM compatible PC market. Engineering is centered in the U.S., while production of components and boards is done in various locations offshore. Subsystems, such as the firms networked CD-ROM towers are produced in Fremont. First shipments were in late 1995. Other storage products include portable CD-ROM and rigid disk drive packages, some with PCMCIA interfaces for expansion of notebook computer systems.

ATronics provides versions of its networked CD-ROM tower with either IDE or SCSI interfaces to CD-ROM drives, depending upon customer needs. The server controller is also manufactured by ATronics.

AXONIX
844 South 200 East
Salt Lake City, UT 84111

Axonix, founded in 1983, integrates and markets storage subsystems, including network attached CD format disk towers. The towers are based on the Ornetix network miniserver.

BOFFIN LIMITED
2500 West County Road #42
Burnsville, MN 55337

Established in 1984 as a retail software outlet, Boffin has moved into the business of storage systems integration and now markets RAID systems and CD towers, many equipped with Nakamichi minichangers.

BORETT AUTOMATION TECHNOLOGIES
31324 Via Colinas
Westlake Village, CA 91362

Founded in 1988, Borett Automation manufactures modular library systems 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. The company is currently in between product generations, with details of future products yet to be announced.

CD INTERNATIONAL
128 York Street
Portland, ME 04101

A 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. A direct network attached model was introduced in 1996.

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.

CHERUB AUDIO VISUAL PRODUCTS
41-801 Corporate Way, Suite 2
Palm Desert, CA 92260

Cherub got started as a manufacturer of autochangers for audio CD disks. The company broadened its activities and introduced a 240 disk library with 6 Nakamichi minichangers at the 1997 AIIM conference. The library has a dual picker mechanism, unusual in a CD-ROM library.

CMS PERIPHERALS (Formerly CMS Enhancements)
3095 Redhill Avenue
Irvine, CA 92626

CMS is a well-known storage subsystem integrator offering a variety of disk and tape subsystems. The company is assembling a line of networked CD-ROM servers, mostly 7 or 14 drive units. The company was formed in mid-1997 as the result of a management buyout of the CMS Enhancements subsidiary of distributor AmeriQuest Technology.

COMPACT DEVICES
200 East Hacienda Avenue
Campbell, CA 95008

Compact Devices started operations in 1995, developing and manufacturing network attached controllers and miniservers for CD-ROM drives, following up with an Intranet oriented miniserver. The firm sells its products to manufacturers of CD towers, network integrators, and end users setting up their own networks, and is considered a significant supplier.

CUTTING EDGE
8191 Center Street
La Mesa, CA 91942

Cutting Edge, founded in 1992, is an integrator and marketer of storage subsystems, including CD towers (host and network attached), CD libraries and RAID systems.

CYBERDATA SYSTEMS
831 Beacon Street, # 292
Newton, MA 02159

Cyberdata produces host and network attached CD towers which can be customized to order. The firm also offers a line of disk drive arrays.

CYGNET STORAGE SOLUTIONS
2560 Junction Avenue
San Jose, CA 95134

Cygnet, founded in May, 1983 as Cygnet systems, was one of the earliest producers of optical libraries employing 12" disks. The company was purchased by ATG, a French organization, and subsequently resold to Dynatek Automation in late 1996 after ATG went into reorganization. 12" libraries are still a major part of the firm's product line, which has been augmented by the addition of the Infinidisc, a CD-ROM library transferred to it by Dynatek when the firm was established as Cygnet Storage Solutions. Cygnet is beginning to give major marketing and manufacturing support to the CD-ROM oriented product line. The company is also reselling CD-R duplicating equipment.

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

1996 total net sales: $7,761,000 Net income: ($3,342,000)

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 32) and disk storage slots (up to 1,478). 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.

DISC is strengthening its OEM and integrator orientation and relying less upon distributors as it grows, adding additional service and support capabilities through staff expansion and third party arrangements. Marketing is increasingly focussed upon selected integrators serving vertical markets.

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. Current products include CD-ROM towers and disk drive arrays. 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. Disks can be added in increments of 250 disks. In 1996, Dynatek acquired ATG Cygnet from ATG Gigadisc, creating Cygnet Storage Solutions as a wholly owned subsidiary. The Infinidisc was transferred to Cygnet at that time.

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1996 total net sales: $15,968,000,000 Net income: $1,288,000,000

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 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, sold to Mitsubishi Kasei in 1990, continued optical media and head development.

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 introduced a two headed drive with 25 gigabyte capacity per disk in mid-1996 for shipment in mid-1997. The drive will be able to read earlier Kodak 14" media.

Eastman Kodak produces automated library units for use with its own 14" drive, but discontinued a 5.25" library for use with purchased drives. The 14" libraries are also sold on an OEM basis. The firm also purchases some library units for systems using 12" drives from other manufacturers. CD-ROM libraries are also sold by Eastman Kodak, with an internally manufactured unit displayed at the 1997 AIIM conference.

ELMS SYSTEMS CORPORATION
2 Holland Street
Irvine, CA 92618

Elms was founded in 1995 after Conner Peripherals purchased Archive by a group that included several Archive Corporation senior managers. The company concentrates upon CD-ROM/CD-R servers for networks. Elms is unusual in that it first designed the software required for subsystem support and network integration before proceeding with the library design, resulting in an unusually complete network integrated product. Since introducing its first library in 1996, Elms has achieved significant visibility as a CD library producer.

EMASS
Subsidiary of E-Systems, Inc. (Subsidiary of Raytheon Company)
10949 East Peakview Avenue
Englewood, CO 80111

EMASS supplies automated data storage systems and software, selling largely through VARs and system integrators. Most of the products are oriented towards tape storage, but some of its libraries can operate with mixed tape and 5.25" optical media, holding over 400 cartridges of various types.

EXCEL COMPUTER
3330 Earhart Drive
Carrollton, TX 75006-5041

Excel distributes and integrates a variety of host attached and network attached CD towers, offering customized configurations as well as standard models. Customers can select the drives or minichangers used, as well as the packaging configuration.

