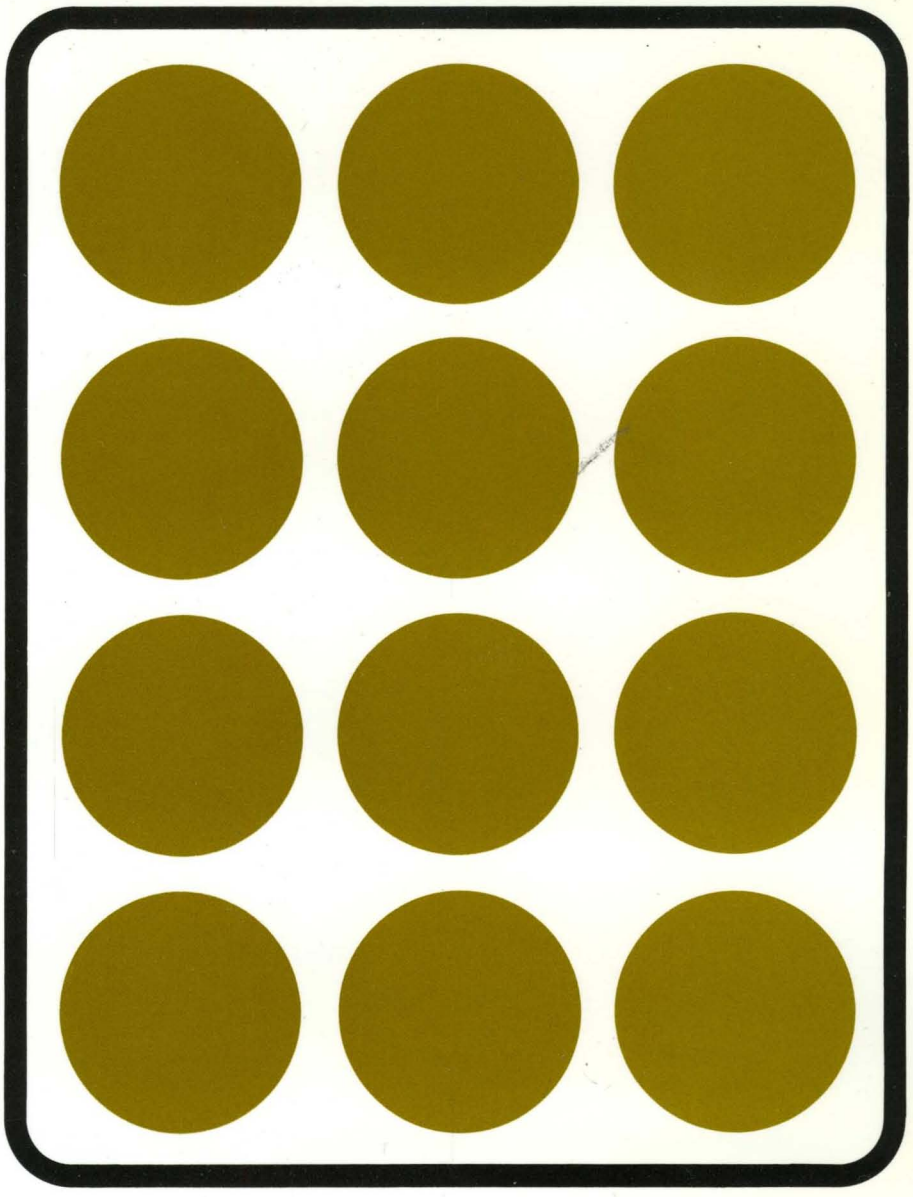
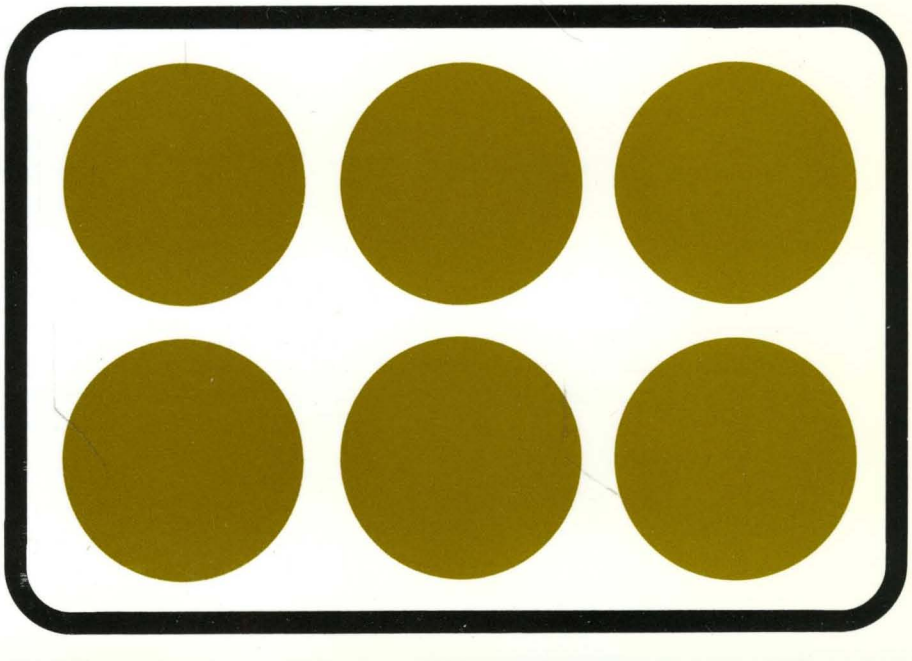


1998 DISK/TREND® REPORT



OPTICAL DISK DRIVES

1998 DISK/TREND® REPORT

OPTICAL DISK DRIVES

August, 1998

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FOREWORD

The optical disk drive industry is entering a period of upheaval and increased instability, but the effects should be beneficial in the long run. CD-ROM drive shipments will be impacted by growing momentum for DVD-ROM drives. CD-R has already been displaced by CD-RW, which in turn is targeted for displacement by DVD-something-or-other after the turn of the century. Falling prices for 3.5" MO drives continue to create increased demand for the moment, until DVD re-writable drive shipments take off. The biggest change of all is the imminent launch of very high capacity MO drives, which are expected to put some sparkle back in the moribund 5.25" MO business and eventually to rescue the 3.5" market as the technology is applied to smaller form factors. The new MO technologies should also help optical libraries compete more strongly against tape libraries and appear to be moving into position to succeed rigid magnetic drives in some applications.

The small CD-ROM autochanger, once thought to be on track for annual shipments in the millions, continues to falter, hampered by higher prices and slower performance than system OEMs will accept. Network attached CD towers are rapidly displacing host attached towers. Coming over the horizon is the hard drive cached tower, offering faster performance, lower cost, and certain to capture a large share of the network attached tower segment.

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

INTRODUCTION

The DISK/TREND Report on optical disk drives and optical disk libraries is now in its 13th year. Reflecting industry changes, the organization of this year's report has been modified to combine all optical libraries using 40 or more disk cartridges into a single product group. Breakdowns in CD-ROM tables have been modified to reflect the rapid evolution of disk transfer rates. DVD-ROM drives now have their own product group. The boundary between high and low capacity read/write optical drives has shifted from 2 gigabytes to 4 gigabytes.

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 1997 market was too small or too concentrated for market share figures to be meaningful.

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

  * CD-ROM optical disk drives
  * DVD-ROM optical disk drives
  * CD/DVD format writable optical disk drives
  * Read/write optical disk drives less than 4 gigabytes
  * Read/write optical disk drives more than 4 gigabytes

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

1997 total worldwide optical disk drive revenues rose 16.5%, exceeding $6.83 billion, driven by growth in CD-ROM, DVD-ROM, and CD-RW drive shipments. Sales of CD-ROM drives alone exceeded $5 billion, while writable CD format sales approached the billion dollar level. Sales revenues for the under 4 gigabyte product group of read/write drives declined to $590 million, due to lower shipments of 5.25" drives and lower prices for 3.5" MO drives. Sales of drives over 4 gigabytes slipped almost 45% to $35.4 million. 2001 total optical drive revenues are forecasted to exceed $9.9 billion. DVD-ROM drives and drives over 4 gigabytes, aided by arrival of very high capacity 5.25" MO drives, are expected to show the strongest revenue growth in the forecast period.

Shipments of 3.5" magneto-optic drives continued to grow in 1997, but OEM interest remains weak, and the prospects for growth in OEM 3.5" sales, which depend upon higher capacity and lower prices, appear to be weakening as the time frame for large writable DVD drive shipments approaches. Shipments of 5.25" drives dropped in 1997, but are expected to increase late in the current forecast period. Shipments of 12" drives continue to drop, as the result of market exits by manufacturers and increasing customer doubts about the survival of the rest.

Over 80.7 million optical drives were shipped in 1997. Of these, 74.6 million were CD-ROM drives, accounting for 92.5% of shipments. Almost 1.2 million DVD-ROM drives were shipped, and 1998 shipments are expected to more than triple to over 4.3 million units. 3.4 million CD format writable drives were shipped, including CD-R, CD-RW and PD drives, with CD-RW becoming dominant in 1998. 3.5" MO drive shipments drove read/write drives under 4 gigabytes up 11.2% to over 1.5 million as shipment growth for 3.5" drives overrode the continuing decline in 5.25" drive shipments. Unit shipments for drives over 4 gigabytes plunged 73% to 2,400 units as the result of shrinking 12" and 14" drive markets. In 2001, unit shipments are forecasted to exceed 144.2 million units, 55.4% of which will be DVD-ROM drives. CD-ROM drives will capture 31.9%, and CD/DVD format writable drives will hold 10.4% share. Read/write drives over 4 gigabytes will have only .9% of shipments, but will acquire 23.6% of 2001 revenue.

Shipments of optical libraries and towers declined 74.2% to 189,600 units as a result of shortfalls in expected sales of CD minichangers to OEMs, and only the CD tower category showed significant 1997 growth. Shipments and revenues are expected to be disappointing in 1998 due to weakening international markets, but moderate growth in all categories is expected in 1999 and thereafter. CD disk tower shipments exceeded 41,100 units in 1997, with network attached unit shipments exceeding host attached units. Hard drive cached configurations are a growing portion of the total. Tower revenues rose 20.3% to 175.6 million as a result of the shift to the higher priced network attached products, and represent the largest revenue component among the libraries and towers. Tower revenues were followed by optical libraries with 40 or more cartridges ($173 million) and CD format libraries ($74.6 million). 1 to 39 cartridge optical libraries are losing ground, impacted by competing technologies, down 26.5% to $48.9 million. Total 2001 revenues of $498.8 million are projected to be shared by CD towers (41.1%), optical libraries of 40 or more cartridges (31.9%), and CD format disk libraries (15.2%), followed by libraries with 1 to 39 cartridges at 11.8%.

U.S. drive manufacturers don't make CD or DVD drives and thus have minimal current participation in the overall market. But U.S. companies continued to lead in library revenues, capturing over 70% of the worldwide total, a gain from the previous year. The U.S. share is expected to increase as advanced MO drives reach the market.

1997 sales of optical disk drives to U.S. destinations accounted for 38.7% of worldwide revenue, a slight decrease from 1996. The U.S. market accounted for 66.4% of library revenues, also an increase from 1996. In 2001, the U.S. optical drive market is expected to be 41.9% of a $9.93 billion drive market, while the proportion of the library market in the U.S. will decline slightly to 64.4% of $498.8 million 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 are currently 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.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	3.0	3.0	--	--	--	--	--	--	--	--
Distributor	14.0	19.3	10.6	15.0	19.8	28.9	53.3	84.8	174.2	270.4
OEM/Integrator	9.2	13.5	7.1	10.0	35.5	48.6	201.0	302.7	924.6	1,695.7
TOTAL U.S. REVENUES	26.2	35.8	17.7	25.0	55.3	77.5	254.3	387.5	1,098.8	1,966.1
Non-U.S. Manufacturers										
Captive	53.4	757.7	61.0	547.5	88.6	520.0	107.3	535.2	131.4	551.3
Distributor	983.3	2,575.3	984.3	2,753.7	952.6	2,772.1	1,028.8	3,021.1	1,195.1	3,078.7
OEM/Integrator	1,580.3	3,462.1	1,460.1	3,204.3	1,405.2	3,465.4	1,564.0	3,783.9	1,735.5	4,342.2
TOTAL NON-U.S. REVENUES	2,617.0	6,795.1	2,505.4	6,505.5	2,446.4	6,757.5	2,700.1	7,340.2	3,062.0	7,972.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,643.2	6,830.9	2,523.1	6,530.5	2,501.7	6,835.0	2,954.4	7,727.7	4,160.8	9,938.3

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK LIBRARIES AND TOWERS

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	45.5	62.6	33.8	53.8	28.9	47.4	27.7	44.8	28.1	45.1
Distributor	122.0	159.8	112.2	147.0	118.3	155.2	115.8	157.2	128.5	180.7
OEM/Integrator	87.6	112.3	78.3	94.6	72.2	89.1	76.4	94.2	80.9	100.4
TOTAL U.S. REVENUES	255.1	334.7	224.3	295.4	219.4	291.7	219.9	296.2	237.5	326.2
Non-U.S. Manufacturers										
Captive	--	11.9	--	12.3	--	12.1	--	12.4	--	14.5
Distributor	33.4	68.7	36.0	68.5	38.0	70.4	44.0	83.4	47.0	88.2
OEM/Integrator	25.1	56.8	25.0	55.8	29.0	59.1	31.4	62.6	35.0	69.9
TOTAL NON-U.S. REVENUES	58.5	137.4	61.0	136.6	67.0	141.6	75.4	158.4	82.0	172.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	313.6	472.1	285.3	432.0	286.4	433.3	295.3	454.6	319.5	498.8

Figure 1

CHANGING PRODUCT MIX

Worldwide Optical Disk Drive Revenue

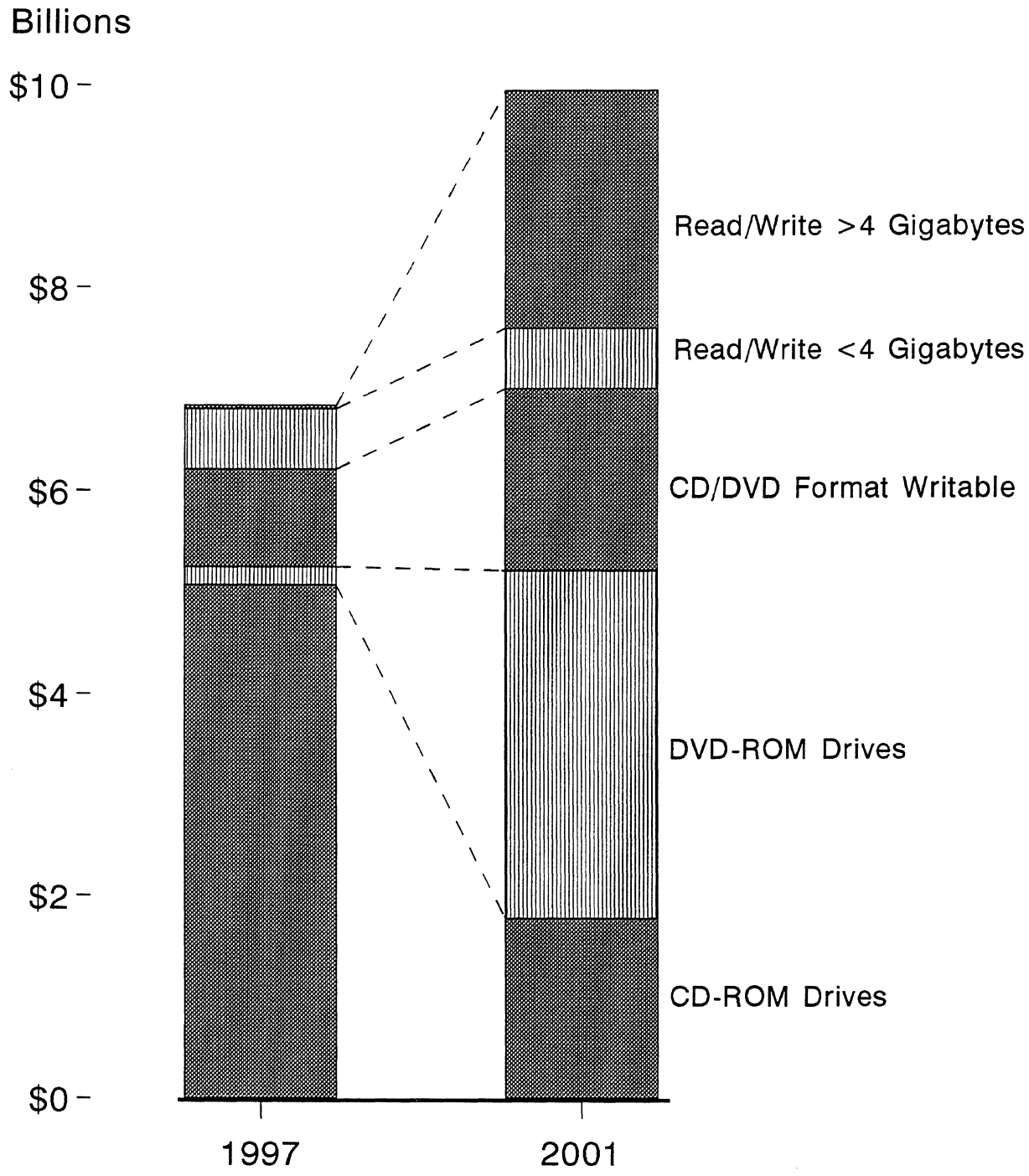
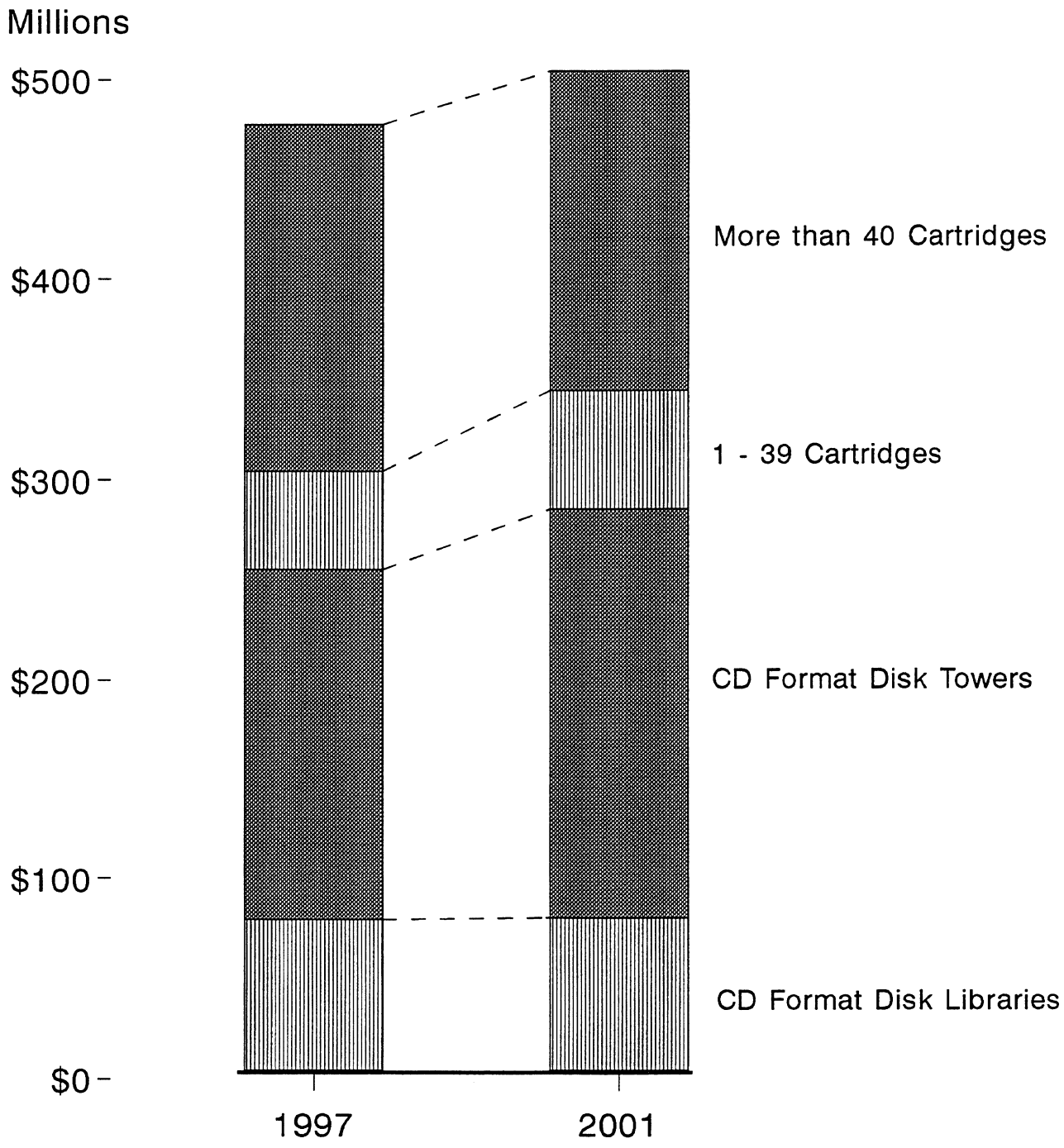


Figure 2

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, Distributor, and OEM/Integrator. Captive drives, libraries and towers are sold as part of systems that are manufactured by the same company. The 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 Distributor channel also includes optical 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.

1997 OEM/Integrator optical disk drive revenues shrank 3.4% to $3.48 billion, reflecting falling prices and declines in shipment growth rates, but still accounting for 50.9% of worldwide sales revenues of $6.83 billion. Distributor revenues were up over 66%, capturing 38% of total revenue, while revenues from the captive channel grew 7.9% and contributed 11% of total revenue. The growth in the captive contribution is at least partially due to slim profile CD-ROM drives sold on a captive basis, but the captive channel contribution is expected to fluctuate throughout the forecast period as a consequence of product mix changes. The OEM/Integrator channel contribution is expected to increase toward the end of the forecast period as the result of the relatively high prices of advanced MO drives sold to OEMs

Optical disk library and tower revenues of $472.1 million in 1997 split 35.8% from OEM/Integrators, 48.4% from the Distributor channel, and 15.8% from the captive channel. Tower sales are heavily biased to the Distributor channel and will help maintain share growth during the forecast period. 2001 revenues, projected at $498.8 million, will be shared among Distributors (53.9%), OEM/Integrator sales with 34.2% and captive sales with 11.9%. 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 Distributor channel. Consequently, the Distributor share of revenues is forecasted to increase at a faster rate than OEM/Integrator revenues.

Revenues in the DISK/TREND 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, 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. Four U.S. companies, 41 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. Taiwan and Korean manufacturers have made major share gains in CDS-ROM production, as Japan shifted focus to DVD technology. Many manufacturers are having drives made on a contract basis by Asian producers, with an increasing number being made in China, but it's interesting to note that one Taiwan firm has located a plant in the U.S. to provide improved customer support.

As of mid-1998, 34 companies produce CD-ROM drives, 33 are non-U.S. firms and 14 are Japanese organizations. 11 manufacturers make read/write drives less than 4 gigabytes. All of these make rewritable drives. Five companies make, or have announced, optical disk drives of more than 4 gigabytes capacity. Three firms produce only 12" write-once drives. Eastman Kodak, the only 14" drive producer, has announced it is leaving the field.

32 U.S. firms, 22 Asian manufacturers and 13 European suppliers offer optical libraries or towers. Of the 67 companies, 20 make CD format libraries. 41 manufacturers make CD format towers. Of these, 13 produce only net attached towers, three produce only host attached towers and the remainder make both types.