FILENET CORPORATION
3565 Harbor Boulevard
Costa Mesa, CA 92626

1996 total net sales: $268,913,000 Net income: ($2,644,000)

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

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

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

1996 total net sales: $38,420,000,000 (FY ending 10/31/96) Net income: $2,586,000,000

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. Hewlett-Packard then announced its own high performance 5.25" magneto-optic disk drive, code named Corsair, in 1991, for volume delivery in 1992. The drives were produced in the Greeley, Colorado, facility, which has also produced optical libraries since 1989. The new H-P optical drives have displaced the Sony drive in H-P system and subsystem products. A double capacity drive with 650 megabytes per side capacity, the Corsair II, was announced at the 1993 AIIM conference. It went into production in 1993, using a mechanism made by a contract manufacturer.

Despite large increases in production, Hewlett-Packard has moved towards a view of internal optical drive manufacturing as nonstrategic and has halted optical drive production, becoming a drive purchaser for future generations of drives. The company is also reselling CD-R drives based on Philips mechanisms.

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. The libraries are used in H-P systems, but H-P also sells them to OEM accounts and through resellers.

INTEGRATED NETWORK SOLUTIONS CORPORATION
10-A Thomas Street
Irvine, CA 92718

INSC is a storage subsystems integrator, offering magnetic and optical disk storage as well as tape backup subsystems. The firm also produces CD-R duplication systems.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1996 total net sales: $75,947,000,000 Net income: $5,429,000,000

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. While not currently manufacturing any optical drives or libraries, IBM remains 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. The firm has played an important role in resolving industry conflicts regarding DVD drives. IBM currently relies on outside purchases of CD-ROM and other CD format drives and is judged unlikely to manufacture its own CD-ROM drives, but 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 was replaced by the double capacity 654 megabyte per side drive introduced in March, 1993. A more recent half high multifunction version used ablative or MO media. The multifunction drive was used in IBM system libraries and also sold to OEMs. The last sales were in 1996.

In 1991, IBM announced a 3.5" 128 megabyte MO drive designed at its Fujisawa facilities. The drive was sold in modest quantities with some PS/2 system models and on an OEM basis. 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 , no longer in production, developed in conjunction with Philips Key Modules 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. Hewlett-Packard was the initial supplier of the library mechanisms but was displaced by Plasmon Data Systems in 1996. Mitsubishi write-once drives were used with the libraries until IBM put its own 5.25" multifunction drive into production. IBM then used its own multifunction drives to provide storage for libraries. The company offers its optical library systems as attachments to large and midrange 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 shut down its optical drive production, selling its existing inventories at bargain prices to OEMs and resellers and ceasing use of its own drives in libraries in late 1996. The firm has since found an alternative manufacturing source for its multifunction 5.25" drive, which is still required by some customers.

KINTRONICS
2 Westchester Plaza
Elmsford, NY 10523-0518

Kintronics, established in 1977, is an integrator and distributor of components, peripherals and storage subsystems, including CD-R subsystems, CD towers and RAID subsystems. Towers are available with drives or minichangers, and may be connected to host systems or networks using the Axis Communications miniserver.

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

Kubik produces 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. A library for 5.25" optical drives was introduced in 1995, but has not generated significant sales. The firm has developed a major customer base in the government and military sectors.

LEGACY STORAGE SYSTEMS INTERNATIONAL, INC.
43 Riviera Drive
Markham, Ontario L3R 5J6
Canada

Legacy Storage Systems was the name adopted in June, 1991, for the firm which resulted from the merger of two earlier Canadian companies. In March, 1996, Legacy acquired Rexon Incorporated, a manufacturer of tape backup systems and subsystems, renaming the reorganized companies for Tecmar,

Rexon's distribution arm because of the broad recognition of the Tecmar name. The firm now offers tape and disk drive subsystems, disk drive arrays and CD towers, including RAID-0/1/3/5/10 arrays based on purchased controllers. These arrays also include tape drive options, and are offered for a variety of PC, NetWare and UNIX network applications. Most recently, the firm has reverted to marketing under the Legacy name.

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 14" rewritable media. Special 14" optical libraries are also under development.

MERIDIAN DATA
1615 Scotts Valley Drive
Scotts Valley, CA 95066

1996 total net sales: $26,116,000 Net income: $4,274,000

Meridian was established in 1986 to create development tools for optical storage products, but has broadened its interests to include CD-ROM/CD-R publishing tools, networked CD-ROM servers and networked CD-R recorder systems. The firm became a public company in 1994, when it merged with Parallan Computer. Meridian makes extensive use of VARs and resellers, and is strengthening its marketing and support programs for these channels.

MICRO DESIGN INTERNATIONAL
6985 Winter Park Boulevard
Winter Park, FL 32792

MDI is a well known integrator and distributor of storage subsystems, hardware and software, including drives, libraries and CD towers. The firm is among the early suppliers of hot swap capability for CD towers, which are available in both host attached and network attached versions.

MICROTEST, INC.
4747 North 22nd Street
Phoenix, AZ 85016

1996 total net sales: $50,400,000 Net income: ($11,600,000)

Microtest is a major supplier of networked CD-ROM towers and network server electronics assemblies operating in Novell and Microsoft environments, all marketed under the DiscPort brand starting in 1993. In 1996, the firm acquired Logicraft (now operating as the Microtest Enterprise Group), adding a storage subsystems capability to its product line. The company also supplies CD-R subsystems and networking software.

MOST, INC.
11205 Knott Avenue
Cypress, CA 90630

MOST was formed in 1987. The firm, then 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 128, 230 and 256 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 and 1995.

In 1995, MOST began shipping a 2.6 gigabyte per cartridge 5.25" optical drive, the first of its breed. A direct overwrite version using light intensity modulation began shipment in July, 1996. 3.5" drives have been 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 the 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. Optical drives are currently 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 included a 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. Current products emphasize fast MO drives using Maxoptix mechanisms.

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.

OPTICAL ACCESS INTERNATIONAL
500 West Cummings Park
Woburn, MA 01801

OAI is an optical storage subsystems integrator specializing in CD format products. It's first shipments were in 1989. Today, the firm produces packaged CD-ROM subsystems, CD-ROM towers and servers, both host and network attached.

ORNETIX
1885 Lundy Avenue
San Jose, CA 95131

Ornetix is a producer of software for CD networking and management that has begun to leverage its software know-how into a line of Intel processor based network miniservers. The software operates with CD format drives, towers, changers and libraries. HyperlinQ, the firm's network server, includes a rigid disk drive cache. It became available in 1997.

PINNACLE MICRO
19 Technology Drive
Irvine, CA 92718

1996 total net sales: $59,921,000 (FY ending 12/28/96) Net income: (20,833,000)

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 internally supplied electronics. The firm established a development center for optical products in Colorado Springs in 1993. Pinnacle Micro has started an optical drive factory, also in Colorado Springs, to produce complete high performance, high capacity 5.25" magneto-optical drives and other products. Pinnacle Micro also remarkets CD-R drives.

In 1994, Pinnacle Micro introduced the Orray, an array of 5.25" optical drives with a controller that can operate them concurrently, but was not successful in developing a significant market for it. In 1995, Pinnacle Micro announced a non-ISO standard drive, the Apex 4.6 gigabyte MO drive. While unable to put it into production at that time, the firm was able to begin shipments in late 1996 after a major management change. The Apex drive's high capacity, coupled with an unusually low OEM selling price, stimulated substantial customer interest. The Vertex, a more conventional 2.6 gigabyte drive, went into production in mid-1996.

PLEXTEC
215 Carlingview Drive, Unit 310
Etobicoke, Ontario M9W 5X8
Canada

Plextec is an integrator and distributor of storage subsystems, especially CD towers. A wide variety of host and network attached configurations is available. The firm distributes in both Canada and the U.S., with much of its business obtained from agencies of the Canadian government.

PROCOM TECHNOLOGY
2181 Dupont Drive
Irvine, CA 92715

1996 total net sales: $73,456,000 (FY ending 7/26/96) Net income: $2,849,000

Procom, which began operations in 1987 supplying packaged floppy drive subsystems, went public in January 1997. The firm is a disk and tape storage subsystem integrator, specializing in products for attachment to personal computers and PC servers. The firm is the largest producer of CD-ROM towers, including both host attached and network attached types. Procom also manufactures disk drive array subsystems, tape backup systems and rigid disk drive storage subsystems.

QUINTA CORPORATION
1415 Koll Circle
San Jose, CA 95112

Quinta, founded by several executives from the disk drive industry, is a new U.S. start-up corporation planning to develop high capacity, high performance optical disk drives. While relatively little information about its target product has been released, the firm is expected to become more visible by the end of 1997 and has stated it will announce products for shipment in 1998. In July, 1997, Seagate announced it was acquiring Quinta for a minimum of 230 million dollars. Quinta will continue to operate as a subsidiary corporation for the time being.

REGAL ELECTRONICS
4251 Burton Drive
Santa Clara, CA 95054

Founded in 1976, Regal has been a supplier of connectors, cables, speakers and other parts to the computer industry. The company has manufacturing facilities in the United States and Taiwan. In late 1995, the firm began marketing a CD-ROM autochanger using a mechanism supplied exclusively by a Japanese manufacturer.

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.

SMART AND FRIENDLY, INC.
20520 Nordhoff Street
Chatsworth, CA 91311

Smart and Friendly, founded in 1982, is a storage subsystems VAR/integrator specializing in optical storage solutions and marketing to other resellers. The firm assembles CD-ROM and CD-minichanger towers with host or network interfaces, plus numerous individual drive packages.

SMS DATA PRODUCTS GROUP, INC.
1501 Farm Credit Drive
McLean, VA 22102

Formed in 1976, SMS provides network integration services and storage system hardware, primarily to defense agencies of the Federal government. The firm's products include host attached and network attached CD-ROM towers.

TAC SYSTEMS INCORPORATED
1035 Putnam Drive
Huntsville, AL 35816

TAC Systems, founded in 1991, provides storage and communications subsystems for computer systems. The company produces CD towers, both network and host attached, supporting up to 63 drives.

TEN X TECHNOLOGY
13091 Pond Springs Road, Suite B-200
Austin, TX 78729

Ten X, which started operations in 1983, is an integrator of optical disk drive and CD-ROM based storage subsystems for Novell and UNIX environments. The firm's networked CD towers offer both individual drives and minichangers.

TERASTOR CORPORATION
95 West Plumeria Drive
San Jose, CA 95134

Founded in 1996 by several disk drive industry veterans, TeraStor is developing a high capacity, high performance optical disk drive employing "near field recording" technology. The company intends to license other firms to manufacture drives using its technology. TeraStor is combining rigid disk drive technology with optical recording technology originally developed by DEC (and subsequently acquired by Quantum, a minority shareholder in the firm) and solid immersion lens technology developed at Stanford. TeraStor's goal is a drive with areal density exceeding rigid drive areal density by a factor of 10 and having near rigid drive performance. Strategic partners include Imation for media, SSI for chips and Seagate for heads.

TeraStor expects to demonstrate products in the first half of 1998. TeraStor has attracted a great deal of industry interest and, if successful, is expected to have a major impact on the removable data storage industry, impacting manufacturers of rigid removable drives, optical drives and tape drives.

TILTRAC CORPORATION
3353 Earhart Drive, Suite 212
Carrollton, TX 75006

TiltRac, a manufacturer of video robotics equipment, is expanding into the CD-ROM library market with a line of large libraries capable of holding up to 550 disks and 42 drives in various combinations. The libraries, introduced at the 1996 AIIM conference, can be customized to user specifications. First shipments occurred in early 1997.

TODD ENTERPRISES
65 East Bethpage Road
Plainview, NY 11803

Todd Enterprises, established in 1971, is a producer of storage subsystems, including CD-ROM jukeboxes, single and multidrive CD-ROM and CD-R subsystems and CD towers. The firm showed a 200 disk library at several trade shows, but has de-emphasized libraries in favor of CD towers.

VISION COMPUTERS
5865 Jimmy Carter Boulevard, Suite 125
Norcross, GA 30071

Vision Computers integrates file servers and storage subsystems, including host and network attached CD-ROM towers. The firm also distributes monitors. Customized configurations are available.

Asian Manufacturers

(All fiscal years end in March, 1996, unless otherwise noted. All companies are in Japan unless otherwise noted.)