Of the 19 read/write library producers, 11 firms make only 5.25" libraries, while seven make larger diameter libraries. Only one company makes a 3.5" library. Three companies make read/write library models in two or more disk drive diameters.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1997 Revenues $M	1997 Revenues %	1998 Forecast $M	1998 Forecast %	1999 Forecast $M	1999 Forecast %	2000 Forecast $M	2000 Forecast %	2001 Forecast $M	2001 Forecast %
U.S. Manufacturers										
Captive	3.0	--	--	--	--	--	--	--	--	--
	-89.3%		--		--		--		--	
Distributor	19.3	.2%	15.0	.2%	28.9	.4%	84.8	1.0%	270.4	2.7%
	-64.7%		-22.3%		+92.7%		+193.4%		+218.9%	
OEM/Integrator	13.5	.1%	10.0	.1%	48.6	.7%	302.7	3.9%	1,695.7	17.0%
	-20.1%		-25.9%		+386.0%		+522.8%		+460.2%	
Total U.S. Manufacturers	35.8	.3%	25.0	.3%	77.5	1.1%	387.5	4.9%	1,966.1	19.7%
	-64.0%		-30.2%		+210.0%		+400.0%		+407.4%	
Non-U.S. Manufacturers										
Captive	757.7	11.0%	547.5	8.3%	520.0	7.6%	535.2	6.9%	551.3	5.5%
	+11.9%		-27.7%		-5.0%		+2.9%		+3.0%	
Distributor	2,575.3	37.7%	2,753.7	42.1%	2,772.1	40.5%	3,021.1	39.0%	3,078.7	30.9%
	+71.2%		+6.9%		+.7%		+9.0%		+1.9%	
OEM/Integrator	3,462.1	51.0%	3,204.3	49.3%	3,465.4	50.8%	3,783.9	49.2%	4,342.2	43.9%
	-3.3%		-7.4%		+8.1%		+9.2%		+14.8%	
Total Non-U.S. Manufacturers	6,795.1	99.7%	6,505.5	99.7%	6,757.5	98.9%	7,340.2	95.1%	7,972.2	80.3%
	+17.9%		-4.3%		+3.9%		+8.6%		+8.6%	
Worldwide Recap										
Captive	760.7	11.1%	547.5	8.4%	520.0	7.6%	535.2	6.9%	551.3	5.5%
	+7.9%		-28.0%		-5.0%		+2.9%		+3.0%	
Distributor	2,594.6	38.0%	2,768.7	42.4%	2,801.0	41.0%	3,105.9	40.2%	3,349.1	33.7%
	+66.4%		+6.7%		+1.2%		+10.9%		+7.8%	
OEM/Integrator	3,475.6	50.9%	3,214.3	49.2%	3,514.0	51.4%	4,086.6	52.9%	6,037.9	60.8%
	-3.4%		-7.5%		+9.3%		+16.3%		+47.7%	
Total All Manufacturers	6,830.9	100.0%	6,530.5	100.0%	6,835.0	100.0%	7,727.7	100.0%	9,938.3	100.0%
	+16.5%		-4.4%		+4.7%		+13.1%		+28.6%	

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	1997 Revenues $M	1997 Revenues %	1998 Forecast $M	1998 Forecast %	1999 Forecast $M	1999 Forecast %	2000 Forecast $M	2000 Forecast %	2001 Forecast $M	2001 Forecast %
U.S. Manufacturers										
Captive	62.6	13.2%	53.8	12.4%	47.4	10.9%	44.8	9.8%	45.1	9.0%
	+15.9%		-14.1%		-11.9%		-5.5%		+.7%	
Distributor	159.8	33.8%	147.0	34.0%	155.2	35.8%	157.2	34.5%	180.7	36.2%
	+1.0%		-8.0%		+5.6%		+1.3%		+14.9%	
OEM/Integrator	112.3	23.7%	94.6	21.8%	89.1	20.5%	94.2	20.7%	100.4	20.1%
	+48.5%		-15.8%		-5.8%		+5.7%		+6.6%	
Total U.S. Manufacturers	334.7	70.7%	295.4	68.2%	291.7	67.2%	296.2	65.0%	326.2	65.3%
	+16.3%		-11.7%		-1.3%		+1.5%		+10.1%	
Non-U.S. Manufacturers										
Captive	11.9	2.5%	12.3	2.8%	12.1	2.7%	12.4	2.7%	14.5	2.9%
	+56.6%		+3.4%		-1.6%		+2.5%		+16.9%	
Distributor	68.7	14.5%	68.5	15.8%	70.4	16.2%	83.4	18.3%	88.2	17.6%
	-25.8%		-.3%		+2.8%		+18.5%		+5.8%	
OEM/Integrator	56.8	12.3%	55.8	13.2%	59.1	13.9%	62.6	14.0%	69.9	14.2%
	-55.0%		-1.8%		+5.9%		+5.9%		+11.7%	
Total Non-U.S. Manufacturers	137.4	29.3%	136.6	31.8%	141.6	32.8%	158.4	35.0%	172.6	34.7%
	-39.3%		-.6%		+3.7%		+11.9%		+9.0%	
Worldwide Recap										
Captive	74.5	15.8%	66.1	15.3%	59.5	13.7%	57.2	12.6%	59.6	11.9%
	+20.9%		-11.3%		-10.0%		-3.9%		+4.2%	
Distributor	228.5	48.4%	215.5	49.9%	225.6	52.1%	240.6	52.9%	268.9	53.9%
	-8.9%		-5.7%		+4.7%		+6.6%		+11.8%	
OEM/Integrator	169.1	35.8%	150.4	34.8%	148.2	34.2%	156.8	34.5%	170.3	34.2%
	-16.2%		-11.1%		-1.5%		+5.8%		+8.6%	
Total All Manufacturers	472.1	100.0%	432.0	100.0%	433.3	100.0%	454.6	100.0%	498.8	100.0%
	-8.2%		-8.5%		+.3%		+4.9%		+9.7%	

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

Product mix

1997 optical disk drive shipments increased to over 80.7 million units. CD-ROM drives once more contributed most of the unit growth, accounting for almost 74.6 million units, 92.5% of the worldwide total. Nearly 1.2 million DVD-ROM drives were shipped, contributing an additional 1.5% share. However, the share for CD-ROM drives is forecasted to decrease to 31.9% in 2001, as shipments of DVD-ROM drives and writable CD/DVD format drives climb. DVD-ROM drives are projected to capture 55.4% of the overall 2001 unit shipment total for all optical disk drives. CD/DVD writable drives are expected to hold a 10.4% share in 2001. CD-ROM and DVD-ROM drive shipments include those associated with both computers and freestanding consumer equipment such as games, but not audio or video players.

The share of read/write drives less than 4 gigabytes was 1.8% of worldwide unit shipments in 1997, as increasing 3.5" MO disk drive shipments were overwhelmed by growth in CD-ROM and DVD-ROM drives. The share of read/write drives over 4 gigabytes was under .1%, but is expected to climb to at least .9% as advanced technology drives enter the market starting in 1999. If 5.25" drives with 10 gigabytes or more in on-line capacity are successful, this product segment has the potential for explosive future growth.

Within the less than 4 gigabytes group, 5.25" drive shipments continued to decline, 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 other technologies, including CD-RW drives, DVD-RAM drives, and advanced technology drives in the future. CD/DVD format writable (CD-R, CD-RW, DVD-RAM and PD) drive shipments jumped 140.7%, to over 3.4 million units, as a result of lower prices for CD-R and CD-RW drives and media. Rewritable drives captured virtually all of the less than 4 gigabytes product group 1997 shipments. Write-once drives in this group have all but vanished.

Only 12" to 14" unit shipments existed in the over 4 gigabyte group in 1997, but 5.25" drives will rapidly outnumber them when introduced in future periods. DVD-RAM rewritable drives are expected to compete with drives in this group in 1999 and after, in applications where drive performance is subordinate to drive price and DVD format compatibility.

1997 sales revenues were derived predominantly from shipments in the CD-ROM drive product group, which provided 74.4% of worldwide optical drive sales revenues. DVD-ROM drives contributed 2.6%. CD/DVD format writable drives boosted their share to 13.9%, while read/write drives less than 4 gigabytes declined to 8.6%. Read/write drives more than 4 gigabytes garnered only a .5% share. The revenue share for CD-ROM drives is expected to decline to 17.8% at the end of the forecast period, while DVD-ROM drives soar to 34.7%. Writable CD/DVD format drive revenues will grow to 17.9%, as DVD writable drives ramp up later in the forecast period, but drives under 4 gigabytes will decline in share as the result of displacement by higher capacity drives. Conversely, the share for read/write drives over 4 gigabytes is expected to show large annual gains starting in 1999, sparked by increasing advanced technology 5.25" drive shipments.

Despite notable shipment declines, CD format optical disk libraries, particularly small autochangers with under 10 disk capacity, again led optical disk library and tower shipments in 1997, attaining a 70.9% share. The next largest segment was the CD format tower, with a 21.7% unit share, followed by 1 to 39 disk cartridge libraries, with a 4.4% share. The share of libraries with 40 or more cartridges was 3%. The largest year-to-year growth rate was exhibited by CD towers, with a 9.8% increase.

Within the tower segment, there is a gradual shift to towers with more drives, 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. Hard drive cached towers are a very rapidly increasing segment of the network attached tower business.

1997 optical library revenues of $472.1 million were shared by CD format towers (37.2%), the 40 or more cartridge group (36.6%), followed distantly by the CD libraries (15.8%) and the 1 to 39 cartridge group (10.4%). Towers are expected to continue to lead in revenue because of higher prices relative to the average CD format library, which is minichanger dominated.

TABLE 5

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1997		Forecast							
ALL MANUFACTURERS	Revenues		1998		1999		2000		2001	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM DRIVES	5,077.0	74.4%	4,368.0	67.0%	3,977.4	58.3%	3,177.1	41.1%	1,771.4	17.8%
	+8.9%		-14.0%		-8.9%		-20.1%		-44.2%	
DVD-ROM DRIVES	178.1	2.6%	474.1	7.3%	979.2	14.3%	1,854.9	24.0%	3,444.7	34.7%
	--		+166.2%		+106.5%		+89.4%		+85.7%	
CD/DVD FORMAT WRITABLE	950.7	13.9%	1,036.2	15.9%	1,121.5	16.4%	1,540.2	19.9%	1,779.3	17.9%
	+89.4%		+9.0%		+8.2%		+37.3%		+15.5%	
READ/WRITE DRIVES	589.7	8.6%	619.5	9.5%	647.1	9.5%	636.8	8.2%	594.6	6.0%
LESS THAN 4 GIGABYTES	-7.1%		+5.1%		+4.5%		-1.6%		-6.6%	
READ/WRITE DRIVES	35.4	.5%	32.7	.3%	109.8	1.5%	518.7	6.7%	2,348.3	23.6%
MORE THAN 4 GIGABYTES	-44.8%		-7.6%		+235.8%		+372.4%		+352.7%	
Total Worldwide Revenue	6,830.9	100.0%	6,530.5	100.0%	6,835.0	100.0%	7,727.7	100.0%	9,938.3	100.0%
	+16.5%		-4.4%		+4.7%		+13.1%		+28.6%	

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	1997		Forecast							
ALL MANUFACTURERS	Revenues		1998		1999		2000		2001	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT OPTICAL LIBRARIES	74.6	15.8%	68.8	15.9%	68.8	15.9%	71.5	15.7%	75.6	15.2%
	-47.3%		-7.8%		--		+3.9%		+5.7%	
CD FORMAT DISK TOWERS	175.6	37.2%	165.3	38.3%	174.0	40.2%	187.1	41.2%	204.8	41.1%
	+20.3%		-5.9%		+5.3%		+7.5%		+9.5%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	48.9	10.4%	45.2	10.5%	44.4	10.2%	50.1	11.0%	58.8	11.8%
	-26.5%		-7.6%		-1.8%		+12.8%		+17.4%	
OPTICAL LIBRARIES MORE THAN 40 CARTRIDGES	173.0	36.6%	152.7	35.3%	146.1	33.7%	145.9	32.1%	159.6	31.9%
	+7.9%		-11.7%		-4.3%		--		+9.4%	
Total Worldwide Revenue	472.1	100.0%	432.0	100.0%	433.3	100.0%	454.6	100.0%	498.8	100.0%
	-8.2%		-8.5%		+.3%		+4.9%		+9.7%	