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 expanded CD-ROM production and moved to larger facilities in 1995, becoming Taiwan's largest producer of CD-ROM drives.

ADAPTIVE INFORMATION SYSTEMS (Subsidiary of Hitachi, Ltd.)
26001 Pala
Mission Viejo, CA 92691

Established in 1989 as a provider of storage, workflow and document imaging systems based on Hitachi products, the company is an integrator and reseller of Hitachi equipment and a turnkey systems integrator. Subsystems based upon Hitachi's 12" optical libraries and optical drives are among the products offered.

ADI CORPORATION
1, Section 4 Nanking East Road
Taipei, Taiwan

ADI was founded in 1979 as a producer of shoes and monitors, and has since concentrated upon electronic equipment including terminals, multimedia and communications equipment. The firm entered the CD-ROM assembly business in the mid-1990s and has assembled a moderate number of CD-ROM and CD-R drives using purchased mechanisms.

ADVANCED INFORMATION (AOpen brand of Acer, Inc.)
156 Ming Sheng East Road, Section 3
Taipei, 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 purchased mechanisms, although it has future plans to develop its own mechanisms. The company formed Advanced Information as a separate business unit for its AOpen brand name products in 1997.

ALLION COMPUTER INC. (Formerly LANBit)
552 Chung Hsiao East Road, Section 5
Taipei, Taiwan

Allion acquired its new identity in June, 1997, but has maintained its product line, which includes hubs, switches and adapters for local area networks, network servers and network attached CD-ROM towers.

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

1996 total net sales: $3,543,583,000 Net income: ($18,919,000)

Alps Electric is a major manufacturer of electronic components and subassemblies for audio, television, instrument and computer applications. Peripheral devices, including printers and floppy disk drives, accounted for 26% of revenues in 1995. Alps supplies components to other companies wishing to make CD-ROMs and can supply design assistance and components, or will 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, except for small CD-ROM autochangers that began shipments in 1996. The autochanger has also been discontinued.

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 1,200 cartridge library, but the company's library focus is on a 450 cartridge unit now in production and marketed through Metrum in the U.S.

AZTECH SYSTEMS LTD.
31 Ubi Road 1
Singapore 1440

1996 total net sales: $302,051,064 (FY ending 12/31/96) Net income: ($8,787,943)

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 higher speed has followed as mechanisms have become available.

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 produces high speed CD-ROM drives using purchased mechanisms.

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

1996 total net sales: $23,517,439,000 (FY ending 12/31/96) Net income: $865,757,000

Canon is a major supplier of business machines, copiers, and cameras, but about 51% 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. However, optical drive shipments have declined markedly as the product nears the end of its life. 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. Production is expected to end in 1997.

CYBERDRIVE
75 Hsin-Tan Wu Road, Section 1
Shi-Chih, Taipei Hsien
Taiwan

Formed in 1996, Cyberdrive is assembling CD-ROM drives using mechanisms procured from Japanese firms and electronics manufactured in Taiwan. The product line includes drives ranging from 12X to 24X speeds. Most sales are in the U.S., but the firm also supplies some drives on an OEM basis to local companies. In July, 1997, Cyberdrive was acquired by Pan International Corp., a manufacturer of cables, connectors and other equipment.

DELTA ELECTRONICS, INC.
144 Min Chuan East Road, Section 3
Taipei 10464, Taiwan

Founded in 1971, Delta manufactures a variety of electronic items, including power supplies, monitors and other items for computers. The company also assembles CD-ROM drives, using Philips mechanisms.

DIAMOND FLOWER ELECTRIC INSTRUMENT CO., LTD. (DFI)
100 Huan-Ho Street
Hsi-Chih Town, Taipei Hsien
Taipei, Taiwan

DFI, as the company is commonly known, was founded in 1981 and became a significant producer of graphic cards. The company now manufactures and markets a variety of computer products, and began assembling CD-ROM drives in 1994. A larger production site near Taipei was established in 1995.

ELITEGROUP COMPUTER SYSTEMS CO., LTD.
88 Chung Shan North Road, Section 6
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 drives, many of which are sold through reseller channels under the Vertos brand name.

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

1997 total net sales: $41,399,835,000 (FY ending 3/31/97) Net income: $424,223,000

Fujitsu is Japan's largest producer of computer systems and also manufactures a wide variety of other electronic equipment. Computer products represent about 67% of Fujitsu's sales.

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. In 1992, Fujitsu began shipping a 5.25" optical library and a high performance 5.25" rewritable drive jointly developed with NTT, 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 and has been largely responsible for the growth of the 3.5" MO market since 1995. 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 one of the pioneers with the 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, followed by faster versions in more recent periods.

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

1997 total net sales: $78,351,000,000 Net income: $812,006,000

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 50% of 1996 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.

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. Hitachi's OEM sales for CD-ROM drives dipped after 1990, but a revitalization of the OEM oriented CD-ROM product line has reestablished Hitachi as a major producer. Hitachi has also taken an aggressive position regarding DVD-ROM, being among the first to introduce a 2X DVD-ROM drive, and was the first to announce a DVD-RAM drive, providing samples in mid-1997.

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. A 1.3 gigabyte per side drive using light intensity modulation to provide direct overwrite capability (LIM-DOW) began shipments in 1996.

Hitachi has also sold 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. The 12" line was discontinued in early 1997 due to disappointing sales.

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

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

HYUNDAI ELECTRONICS INDUSTRIAL CO., LTD.
705-19 Yeoksam-dong
Kangnam-ku
Seoul, South Korea

Hyundai has introduced a 50 disk CD-ROM library based upon an earlier developed video CD changer. As announced, the library incorporated a 4X drive manufactured by Philips.

INTERNATIONAL MANUFACTURING AND ENGINEERING SERVICES CO., LTD. (IMES)
3 Kirahara-cho, Fujisawa
Kanagawa 252

IMES was established in 1990 by a group of early retirees from IBM Japan with funding from that organization. The firm provides engineering development, manufacturing and marketing services. Included in IMES' product line are CD-ROM drives, first made using purchased mechanisms and then with IMES' own designs. A CD-ROM tower was marketed for a short time, but the firm withdrew from the CD tower business after deciding it did not fit well with the future direction of the company.

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 CD-ROM drives using purchased mechanisms began in 1995.

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

1996 total net sales: $7,414,516,000 Net income: $39,925,000

JVC, as it is commonly known, is a major producer of consumer audio equipment, including CD players. Matsushita Electric Industrial (MEI) holds a 52.4% share in the company. Since 1985 JVC has experimented with several computer peripheral programs. 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. Drives with 4X read and 2X write are currently in production.

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

1996 total net sales: $9,851,829,000 Net income: $236,330,000

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. Kubota manufactures 5.25" optical libraries for Maxoptix, also selling them in Japan under its own name.

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

1996 total net sales: $2,936,367,000 Net income: $5,837,000

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. About 68% of revenues come from information, office and video equipment. The company manufactures CD-ROM pickup and positioning assemblies and has begun manufacturing drives for other companies. CD-ROM drives are manufactured by multiple divisions of the company. KME has become a significant supplier of thin CD-ROM mechanisms for notebook computers, offering some as thin as 1/2 inch.

LG ELECTRONICS, INC.
20 Yoido-dong
Youngdungpo-gu
Seoul 150, South Korea

1996 total net sales: $14,755,120,000 (FY ending 12/31/96) Net income: $36,480,000

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 CD-ROM drives and DVD-ROM drives, and has become Korea's largest producer of CD format drives.

LIKOM COMPUTER SYSTEM SDN BHD
Subsidiary of Lion Group
Kawasan Perindustrian Cheng, Fasa III
Mukim Cheng, Daerah Melaka Tengah
75250 Melaka, Malaysia

Likom is a member of the Lion Group, a Malaysia based organization. The firm does a considerable amount of contract manufacturing as well as producing its own brand of drives. Production of drives 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.

LITE-ON TECHNOLOGY CORPORATION
16 Nanking East Road, Section 4
Taipei, Taiwan

1996 total net sales: $760,770,000
(FY ending 12/31/96)

Established in 1989, Lite-On has become a major producer of monitors. In late 1995, the firm established an optoelectronics business unit and has constructed a factory to produce CD-ROM drives. A major ramp up occurred in late 1996 and 1997 as new production capacity was added in Taiwan and offshore locations. The company expects to introduce DVD-ROM drives in late 1997.

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

1997 total net sales: $70,563,633,000 Net income: $1,267,264,000
(FY ending 3/31/97)

MEI's Panasonic, National, Technics, and Quasar brands are among the most widely known in the world for appliances, consumer electronics, and communications equipment. Subsidiary 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 increased rapidly and Matsushita remains the largest producer of CD-ROM drives. The company also offers CD format libraries.

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 write-once drives has been discontinued.

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, although moderate success was achieved 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 and TEAC.

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

1996 total net sales: $5,084,000,000 Net income: $72,000,000

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, LS-120 high capacity floppy drives, 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 remains a significant supplier of high performance drives, although emphasizing its system integration business. Kubota also produces 5.25" optical libraries for Maxoptix.

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

1996 total net sales: $32,279,454,000 Net income: $544,264,000

Mitsubishi is most noted for heavy machinery production, but is also active in defense electronics and consumer electronics. Data and communications systems represent about 38% of revenues, while consumer electronics accounts for 18% of sales.

In the past, Mitsubishi has manufactured 5.25" MO drives, write-once drives (sold to IBM) and optical libraries, but left the optical storage peripherals business in 1993. In 1996, the firm announced a DVD-ROM drive and mechanism, with samples to be delivered in August and a production start in late 1996. The drive has a dual laser pickup, and thus is able to read CD-R disks as well as DVD-ROM and CD-ROM disks.

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

1996 total net sales: $1,400,000,000 (FY ending 9/30/96) Net income: ($30,980,000)

Mitsumi, founded in 1949, is primarily a manufacturer of electronic components, but 20% of revenues are derived from CD-ROM drives and 13% from floppy drives. 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. In 1995, the firm made very large quantities of 4X CD-ROM drives, becoming the second-largest producer of CD-ROM drives. The firm has since transitioned to faster models.

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

1996 total net sales: $160,627,000 (FY ending 2/28/96) Net income: ($34,574,000)

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 68% of 1996 sales were computer related items.

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. Half height four disk CD-ROM autochangers were introduced in 1995 and became the firm's major effort in the optical disk drive market. A five disk, 16X model was introduced in 1997.

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

1997 total net sales: $45,505,000,000 (FY ending 3/31/97) Net income: $1,114,000,000

NEC has defined its product area as communications and computers, with computer products accounting for about 41% of 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 2.5 gigabyte drive was introduced in 1990. A 5.25" MO rewritable drive began production in mid-1989, and a 650 megabyte per side version was introduced in mid-1993. A direct overwrite version with 1.3 gigabyte per side capacity began shipping in early 1996.

NEC has licensed Matsushita's PD drive and phase change technology. The PD production ramp was scheduled for the spring of 1996, but technical difficulties forced a rescheduling to late 1996. 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 had moderate success with a modified CD audio drive as a CD-ROM add-on to its PC Engine consumer system. An attempt to market a similar product in the U.S. was not successful.

In 1992, NEC introduced 2X CD-ROM drives, with faster models introduced in subsequent years. 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. NEC has also entered the small CD-ROM autochanger market, and as of mid-1996 had begun an aggressive pricing effort to expand the firm's market share, although this activity has since been discontinued.

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

1996 total net sales: $3,050,377,000 Net income: $170,813,000

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 Cygnet Storage Solutions in its 12" libraries. A 5.25" LIM-DOW MO drive, developed in conjunction with Hitachi, was introduced in 1996.

NIPPON COLUMBIA CO., LTD.
14-14, Akasaka 4-Chome
Minato-ku, Tokyo, 107-11

1996 total net sales: $958,200,000 Net income: ($5,617,000)

Nippon Columbia, a major manufacturer of audio equipment, was an early entrant into the CD-ROM industry, but discontinued manufacturing in 1991 due to disappointing sales. The firm has reentered the computer peripherals business with an optical library for CD-ROM drives, which can hold up to 200 disks. Shipments began in 1996. The company markets the library through Plextor in the United States.