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	1997		Forecast							
IN THOUSANDS	Shipments		1998		1999		2000		2001	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM DRIVES	74,580.9	92.5%	83,237.5	88.5%	87,295.0	78.7%	76,573.0	59.8%	46,053.0	31.9%
	+34.2%		+11.6%		+4.9%		-12.3%		-39.9%	
DVD-ROM DRIVES	1,199.0	1.5%	4,365.0	4.6%	13,120.0	11.8%	37,320.0	29.1%	79,727.0	55.4%
	--		+264.1%		+200.6%		+184.5%		+113.6%	
CD/DVD FORMAT WRITABLE	3,413.7	4.2%	4,789.9	5.1%	8,585.0	7.7%	12,037.0	9.4%	15,005.0	10.4%
	+140.7%		+40.3%		+79.2%		+40.2%		+24.7%	
READ/WRITE DRIVES	1,554.6	1.8%	1,809.5	1.8%	2,010.0	1.8%	2,070.0	1.6%	2,031.0	1.4%
LESS THAN 4 GIGABYTES	+11.2%		+16.4%		+11.1%		+3.0%		-1.9%	
READ/WRITE DRIVES	2.4	--	2.5	--	53.0	--	312.0	--	1,435.0	.9%
MORE THAN 4 GIGABYTES	-73.0%		+4.2%		--		+488.7%		+359.9%	
Total Worldwide Shipments	80,750.6	100.0%	94,204.4	100.0%	111,063.0	100.0%	128,312.0	100.0%	144,251.0	100.0%
	+38.3%		+16.7%		+17.9%		+15.5%		+12.4%	
% U.S. Manufacturers	--		--		--		.2%		.8%	

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	1997 Shipments Units	1997 Shipments %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %	2000 Forecast Units	2000 Forecast %	2001 Forecast Units	2001 Forecast %
CD FORMAT OPTICAL LIBRARIES	134,208	70.9%	130,685	69.5%	145,637	70.5%	159,625	70.6%	173,337	70.2%
	-80.3%		-2.6%		+11.4%		+9.6%		+8.6%	
CD FORMAT DISK TOWERS	41,197	21.7%	43,748	23.3%	47,062	22.8%	50,764	22.4%	54,832	22.2%
	+9.8%		+6.2%		+7.6%		+7.9%		+8.0%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	8,355	4.4%	7,614	4.0%	7,630	3.7%	8,910	3.9%	10,675	4.3%
	-20.3%		-8.9%		+.2%		+16.8%		+19.8%	
OPTICAL LIBRARIES MORE THAN 40 CARTRIDGES	5,862	3.0%	5,970	3.2%	6,320	3.0%	6,875	3.0%	8,225	3.3%
	+.6%		+1.8%		+5.9%		+8.8%		+19.6%	
Total Worldwide Shipments	189,622	100.0%	188,017	100.0%	206,649	100.0%	226,174	100.0%	247,069	100.0%
	-74.2%		-.8%		+9.9%		+9.4%		+9.2%	
% U.S. Manufacturers	31.8%		23.9%		23.0%		22.4%		22.4%	

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

Figure 3

WORLDWIDE SHIPMENT SUMMARY

Total Optical Disk Drives

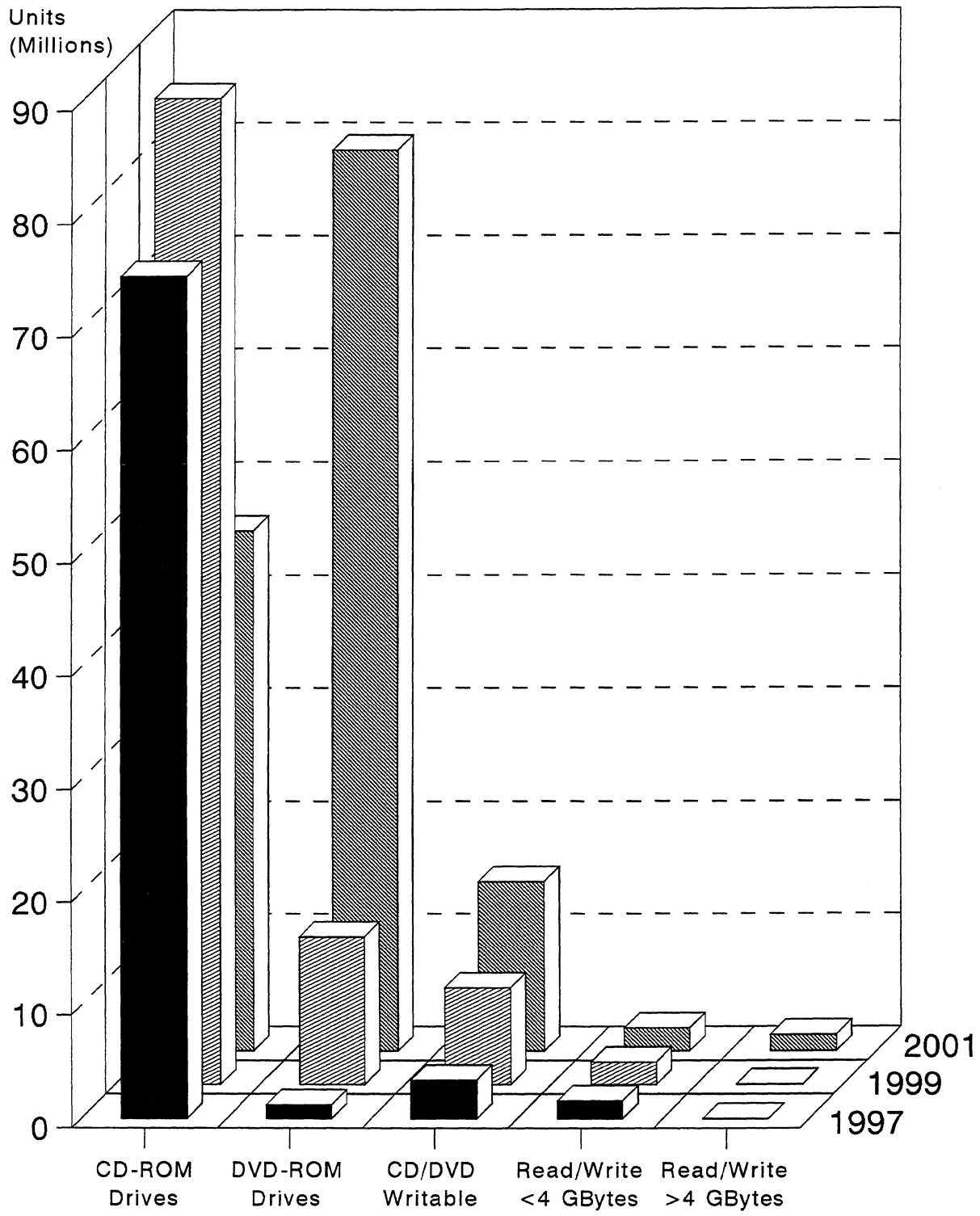
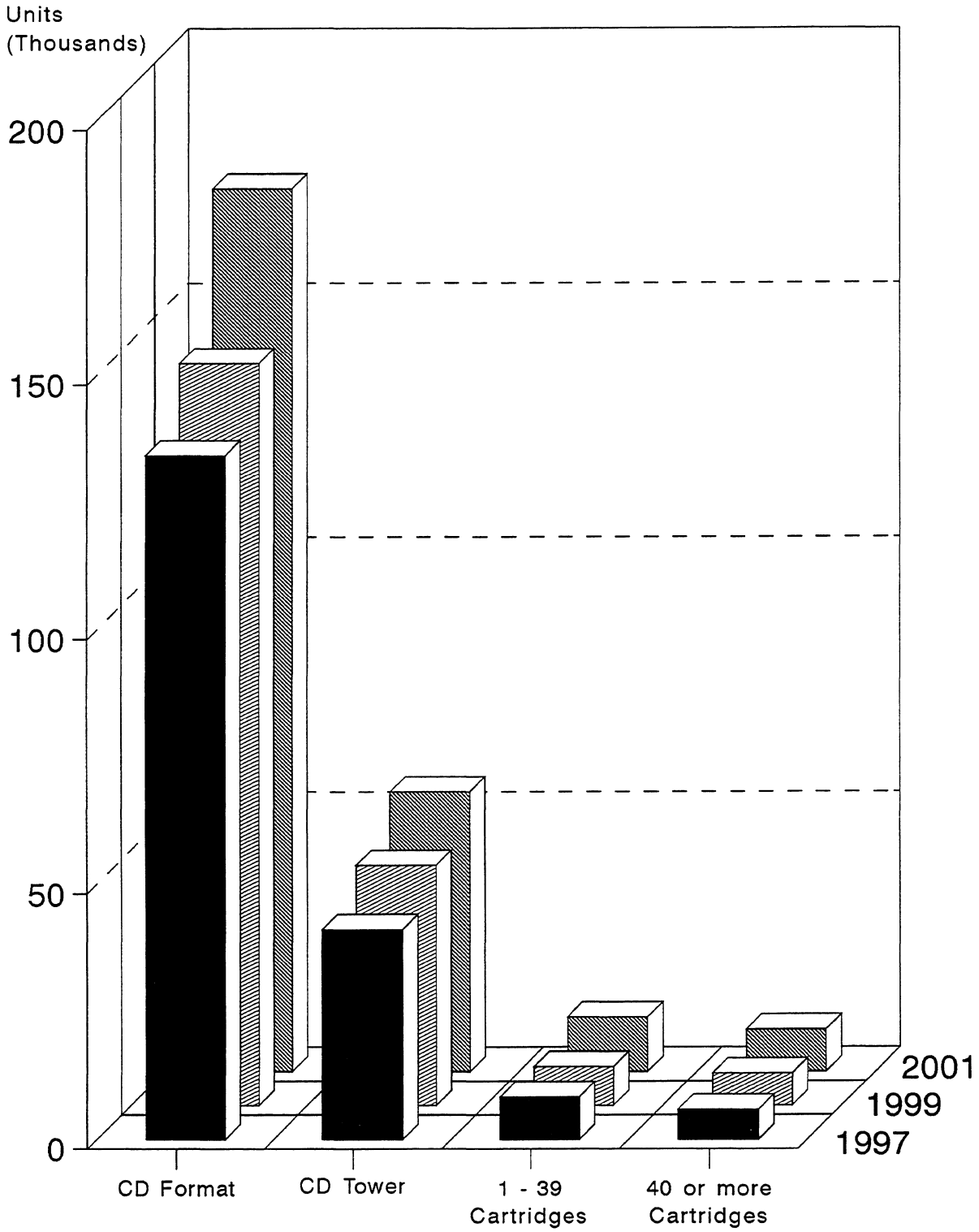


Figure 4

WORLDWIDE SHIPMENT SUMMARY

Total Optical Libraries



Noncaptive market

CD-ROM and DVD-ROM disk drives continued to be shipped in increasingly large quantities to system makers in 1997, capturing 94% of the noncaptive (OEM/Integrator and Distributor channels) total. Shipments of CD/DVD format writable drives accounted for 4.1%, while the share of read/write drives less than 4 gigabytes shrank to 1.9% of noncaptive optical disk drive total unit shipments. The share for read/write drives over 4 gigabytes was again less than .1%.

The combined share of CD-ROM and DVD-ROM drives will decline to 87.5% at the end of the forecast period, as shipments of rewritable CD/DVD format drives increase, and their falling prices make them increasingly attractive to system manufacturers as built-in equipment.

CD-ROM and DVD-ROM drives together held 77.7% of 1997 noncaptive revenues, while CD/DVD format writable drives collected 13.2% of the noncaptive revenues. The revenue share for read/write drives less than 4 gigabytes shrank to 8.7%, while read/write drives more than 2 gigabytes saw their share decline again to .4%. 2001 noncaptive revenues of over $9.4 billion will again largely go to CD-ROM and DVD-ROM drives, which together are expected to capture 51.9% of the total. Drives more than 4 gigabytes will increase in noncaptive revenue share rapidly after 1998, obtaining 24.9% in 2001, as the result of increasing shipments of higher capacity 5.25" drives. The share of CD/DVD writable drives will increase to 17.6% of 2001 revenues.