NISTEC (Unit of 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.

OCEAN OFFICE AUTOMATION LTD.
22 Kai Cheung Road
Kowloon Bay, Kowloon
Hong Kong

Founded in 1986 as an electronics sales and repair firm, Ocean has steadily grown and diversified its activities, becoming publicly held in 1992. The firm's drives, marketed under the Octek brand name, are assembled with purchased mechanisms.

OLYMPUS OPTICAL CO., LTD.
22-2, Nishi-Shinjuku 1-chome
Shinjuku-ku, Tokyo

1996 total net sales: $2,354,734,000 Net income: $18,763,000

Founded in 1919, Olympus Optical company is known primarily for 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 several manufacturers as the basis of their own rewritable drives.

Olympus began marketing under its own 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. In 1996, the firm introduced a reduced cost and aggressively priced ($299) 3.5" 1 inch high MO drive and a 1.3 gigabyte per side 5.25" drive, becoming a major supplier of 3.5" drives as a result.

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. Product strategy emphasizes early development and introduction of high performance drives.

The firm's initial products were based upon double speed Philips mechanisms, with production starting in 1993. Optics Storage has aggressively developed the market for several generations of higher speed drives.

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

1996 total net sales: $4,657,143,000 Net income: ($91,837,000)

Pioneer, founded in 1947, is a major manufacturer of consumer electronic equipment. 93% of Pioneer's 1996 revenues came from sales of audio, video and automotive electronic equipment. The firm is especially strong in the laserdisc and automotive audio CD markets.

Pioneer and Ricoh had a joint development program on an 8" 750 megabyte optical write-once disk drive, with Ricoh being Pioneer's most significant customer for the product. First shipments began in late 1985, and Pioneer has estab-

lished 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, sampled servo drive using dye or MO media interchangeably.

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 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 has been surpassed by other producers. At the 1994 AIIM show, Pioneer displayed a 500 disk CD-ROM library based upon a karaoke system also produced by Pioneer. A 100 disk unit began shipping in late 1996. In the second half of 1996, Pioneer began a marketing effort to sell Pioneer brand CD-ROM and DVD products in the U.S., including a 10X CD-ROM drive with dual CAV and CLV modes, the first CD-ROM drive of that type.

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. Faster drives have been announced subsequently. Plextor is one of the few companies to retain the caddy as a standard feature, which has helped the company gain entry to the CD-ROM jukebox market as a drive supplier.

Plextor also produces host and network attached CD-ROM towers, and is the U.S. marketing channel for Nippon Columbia's line of CD-ROM libraries.

REXAS CORPORATION
3-2-1 Sakado, Takatsu-ku
Kawasaki, Kanagawa 213

Rexas is a manufacturer of CD-ROM and CD-R storage subsystems, including towers and servers. The firm distributes its products in the United States through trading company Kanematsu.

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

1997 total net sales: $12,098,474,000 (FY ending 3/31/97) Net income: $265,876,000

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 22% of 1995 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 1994, Ricoh ceased production of write-once drives to concentrate upon MO, CD-R and CD-RW drives.

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, but has since been dropped from the product line.

Ricoh began manufacturing CD-R drives 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, followed by a 4X read, 2X write model in 1996. Ricoh began the manufacture of CD-RW drives in 1997.

SAMSUNG ELECTRONICS
7 Soonwha-Dong
Seoul, South Korea

1996 total net sales: $19,719,930,000 Net income: $203,919,000

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 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. Faster drives have subsequently been added to the product line.

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

1996 total net sales: $4,822,605,000 (Partial FY ending 3/31/96) Net income: ($34,363,000)

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, especially in China. About 30% 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. Sanyo and its subsidiaries currently produce several models of CD-ROM drives. In 1995, Sanyo entered the CD-ROM autochanger market with a three disk model capable of fitting into a standard 5.25" half height form factor. It incorporated a 4X drive with IDE/ATAPI interface, and inspired competitors to bring out competing minichangers.

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

1996 total net sales: $3,537,562,000 Net income: $38,684,000

Sega, founded in 1960, is one of the world's major producers of electronic games and arcade equipment. About three fourths of its sales are derived from

consumer equipment. The CD-ROM drives included with the games are made on a contract basis for Sega by several firms.

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

1997 total net sales: $16,460,563,000 (FY ending 3/31/97) Net income: $446,277,000

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 23% 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, but the company is now phasing out of this 5.25" MO product line. Sharp is a Sony licensee for the MiniDisc system and is expected to produce a version for use as a mass storage device with an upcoming video camera.

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

1997 total net sales: $52,060,434,000 (FY ending 3/31/97) Net income: $1,282,037,000

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 63% of revenues. Sony also holds the largest share of the 5.25" magneto-optic disk drive market. 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 five 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 its first write-once CD format recorder as part of a CD-ROM mastering system at the 1990 Microsoft Conference. In 1996, Sony announced CDRFS, a CD-R packet writing system for which it hopes to gain industry acceptance.

Sony fields a product line of CD-ROM, write-once and multifunction optical drives. A 12" write-once product line with up to 7.5 gigabytes per side capacity has been discontinued. Rewritable 3.5" MO drives have been deemphasized, although some development on higher capacity models continues. The 5.25" rewritable and multifunction drive product line remains strong, partially as the result of Sony's absorption of discontinued product lines of other companies.

To support its 12" write-once drives, Sony offered automated library units, first shown at COMDEX in the Fall of 1985, but the 12" line was discontinued in early 1997. In 1994, Sony introduced a 20 disk 5.25" library, followed by a 60 disk library in 1995. Both are manufactured in the United States. Sony has filled in its line of optical libraries with models purchased from other suppliers. An aggressively priced CD-ROM library was announced in 1997.

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 introduced in 1995, appears to have brighter prospects, although competition from CD-ROM games for personal computers have restrained sales.

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 since 1989, Sony has been the largest supplier of 5.25" rewritable optical disk drives. Sony's 5.25" program languished for a few years, but has immensely benefited from the decisions by IBM and HP to cease drive manufacturing.

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 made a strategic decision to leapfrog the competition and go directly to higher capacity drives with a 650 megabyte drive. However, the new design isn't compatible with any other product and has received little industry support.