The leading 1997 OEM/Integrator drive revenue producers were Matsushita Electric, Toshiba, Hitachi, Sony and LG Electronics, in that order. The top five companies accounted for 56% of total OEM/Integrator sales of nearly $3.5 billion, again down from the previous year and reflecting increased participation by CD-ROM producers in Taiwan and Korea. Matsushita Electric led with 18.9% of the OEM/Integrator total. LG Electronics has taken the lead in Distributor sales as a result of its rapid growth in CD-ROM sales, followed closely by Fujitsu, which benefits from increased 3.5" MO drive sales. Other major participants were Pan International, Mitsumi, and Samsung Electronics. The top five together account for only 37.9% of the $2.6 billion sales in this channel. All are major CD/DVD-ROM producers, except for Fujitsu. U.S. producers captured only .4% of total 1997 OEM/Integrator revenues, a further decline from 1996, and U.S. firms' share of Distributor revenues declined to .7%.

CD format library shipments claimed 71.9% of almost 187,000 noncaptive optical libraries and towers shipped in 1997, followed by CD format towers (21.7%, up sharply from 1996), and 1-39 cartridge libraries (3.9% share). The more than 40 cartridge group held less than a 2.5% share. The CD format library is expected to retain its dominance through 2001, holding 71.5% of the year's total. CD format towers are projected to hold about the same share at 21.8%, and the remaining product groups are also expected to close out the forecast period at share levels similar to their 1997 holdings.

1997 noncaptive library revenues shrank 12.2% to $397.6 million, but are expected to restart growth in 1999 and increase to $439.2 million in 2001. Because of higher prices, revenue shares for towers and larger libraries exceeded their unit shipment shares. The CD tower product group repeated its 1997 leadership with 43.8%, followed by the more than 40 cartridge library segment with 27.4%, the CD format libraries with 18.6%, and the 1-39 cartridge segment with 10.2% share.

The optical disk library groups are expected to gain ground towards the end of the forecast period, as advanced MO drives make these products more attractive, but some of the effect will be masked because a significant percentage of the libraries are expected to be sold on a captive basis. In 2001, CD format towers are expected to capture over 45% of noncaptive revenues, followed by the CD format libraries (17%) and the more than 40 cartridge group with 26.6%. A moderate share increase to 11.3% is forecasted for 1 to 39 cartridge optical disk libraries.

U.S. library and tower manufacturers did far better than U.S. optical disk drive makers in 1997, capturing 66.4% of OEM/Integrator channel revenues and 69.9% of Distributor channel revenues. Hewlett-Packard, Procom and Plasmon Data were the leading OEM/Integrator suppliers, accounting for 28% of the $169.1 million channel revenues. The 35.2% share of "Other U.S." OEM/Integrators is noteworthy, as it reflects the very fragmented nature of the optical storage subsystems market in the U.S. In the Distributor channel, Hewlett-Packard, Meridian Data, Procom, and Plasmon Data were the leaders, together capturing 48.7% of over $228.5 million in sales in the channel.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1997		Forecast							
ALL MANUFACTURERS	Revenues		1998		1999		2000		2001	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD-ROM DRIVES	4,546.6	75.0%	3,996.6	66.9%	3,639.9	57.7%	2,987.7	41.6%	1,641.0	17.5%
	+11.8%		-12.1%		-8.9%		-17.9%		-45.1%	
DVD-ROM DRIVES	161.8	2.7%	441.2	7.4%	928.5	14.7%	1,712.8	23.9%	3,225.9	34.4%
	--		+172.7%		+110.4%		+84.5%		+88.3%	
CD/DVD FORMAT WRITABLE	801.3	13.2%	957.8	16.0%	1,059.0	16.8%	1,405.3	19.5%	1,644.3	17.6%
	+70.9%		+19.5%		+10.6%		+32.7%		+17.0%	
READ/WRITE DRIVES	528.1	8.7%	554.7	9.3%	577.8	9.2%	568.0	7.9%	527.5	5.6%
LESS THAN 4 GIGABYTES	-6.8%		+5.0%		+4.2%		-1.7%		-7.1%	
READ/WRITE DRIVES	32.4	.4%	32.7	.4%	109.8	1.6%	518.7	7.1%	2,348.3	24.9%
MORE THAN 4 GIGABYTES	-41.4%		+.9%		+235.8%		+372.4%		+352.7%	
Total Worldwide Revenues	6,070.2	100.0%	5,983.0	100.0%	6,315.0	100.0%	7,192.5	100.0%	9,387.0	100.0%
	+17.7%		-1.4%		+5.5%		+13.9%		+30.5%	

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	------1997-----		----------Forecast----------							
ALL MANUFACTURERS	----Revenues---		------1998-----		------1999-----		------2000-----		------2001-----	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT OPTICAL LIBRARIES	74.0	18.6%	67.9	18.6%	67.9	18.2%	70.7	17.8%	74.8	17.0%
	-47.7%		-8.2%		--		+4.1%		+5.8%	
CD FORMAT DISK TOWERS	173.6	43.8%	160.4	43.9%	169.2	45.3%	181.8	45.8%	197.7	45.1%
	+18.9%		-7.6%		+5.5%		+7.4%		+8.7%	
OPTICAL LIBRARIES	40.6	10.2%	38.4	10.5%	37.4	10.0%	41.9	10.6%	49.3	11.3%
1-39 CARTRIDGES	-26.3%		-5.4%		-2.6%		+12.0%		+17.7%	
OPTICAL LIBRARIES	109.4	27.4%	99.2	27.0%	99.3	26.5%	103.0	25.8%	117.4	26.6%
MORE THAN 40 CARTRIDGES	-.6%		-9.3%		--		+3.7%		+14.0%	
Total Worldwide Revenues	397.6	100.0%	365.9	100.0%	373.8	100.0%	397.4	100.0%	439.2	100.0%
	-12.2%		-8.0%		+2.2%		+6.3%		+10.5%	

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	1997		Forecast							
IN THOUSANDS	Shipments		1998		1999		2000		2001	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD-ROM DRIVES	68,968.1	92.5%	78,910.2	88.5%	82,973.0	78.5%	74,029.0	60.1%	44,190.0	32.0%
	+35.6%		+14.4%		+5.1%		-10.8%		-40.3%	
DVD-ROM DRIVES	1,096.0	1.5%	4,055.4	4.5%	12,604.0	11.9%	35,742.0	28.9%	76,992.0	55.5%
	--		+270.0%		+210.8%		+183.6%		+115.4%	
CD/DVD FORMAT WRITABLE	3,101.7	4.1%	4,607.2	5.2%	8,365.0	7.9%	11,423.0	9.3%	14,135.0	10.2%
	+127.5%		+48.5%		+81.6%		+36.6%		+23.7%	
READ/WRITE DRIVES	1,484.0	1.9%	1,721.1	1.8%	1,902.0	1.7%	1,953.0	1.5%	1,910.0	1.4%
LESS THAN 4 GIGABYTES	+10.7%		+16.0%		+10.5%		+2.7%		-2.2%	
READ/WRITE DRIVES	2.3	--	2.5	--	53.0	--	312.0	.2%	1,435.0	.9%
MORE THAN 4 GIGABYTES	-72.9%		+8.7%		--		+488.7%		+359.9%	
Total Worldwide Shipments	74,652.1	100.0%	89,296.4	100.0%	105,897.0	100.0%	123,459.0	100.0%	138,662.0	100.0%
	+39.3%		+19.6%		+18.6%		+16.6%		+12.3%	
% U.S. Manufacturers	--		--		--		.2%		.8%	

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	1997 Shipments Units	1997 Shipments %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %	2000 Forecast Units	2000 Forecast %	2001 Forecast Units	2001 Forecast %
CD FORMAT OPTICAL LIBRARIES	134,128	71.9%	130,565	70.8%	145,527	71.7%	159,519	71.8%	173,237	71.5%
	-80.3%		-2.7%		+11.5%		+9.6%		+8.6%	
CD FORMAT DISK TOWERS	40,657	21.7%	42,328	23.0%	45,617	22.5%	49,174	22.1%	53,052	21.8%
	+8.4%		+4.1%		+7.8%		+7.8%		+7.9%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	7,174	3.9%	6,654	3.6%	6,685	3.2%	7,800	3.5%	9,385	3.9%
	-21.5%		-7.2%		+.5%		+16.7%		+20.3%	
OPTICAL LIBRARIES MORE THAN 40 CARTRIDGES	4,889	2.5%	5,021	2.6%	5,400	2.6%	5,895	2.6%	7,090	2.8%
	-3.5%		+2.7%		+7.5%		+9.2%		+20.3%	
Total Worldwide Shipments	186,848	100.0%	184,568	100.0%	203,229	100.0%	222,388	100.0%	242,764	100.0%
	-74.5%		-1.2%		+10.1%		+9.4%		+9.2%	
% U.S. Manufacturers	30.9%		22.6%		21.9%		21.3%		21.2%	