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.

TAE IL MEDIA COMPANY, LTD.
456-1 Moknae-dong
Ansan, Kyonggi-do, South Korea

Founded in 1983, Tae Il is a major producer of magnetic heads and media. The firm has entered the floppy disk drive and CD-ROM drive markets. A 6X drive was introduced in 1995, with 16X and 20X models in the current product line.

TAKAYA CORPORATION
661-1 Ibara-cho, Ibara-shi
Okayama 715

Over 100 years old, Takaya is a relative newcomer to the CD-ROM drive industry. The firm is currently producing 12X and 16X CD-ROM drives, marketing primarily to Asian producers of personal computers.

TATUNG COMPANY
22 Chungshan North Road, Section 3
Taipei 10451, Taiwan

Tatung was founded in 1918 and has grown to become a major supplier of industrial and electronic equipment. The company recently entered the CD-ROM market, assembling drives using purchased mechanisms. Most drives are used with Tatung's line of personal computers.

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

1996 total net sales: $1,039,575,000 Net income: ($15,370,000)

TEAC is best known for its leadership position in the flexible disk drive industry, but the firm also manufactures optical disk drives. About 70% of revenues come from sales of computer peripheral devices. TEAC offers a line of CD-ROM drives, starting with 4X drives introduced in 1994. Faster models have been subsequently introduced, as well as slim drives for use in notebook computers. TEAC has also introduced CD-R drives. The firm expects to be in production of PD drives in 1997.

TEKRAM TECHNOLOGY CO., LTD.
5, Lane 768, Pateh Road Section 4
Taipei, Taiwan

Tekram, founded in 1990, began as a producer of controller cards. The firm's announced products include a mirroring disk controller displayed at COMPUTEX in 1994. CD format disk towers were introduced in 1997.

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

1997 total net sales: $50,101,000,000 (FY ending 3/31/97) Net income: $1,153,705,000

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 62% of revenues are 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 5.25" write-once optical disk drives in early 1989, although it began shipping samples 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, and Toshiba appears poised to become a leading producer of CD-ROM drives in 1997. Toshiba's later CD-ROM models have unusually fast 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. Slim drives used in notebook computers are becoming increasingly prominent in the product line, with substantial quantities produced for Toshiba's own notebook computers. DVD drives are a major Toshiba initiative, and Toshiba is among the early introducers and shippers of DVD and DVD-ROM drives.

UNITRON INC.
542-3 Chung Cheng Road
Hsin Tien 23138
Taipei, Taiwan

Unitron has been assembling CD-ROM drives using purchased mechanisms since 1995. Most of Unitron's drives are sold in Japan.

USDRIVES TECHNOLOGY CORP.
850 Auburn Court
Fremont, CA 94538

Established in 1997 to provide a U.S. source for CD-ROM drives, the firm assembles mechanisms from Japan and boards produced by a sister company in Taiwan into complete CD-ROM drives, which are then sold through distribution and to OEMs. As of mid-1997, the USDrives product line extended from 16X to 24X drives.

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 disk drive 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.

YAMAHA CORPORATION
10-1 Nakazawa-machi
Hamamatsu, Shizuoka

1996 total net sales: $4,883,582,000 Net income: $86,689,000

Yamaha is the world's largest manufacturer of musical instruments, which account for 45% of the firm's sales. The firm is also a major supplier of thin film heads for rigid disk drives and is rapidly increasing its output of heads.

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. An aggressively priced 2X write/4X read model was introduced in 1996.

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

Marketing through Lxycon Enterprise Corporation, Yung Fu produces CD-ROM drives using purchased mechanisms. Production of the double speed unit began in late 1994, with production of faster drives following in later periods.

European Manufacturers

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 1,500 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 CYGNET SA
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, reorganizing as ATG Cygnet, with the major portion of ownership held by Credit Lyonnaise, a French financial institution. 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. The company had difficulty in achieving financial stability, and entered "judicial review" status, the French equivalent of Chapter 11. In late 1996, the firm sold the Cygnet operations to Dynatek Automation, but retained its corporate name.

ATG Cygnet products now include 12" write-once drives with up to 5.1 gigabytes per side capacity, plus a library storage unit containing a drive and six 12" disks. A dual head 16 gigabyte 12" WORM drive, scheduled for production in late 1996, is now scheduled for shipment in mid-1997, as is a six disk 12" optical library unit.

AXIS COMMUNICATIONS AB
Scheelevagen 16
S-223 70 Lund
Sweden

1996 Total net sales: $48,697,000 Net income: $4,913,000

Rapidly growing Axis, founded in 1984 as a supplier of print servers, is one of the major OEM producers of CD-ROM server assemblies for Ethernet and Token Ring LANS, providing boards and enclosed controllers to integrators and distributors. CD-ROM server production began in 1995. The firm's servers are also usable with printers, digital cameras and other devices. In addition, Axis produces protocol converters to permit attachment of a variety of printers to IBM mainframe and midrange systems. Current development focuses upon adding 100BaseT Ethernet capability and offering server support for other types of equipment, including rigid cartridge disk drives such as the Iomega Jaz drive.

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.

DTS COMPUTER GMBH
Eiserfelder Strasse 316
D-57080 Siegen
Germany

DTS is an integrator of storage subsystems. The company product line includes CD towers, usually fabricated with TEAC drives and Axis Communications network controllers.

GRUNDIG PROFESSIONAL ELECTRONICS GMBH (Formerly K & S Systemtechnik U. Vertriebs GmbH)
Wurzburger Strasse 150
D-90766 Furth
Germany

Grundig acquired 51% of K&S (which was founded in 1985 as a consulting firm for data processing and automation) in 1995. K&S 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 1,600 disk CD-ROM library in 1994. A 200 disk library was introduced in 1995.

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 growing library sales led NSM to establish a separate division, NSM Jukebox GmbH, in early 1994. 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 1994. The new library is offered with CD-R drives as well as CD-ROM drives. A direct network attached version became available in 1996. NSM originally marketed primarily in Europe, but now has 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

1996 total net sales: $41,187,500,000 Net income: ($351,190,000)

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 provided a series of 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 results have been intermittent. Philips supplied 3.5" MO mechanisms for other manufacturers for a few years.