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

Figure 5

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Disk Drives

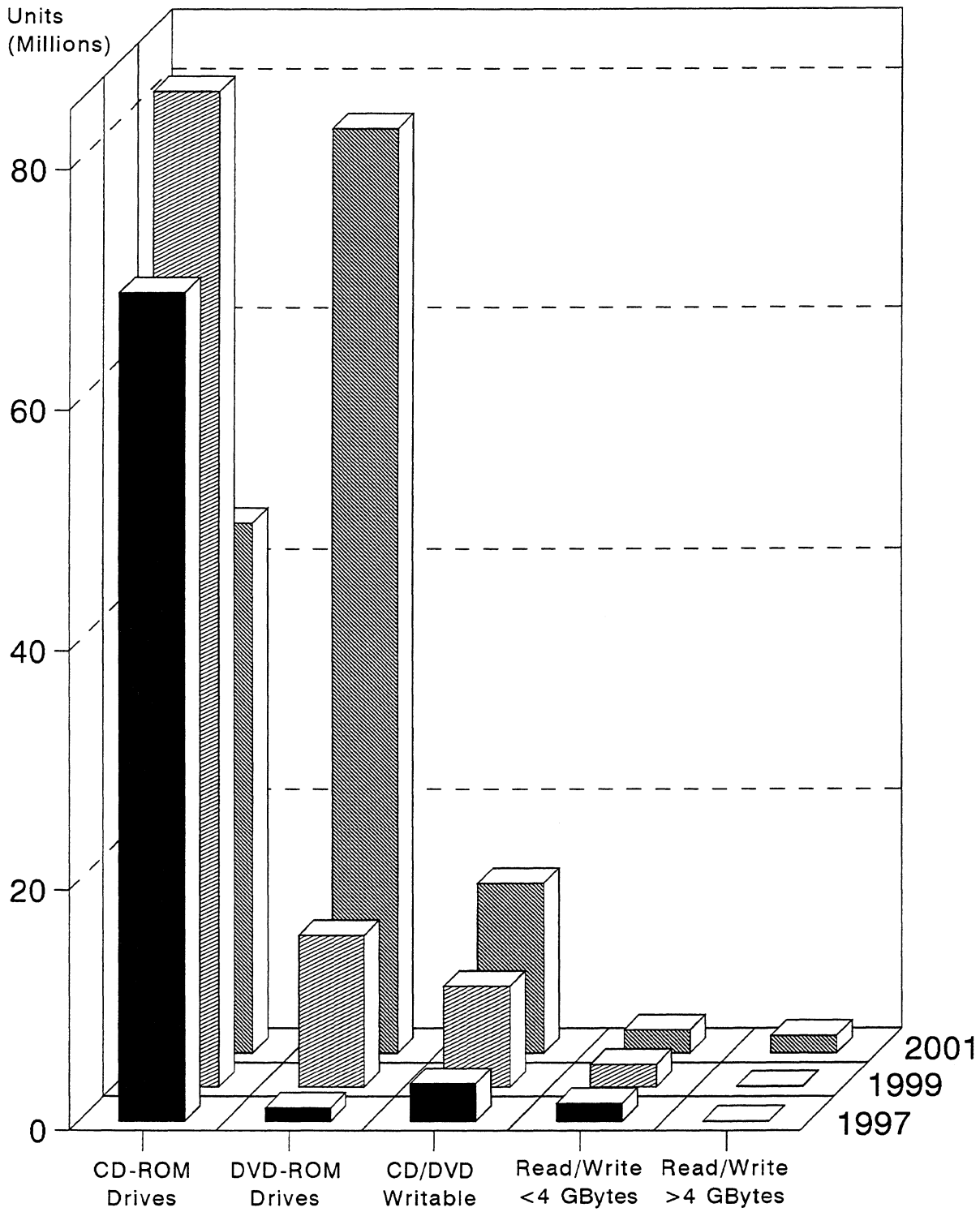


Figure 6

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Libraries

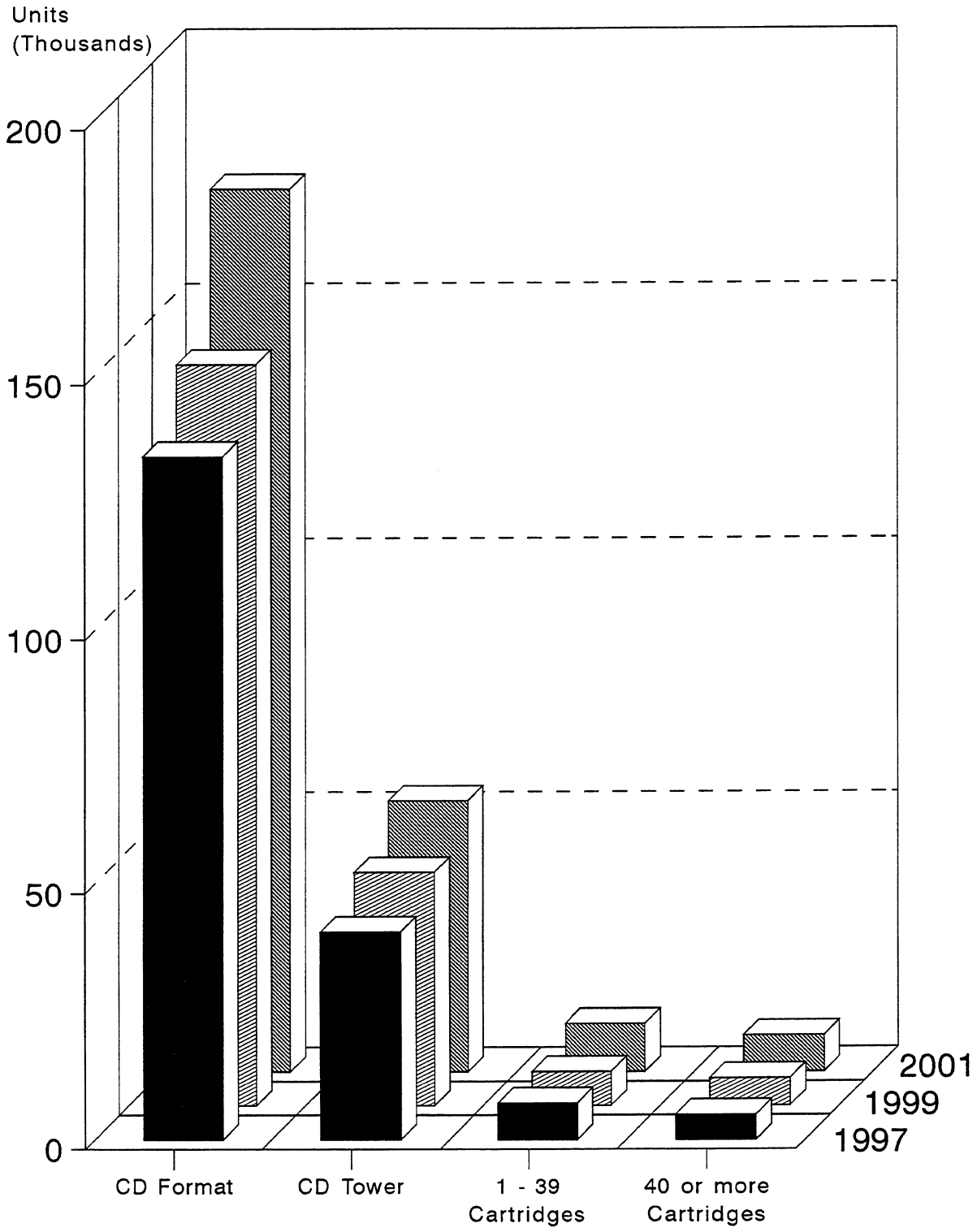
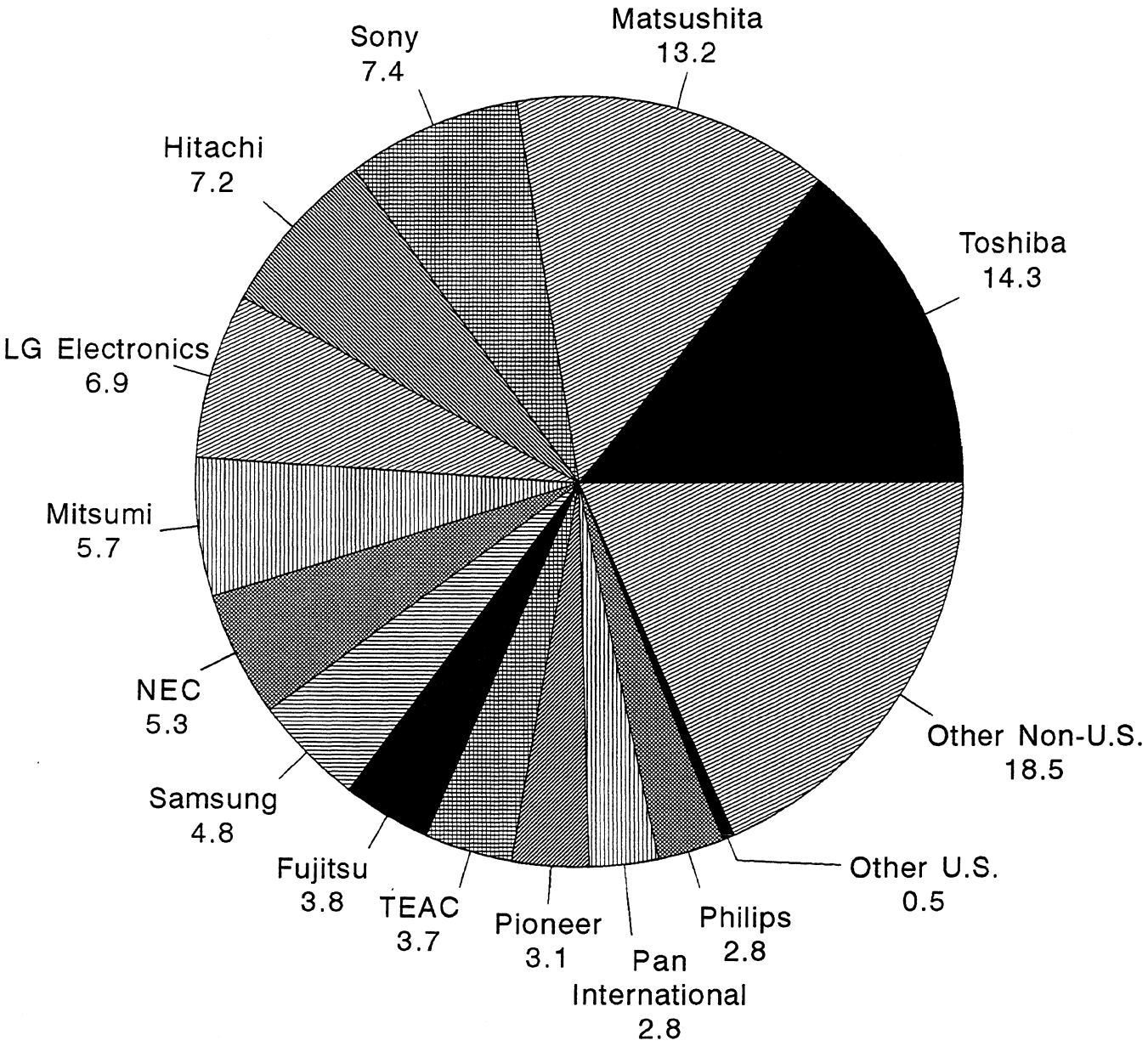


Figure 7

1997 ESTIMATED MARKET SHARES

Worldwide Revenue Percentages of all Optical Disk Drives



1997 Revenues: $6,830,900,000

TABLE 13

1997 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK DRIVES
(Value of non-U.S. currencies estimated at average 1997 rates)

	CAPTIVE		DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Other U.S.	3.0	.4	19.3	.7	13.5	.4	35.8	.5
U.S. Total	3.0	.4	19.3	.7	13.5	.4	35.8	.5
NON-U.S. MANUFACTURERS								
Fujitsu	23.9	3.1	217.6	8.4	20.0	.6	261.5	3.8
Hitachi	14.4	1.9	116.1	4.5	362.3	10.4	492.8	7.2
LG Electronics	9.9	1.3	223.2	8.6	241.4	6.9	474.5	6.9
Matsushita Electric Industrial	121.4	16.0	121.1	4.7	657.6	18.9	900.1	13.2
Mitsumi Electric	--	--	179.3	6.9	207.5	6.0	386.8	5.7
NEC	76.8	10.1	99.2	3.8	182.8	5.3	358.8	5.3
Pan International (Cyberdrive)	--	--	188.6	7.3	--	--	188.6	2.8
Philips	--	--	41.0	1.6	152.2	4.4	193.2	2.8
Pioneer Electronic	--	--	101.0	3.9	113.9	3.3	214.9	3.1
Samsung Electronics	32.5	4.3	167.7	6.5	124.6	3.6	324.8	4.8
Sony	55.2	7.3	156.0	6.0	293.7	8.5	504.9	7.4
TEAC	--	--	76.0	2.9	179.2	5.2	255.2	3.7
Toshiba	423.7	55.6	165.1	6.4	391.2	11.3	980.0	14.3
Other Non-U.S.	--	--	723.4	27.8	535.7	15.2	1,259.0	18.5
Non-U.S. Total	757.7	99.6	2,575.3	99.3	3,462.1	99.6	6,795.1	99.5
WORLDWIDE TOTAL	760.7	100.0	2,594.6	100.0	3,475.6	100.0	6,830.9	100.0

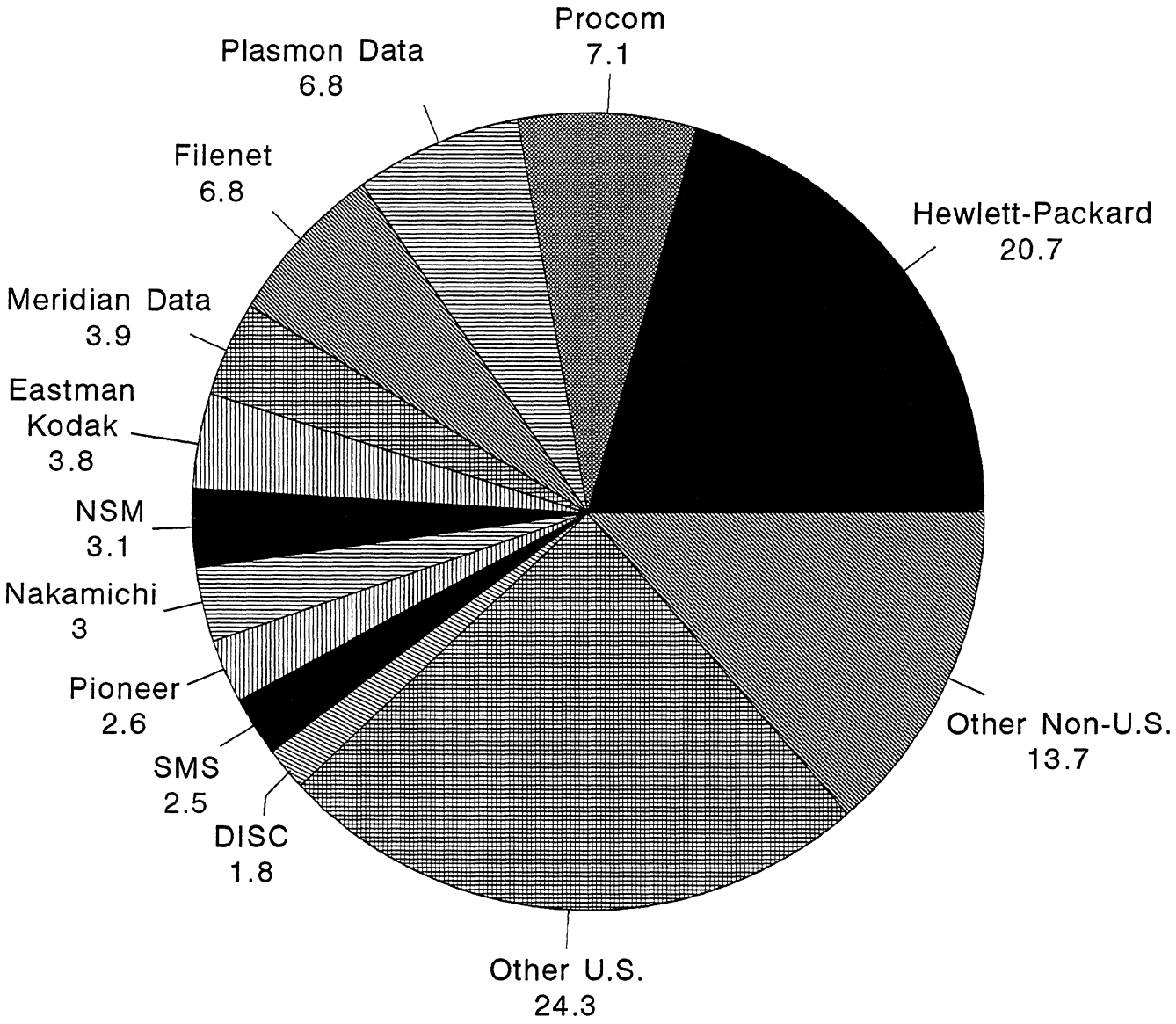
Note: 1. Drives sold in the Distributor market by other than the original manufacturer are valued at Distributor prices above, to avoid distortion of total market value.

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

1997 ESTIMATED MARKET SHARES

Worldwide Revenue Percentages of all Optical Disk Libraries and Towers



1997 Revenues: $472,100,000

TABLE 14

1997 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK LIBRARIES AND TOWERS
(Value of non-U.S. currencies estimated at average 1997 rates)

	CAPTIVE		DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
DISC	--	--	.4	.2	8.2	4.8	8.6	1.8
Eastman Kodak	7.5	10.1	--	--	10.5	6.2	18.0	3.8
Filenet	30.5	40.9	--	--	1.7	1.0	32.2	6.8
Hewlett-Packard	22.9	30.7	58.3	25.5	16.5	9.8	97.7	20.7
Meridian Data	--	--	18.2	8.0	--	--	18.2	3.9
Procom	--	--	17.7	7.7	15.9	9.4	33.6	7.1
SMS	--	--	11.7	5.1	--	--	11.7	2.5
Other U.S.	1.7	2.3	53.5	23.4	59.5	35.2	114.7	24.3
U.S. Total	62.6	84.0	159.8	69.9	112.3	66.4	334.7	70.9
NON-U.S. MANUFACTURERS								
Nakamichi	--	--	10.8	4.7	3.2	1.9	14.0	3.0
NSM	--	--	6.6	2.9	7.9	4.7	14.5	3.1
Pioneer	--	--	7.4	3.2	4.9	2.9	12.3	2.6
Plasmon Data	--	--	17.1	7.5	14.9	8.8	32.0	6.8
Other Non-U.S.	11.9	16.0	26.8	11.8	37.6	15.3	64.6	13.6
Non-U.S. Total	11.9	16.0	68.7	30.1	56.8	33.6	137.4	29.1
WORLDWIDE TOTAL	74.5	100.0	228.5	100.0	169.1	100.0	472.1	100.0

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

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

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

TABLE 15

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL DISK DRIVES

DISK/TREND PRODUCT GROUP:		20	21	22	23	24
U.S. Manufacturers (4)	Type	CD Format Read-Only Drives	DVD Format Read-Only Drives	CD/DVD Format Writable Drives	Read/Write Optical Drives <4 GB	Read/Write Optical Drives >4 GB
Eastman Kodak	C,O,D					14
Hewlett-Packard	C,O,D			12 cm	5.25E	
Mountain Optech	O	12 cm			3.5E, 5.25E	
Pinnacle Micro	O,D			12 cm		5.25E
Asian Manufacturers (41)						
Acer Peripherals	O,D	12 cm		12 cm		
Actima	O,D	12 cm				
AOpen	C,O,D	12 cm	12 cm	12 cm		
Asustek Computer	O,D	12 cm				
Behavior Tech Computer	O,D	12 cm		12 cm		
Calix Technology	O,D	12 cm				
Delta Electronics	O,D	12 cm		12 cm		
Elite Peripheral, Inc.	O,D	12 cm				
Fujitsu	O,D				3.5E	
Hitachi	C,O,D	12 cm	12 cm	12 cm	5.25E	
Hopax Industries	O,D	12 cm				
JVC	O,D			12 cm		
Kenwood	O,D	12 cm				
Konica	O,D				3.5E	
Leoptics	O,D	12 cm		12 cm		
LG Electronics	C,O,D	12 cm	12 cm	12 cm		
Lite-On Technology	O,D	12 cm		12 cm		
Matsushita Electric Ind.	C,O,D	12 cm	12 cm	12 cm		
Maxoptix	O,D				5.25E	
Mitsumi Electric	O,D	12 cm	12 cm	12 cm		
NEC	C,O,D			12 cm	5.25E	12
NEC Home Electronics	C,O,D	12 cm				
Nikon	O,D				5.25E	
Norm Pacific Automation	O,D	12 cm				
Olympus	O,D				3.5E, 5.25E	
Optics Storage	O,D	12 cm				
Pan-International (Cyberdrive)	O,D	12 cm	12 cm	12 cm		
Pioneer	O,D	12 cm	12 cm	12 cm	5.25E	
Plextor (Shinano Kenshi)	O,D	12 cm		12 cm		
Ricoh	O,D			12 cm		
Samsung Electronics	O,D	12 cm	12 cm	12 cm		
Sanyo Electric	O,D	12 cm		12 cm		
Sony	C,O,D	8 cm,12 cm	12 cm	12 cm	5.25E	
TEAC	O,D	12 cm	12 cm	12 cm		
Toshiba	C,O,D	12 cm	12 cm	12 cm		
Ultima Electronics (Artec)	O,D	12 cm		12 cm		
Unitron	O,D	12 cm				
USDrives	O,D	12 cm		12 cm		
Wearnes Peripherals	O,D	12 cm		12 cm		
Yamaha	O,D			12 cm		
Yung Fu (Lxycon)	O,D	12 cm				
European Manufacturers (3)						
ATG	O					12
Philips	O,D	12 cm	12 cm	12 cm		
Philips LMS	O,D					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 H = Host attached
O = OEM/Integrator N = Net attached
D = Distributor

DISK/TREND PRODUCT GROUP:		50	51	52	53
U.S. Manufacturers (32)	Type	CD Format Optical Libraries	CD Format Towers	Read/Write Optical Libraries 1-39 Disks	Read/Write Optical Libraries 40+ Disks
Advanced Media Services	O,D		H,N		
Atronics	D		N		
Axonix	D		N		
Boffin	D		H,N		
CD International	D		H,N		
CMS Enhancements	D		N		
Compaq Computer	C,D		H		
Cutting Edge	D		H,N		
DISC	O,D	12 cm			5.25
Eastman Kodak	C,O,D	12 cm			14
EMASS	O,D				5.25
Excel Computer	D		H,N		
FileNet	C,O				12
Hewlett-Packard	C,O,D		H,N	5.25	5.25
IBM	C,D			5.25	5.25
JES	D		H		
Kintronics	D		H,N		
Kubik Enterprises	O	12 cm			
Legacy Storage Systems	O,D		H,N		
Meridian Data	D		H,N		
Micro Design International	D		H,N		
Microtest	O,D		N		
Open Storage Solutions	O,D		N		
Optical Access International	O,D		H,N		
Plextec	D		H,N		
Procom Technology	O,D		H,N		
Smart and Friendly	D		H,N		
SMS Data Products	O,D		H,N		
TAC Systems	O,D		H,N		
Ten X Technology	O,D		N		
Todd Enterprises	O,D		H		
Vision Computers	D		H,N		

TABLE 16 (Continued)

DISK/TREND PRODUCT GROUP:		50	51	52	53
Asian Manufacturers (22)	Type	CD Format Optical Libraries	CD Format Towers	Read/Write Optical Libraries 1-39 Disks	Read/Write Optical Libraries 40+ Disks
Allion Computer	O,D		N		
Asaca	O,D	12 cm			5.25
Chia Shin Technology	D		N		
Fujitsu	C,O			3.5, 5.25	5.25
Hitachi	C,O,D	12 cm		5.25	5.25
JVC	O,D	12 cm	H		
Kubota	O			5.25	5.25
Matsushita Electric Ind.	O,D	12 cm			
Maxoptix	O,D			5.25	5.25
Nakamichi	O,D	12 cm			
NEC	C,O			5.25	5.25
Newtech	D		N		
Nippon Columbia (Denon)	O,D	12 cm			
Nistec	D	12 cm			
Optics Storage	D		N		
Pioneer	O,D	12 cm			
Plextor (Shinano Kenshi)	D	12 cm	H,N		
Rexas	D		H,N		
Sony	C,O,D	12 cm		5.25	5.25
Svec Computer	D		N		
TEAC	O,D	12 cm	N		
Tekram	O,D		N		
European Manufacturers (13)					
ASM	O,D	12 cm		5.25	5.25,12
ATG	O			12	
Axis Communications	O,D		N		
CYCMA	D		H,N		
Cygnet Storage Solutions	O,D	12 cm		12	12
DSM	O,D	12 cm			5.25, 12
DTS Computer	D		N		
Grundig	O,D	12 cm			
NSM	O,D	12 cm			
Ornetix	O,D		N		
Philips LMS	O,D			12	12
Plasmon Data Systems	O,D	12 cm		5.25	5.25
SciNet	D		N		

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

TECHNICAL REVIEW

Changes in the optical disk drive industry continue at a rapid pace. Because the rate of change in CD-ROM drives is starting to slow as CD-ROM drives near their shipment peak, rapidly falling prices have made it difficult for CD-ROM drive makers to achieve adequate profitability. Among writable drives, CD-RW finally seems to have caught on, but soon must face competition from writable DVD drives which are starting to ship. From a performance point of view, the rate of change still lags that of the magnetic drive industry, but promising new technologies point to accelerated capacity improvements and areal density in excess of rigid drive technology. Signs of convergence of the technologies used to develop rigid magnetic drives and optical drives are increasingly evident.

Some of the key areas where improvements continue are:

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

* Fiber optic transmission of laser signals between sliders and light emitter/detector assemblies.

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

* Improved ASICs to do specialized coding, compression, or other signal processing functions. Higher degree of functional integration on chips to reduce costs.

* 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 competition from rigid drives, as multigigabyte rigid disk drives continue to decimate the low end of the 5.25" optical drive and library markets, and the newest generation of

removable magnetic drives with capacities of two gigabytes per cartridge is contributing to 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% annual improvement rate in areal density. Beginning in 1999, 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. Quinta's nonremovable media design may compete uniquely with rigid magnetic drives where high capacity, low cost per gigabyte and moderate performance are the requirements.

Optical disk technology and applications

Three types of optical disk drives used as computer peripheral devices are discussed in the following sections: CD format (usually 120 mm) read-only disk drives (including CD-ROM and 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 format read-only disk drives: In optical read-only recording, the disk is normally mass produced using a mold which impresses the data upon one or more surfaces 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 limited 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 has become widely available. Multi-surface DVD-ROM offers 8.5 gigabytes per side of on-line capacity, taking advantage of the drive's capability to adjust the focal plane of the reading head optics.