Manufacturing of CD-ROM drives, CD-R drives and MO drives (and mechanisms) is the responsibility of Philips Key Modules Group, which sells large quantities 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. In 1992, the firm began sales of CD-ROM drive subsystems bundled with software. 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.

OPTOMEDIA ENGINEERING LIMITED
Chalke House, 3 Brunel Road
Salisbury, Wiltshire SP2 7PU
United Kingdom

Optomedia supplies a CD-R duplicator using from one to four CD-R drives. Up to 72 disks can be stored. The loaders use 2X write, 4X read Yamaha drives. Media can be loaded 12 disks at a time, although each disk must be enclosed in a caddy.

PHILIPS LMS
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, introduced in 1987, has since been discontinued. Philips LMS produced CD-ROM drives for a few years, but CD-ROM production 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 disk media. The drive uses 12" media and is available as a freestanding disk 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 manufacturing facilities at Blackburn in the UK.

PLASMON DATA, INC.
Division of Plasmon PLC
9625 West 76th Street
Eden Prairie, MN 55344

1996 total net sales: $16,721,280 (FY ending 3/31/97) Net income: $573,000

Founded in 1985 as the U.S. subsidiary of Plasmon PLC, an optical media manufacturer, Plasmon acquired the assets of International Data Engineering in 1994 to become an optical library manufacturer. 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 10 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 eight 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.

Plasmon Data Systems is now one of the leading suppliers of 5.25" optical libraries, and 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. The firm has acquired several major OEM customers in 1995 and 1996, including IBM, and is the second largest producer of optical libraries, following Hewlett-Packard.

SCINET (Subsidiary of Scinets, Ltd., Israel)
268 Santa Ana Court
Sunnyvale, CA 94086

Scinet is a specialized producer of CD-ROM network server software and direct net attached storage subsystems. Research and development is done at the firm's parent in Israel, while manufacturing and marketing are done in the U.S. The firm designs and manufactures its own server electronics, which is sold only as part of a complete CD server system.

1997 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 1997 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1997 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

1997 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:MASK?2.MSK (if you are using AutoImport version 2.xx)
   COPY A:MASK?3.MSK (if you are using AutoImport version 3.xx)

   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. For Lotus 1-2-3:

   /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 tables for flexible drives in 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. See below to easily create your own masks for such tables.

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, Host/Net Attach 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	1997 Rigid Report	1996 Removable Report	1997 Optical Report	1996 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	MASKD	--
28	MASKA	MASKA	--	--
29	MASKA	MASKA	MASKA	MASKA
30	--	MASKA	MASKA	MASKA
31	--	MASKH	--	--
32	MASKD	MASKD	--	--
33	MASKI	--	MASKD	--
34	--	MASKA	--	--
35	MASKA	MASKA	MASKA	
36	MASKA	--	MASKA	
37	--	--	--	
38	--	MASKI	--	
39	MASKD	MASKD	MASKE	
40	MASKI	--	MASKD	
41	--	MASKA	--	
42	MASKA	MASKA	MASKA	
43	MASKA	--	MASKA	
44	--	--	--	
45	--	MASKD	--	
46	MASKD	--	MASKA	
47	MASKI	MASKA	MASKA	

Cross-reference (continued)

Table Number	1997 Rigid Report	1996 Removable Report	1997 Optical Report	1996 Array Report
48	--	MASKA	--	
49	MASKA	--	--	
50	MASKA	--	MASKE	
51	--	MASKD	MASKA	
52	--	--	MASKA	
53	MASKD		--	
54	MASKI		--	
55	--		MASKE	
56	MASKA		MASKA	
57	MASKA		MASKA	
58	--		--	
59	--		--	
60	MASKD		MASKE	
61	MASKI		MASKA	
62	--		MASKA	
63	MASKA		--	
64	MASKA		--	
65	--		MASKE	
66	--			
67	MASKD			
68	MASKI			
69	--			
70	MASKA			
71	MASKA			
72	--			
73	--			
74	--			
75	MASKD			
76	MASKI			
77	--			

-- indicates that the format of this table is variable. Create a mask using AutoImport if a spreadsheet is needed.

Translation using precomputed masks

1. First, copy the files you wish to translate to the AIMP directory from DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

   COPY A:?T*.*
   COPY A:MASK?2.MSK *.MSK (if using AutoImport version 2.xx)
   COPY A:MASK?3.MSK *.MSK (if using AutoImport version 3.xx)

   These commands copy the data files and mask files you need.

   If you are using a two floppy disk system, copy the files you want to translate to a second floppy disk along with the mask files. Make sure that no more than half of the floppy disk is filled, because you will need space for the converted files.

2. Now start AutoImport. When the opening screen appears, select the "File" menu bar item using the mouse keys or just type /F. (The AutoImport menu system works 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 press (or click on) the down arrow to get a list of mask names. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press 'ENTER' (or double click on the selected name). Now position the cursor on the "RETRIEVE MASK" button and select it to load the mask.

4. Select the 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: RT4.97R OT14.97O AT19.97A VT6.97V

5. Select the Output File Name option on the File Selection Menu. (Should always be done after mask retrieval.)

   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. Press 'ENTER'.

   Examples: RT4 OT14 AT19 VT6

6. The default spreadsheet type to which the translation is made is Lotus 1-2-3 version 2.x. If you wish to translate to a different spreadsheet format you may choose it by selecting Format from the File Selection Menu and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Please recheck all the file names displayed to be CERTAIN they are correct. Select the "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. If it does not scroll during translation, you may have a damaged mask file. See the next section for details on mask file creation.

8. If you want to do more translations, repeat from step 3.

9. When you are done translating, leave AutoImport by typing /Q (Quit) to 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: OT10.97O

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: OS197 Optical disk drive specification table.
LS197 Optical library specification table.
TS197 CD tower 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:

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

Saving time

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

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

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

If you are interested 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: **650-961-6209**, or Email to dtinfo@disktrend.com

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 and CD format 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 ??95 in the criterion field for the First Ship Date column will cause all products first shipped in 1995 to be extracted.