Two contending groups of manufacturers proposed feasible, but incompatible, specifications for drives in the multiple gigabyte range and reached general agreement in late 1995 for a combined standard. 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 writable DVD format drives continue to plague 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 provided approximately 9 times (9X) the data rate of the first CD-ROM drives, but not low average access times. The 1X DVD data transfer rate, about 1.35 megabytes/second, is inferior to CD-ROM rates for 12X drives and faster. 2X DVD-ROM are shipping, and a transition to a 4X-5X generation is well under way. DVD 8X may be possible, but is considered technically difficult at present.

Disagreement between major suppliers and between suppliers and content providers on specifications, standards and copy protection delayed availability of DVD-ROM, DVD-R and DVD-RAM, although it appeared that general agreement on copy protection and related restrictions desired by the entertainment and software industries had been reached as of mid-1997. Unfortunately, the format war that broke out in 1997 between supporters of various writable DVD formats shows no sign of being settled

soon. As has been the custom in the optical segment of the storage industry, writable CD format optical drive purchasers will soon have a wide variety of format standards from which to choose.

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 to 32X in data transfer rate in order to improve output, and it appears that there has been at least limited OEM acceptance of 40X drives, despite the probability that their use may actually degrade performance with marginally replicated media.

The industry speed race 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.

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. Variable packet writing 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. 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, and the low cost of CD-R media make it a popular choice for archiving and backup, provided that the marginal performance of such drives is acceptable.

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 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.

Applications for write-once recording technology, including CD-R, include distribution of data, backup 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 CD format 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 $200 level and the low cost of CD-R media makes them popular devices for data distribution, archiving and backup. However, pure CD-R drives are being phased out in favor of CD-RW drives that can read and write inexpensive CD-R media as well as the more expensive rewritable media.

While the market for write-once optical storage is limited to niche markets that can tolerate nonreversibility, the ability of write-once storage to main-

tain an audit trail or indicate whether or not stored data has been modified is a benefit in applications requiring a high integrity audit trail.

* Rewritable optical disks: Magneto-optic (MO) recording, whose roots go back over 35 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 based 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. Recently produced 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 can 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 writable DVD 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. 5.25" 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 were announced in late 1997 and early 1998, with 1998 availability. 1999 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 on 4.72" or 5.25" media. These are expected to offer limited only compatibility with earlier drives, and some will not use removable media.

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 1999. 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 1,000 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. Optical libraries typically attach to a host processor, but some are appearing with direct network attach capability. Others employ hard disk drives as a buffer to cache disk images and improve response time to a data request.

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 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 typically holding 5 or 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, drive 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.

* 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. Recent designs incorporate a rigid disk drive and a single changer or CD format drive, allowing data to be loaded from CD/DVD ROM disks to the hard drive, which can then be accessed by multiple users at a much faster rate than data on several CD-ROM drives. Significant improvements in cost and footprint are also achieved.

  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, security 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, typical magnetic drive areal density has for the moment surpassed typical 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 most rigid magnetic drives, but some magnetic rigid drives already exceed 4.1 gigabits per square inch.

  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. Some projected advances in optical disk drives, 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. Another method of improving areal density is to employ multiple bit recording per spot location. This approach is being pursued most visibly by Callimetrics, but it will prove difficult to convince disk producers and drive makers to adopt a non-standard design in the absence of a totally compelling need.

  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 1999, 5 to 10

times the areal density of 1998 magnetic drives, by use of a solid immersion lens embedded in the slider and the use of near field recording. 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 are 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 new generation of 5.25" drives has 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 offer up to 8.5 gigabytes per side, assuming double layer media is used. The ASMO (Advanced Storage Magneto Optic) group has specified 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.

While TeraStor is most often associated with near field recording, near field recording is being investigated by other organizations, including Japan's National Institute for Advanced Interdisciplinary Research, which has succeeded in producing 90 nanometer spots using a 680 nanometer laser with a 1 micron spot size and masking layers to generate the NFR aperture.

* 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, but archivists require a much more extended generational capability.

  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, but DVD-ROM drives won't be able to read DVD-RAM media until new designs appear in late 1998.

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, and even CD-ROM drives now can achieve sub-100 millisecond average access times.

  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 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.

  Performance can be improved by reading or writing multiple tracks simultaneously. A multitrack read head, developed by Zen Research, is in use

in a Kenwood CD-ROM drive. It can read 7 tracks simultaneously, providing 40X performance at 12X rotation rates, improving reliability and decreasing power needs. However, the head is expensive compared to the cost of standard CD-ROM components.

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 temperature, and IBM demonstrated a 2.5 gigabit per square inch areal density using a frequency doubled 856 nanometer laser and magneto-optic media with a blue sensitive active layer to reduce the writing power required. A read rate of 2 megabytes per second was achieved with this combination.

  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 multiple layer 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 layers 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, Fujitsu, Sony and Maxoptix in current 5.25" drives. Hitachi Maxell and M.N. Optical supply the media, although the media is still in very limited production.

  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. However, replicators are having some difficulty in adjusting production processes to achieve economic yields. Multilayer recording presents more problems, resulting in lower writable capacity than readback capacity and creates 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 offer 2.6 gigabytes per surface, with 4.7 gigabytes per surface expected in 2000.

* 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 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, was proposed as a standard for 3.5" rewritable drives, but was not 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 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 25.4 millimeter high space.

  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 9.5 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, but a growing number of notebook computers incorporate internal thin profile CD-ROM drives operating at lower spin rates to conserve power. 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. SCSI is also used on CD format drives installed in libraries or towers. 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, NSM and Cygnet are among the firms offering such capabilities.

With new computer models incorporating the Universal Serial Bus (USB) entering the market, an increasing number of optical drives with USB interfaces are expected to be shipped into the aftermarket, but most drives shipped to OEMs are expected to continue to have the IDE/ATAPI bus structure, as USB equipped computers will already have an internal CD or DVD type drive installed by the manufacturer.

* 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 verification, 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.

* 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. 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.

  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, an action instrumental in helping the industry arrive at a single compromise standard that adopted features from both proposed standards. Having settled the DVD-ROM format dispute, the industry promptly launched a new format war, pitting the DVD-RAM forum against the DVD+RW group spearheaded by Sony and Philips, with other pro-

posals by Pioneer (for DVD-R and DVD-RW) and NEC adding additional contention. The outcome of this battle, waged with great passion (much to the disgruntlement of the OEM and end user communities), can't yet be foretold, though it is likely that DVD-RAM which will achieve real volume production first will be the winner. Pending resolution, shipments of DVD writable drives and DVD-ROM are being negatively impacted. It is likely that coexisting standards for several DVD writable formats will be generated, leaving it to the market to decide between them.

Aside from the DVD related conflicts, multimedia formats remain an area of standards conflict. 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.

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 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 competed strongly with 3.5" 230 and 128 megabyte optical drives. The 1 and 2 gigabyte Iomega Jaz drives, the SyQuest 1 gigabyte Sparq, and 1.5 gigabyte SyQuest SyJet compete with 640 megabyte 3.5" MO drives and 5.25" optical drives. And the SyQuest 4.7 gigabyte Quest, which might appear in late 1998, could turn out to be a competitor to DVD-RAM and lower capacity 5.25" MO drives. 5.25" fixed disk drives, such as the Seagate 47 gigabyte Elite 47, challenge the existing 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, despite the announced timetables of several companies.

While future optical drives may improve performance to the point where they can offer 15-20 millisecond average seek time on a 10-20 gigabyte drive, magnetic drives typically offer sub-12 millisecond times on drives of the same capacity or larger. Sub-7 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 7,200 RPM to 10,000 RPM and 12,000 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 4,100 megabits per square inch, now compete against the areal density available with optical disk drives and are expected to be in the range of 10 gigabits per square inch by the end of the decade. Although advanced optical drives with greater areal density may possibly begin shipments in late 1998, it is unlikely that the magnetic rigid disk drive will be seriously threatened by optical disk drives in its role as a high performance system disk. However, 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, 200 megabyte Sony HiFD, 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 rewritable 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

* Ion Milling: Norsam Technologies, along with research partner IBM, are investigating the commercialization of recording using ion milling to create a very high density (50 nanometer spot size), very durable disk capable of being read optically. The 120 millimeter disk could hold 165 gigabytes of data at the proposed density, but writing equipment is specialized, expensive and (at 20 megabytes per second) slow, relative to disk capacity. An X-Y writing format is also being investigated for document image storage. A scanning electron microscope is required for reading the recorded information.

* Optical cards: Three companies announced the first 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 purchased licenses permitting them to make optical card drives using Drexler patents, but the write-once format and low capacity of these optical cards limited them to specialized applications. The cost of the drive is unlikely to decrease below the cost of a floppy disk drive, so the low capacity optical card is unlikely to displace floppy disks for software distribution.

  A high capacity optical card was announced by Ioptics in 1997. This unique read-only card holds 128 megabytes of data, allowing it to compete as a data distribution device. There are no moving parts, suiting it for uses requiring ruggedness. Data transfer rate is 1.6 megabytes per second. However, its specialized format and anticipated $150-200 reader costs will limit it to specialized uses in military, equipment maintenance, mapping/routing data and handheld equipment operating with Microsoft's

Windows CE. (Microsoft is an investor in Ioptics.) The cards are expected to be sold in the $2-3 range, with production expected in 1999.

Because of its relatively limited capacity and/or performance, the optical card is not a competitor to the optical disk drive (It is a likely flash memory card competitor). 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, including Eastman Kodak, 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 can have no moving mechanical parts, they have applications in military, industrial, and other applications where ruggedized data storage is absolutely 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, probably in the 2004-2010 period.

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 some of the early problems have been reduced or eliminated, though suitable media materials remain elusive. Recent interest has focused upon organic materials formed upon the surface of a rotating disk.

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 memo-

ries in a 5.25" form factor in 1992 and established a subsidiary corporation, Tamarack Storage Devices, to commercialize the technology.

Though Tamarack's efforts did not result in a salable product, other companies and universities have formed a consortium (called 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 $50 million (to date) 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.

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 by the end of 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 35 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 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 store up to 2.6 gigabytes. Some drive manufacturers adopted the physical format of the IBM 3480 cartridge 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 drives, CD-R write-once and CD-RW rewritable technology, and will definitely be impacted by rewritable optical disks such as TeraStor's if they offer 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, but have occasionally been 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 writable optical media for software distribution will not become widespread until media costs are approximately equivalent. CD-R media (now in the .15 cents per megabyte range) is currently considered to be the most competitive writable optical media.

  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, 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 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 FileNet 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 Distributor shipments are included in the noncaptive sales channel.

Example:

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

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. 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 manu-

facturing 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

Drives: 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 drives.

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, Distributor or OEM/Integrator levels. All prices are in 1998 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:

Specialized high performance systems: Disk drives or disk libraries attached directly to the system or to a terminal associated with a supercomputer, video server, editing system or a high end imaging system.

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

Networks/midrange systems: Drives, libraries or CD towers directly attached to networks or to network file servers, minicomputers and other midrange computer systems. Examples: IBM System AS/400, Hewlett-Packard 3000, Compaq ProLiant, and workstations used for engineering, graphics, medical and other applications.

Desktop personal computers: Used with a personal computer intended primarily for nonconsumer applications. Examples: IBM PC series, Apple Macintosh, Dell Dimension series.

Consumer computers: Desktop personal computers sold to consumers primarily for nonbusiness purposes, and dedicated systems for computer games and other applications. Examples: Sony PlayStation, Sega Genesis.

Portable computers: Laptop, notebook, subnotebook and smaller general purpose and specialized computer systems.

Other applications: Any application not included above, including nonconventional uses such as intelligent fax machines, copiers, scanners, intelligent personal communications devices, automotive navigation systems, digital cameras, factory data collection equipment, etc.

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

1998 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

Acer Peripherals	CD-632A, CD-636A
Actima	24.X, 32.X, 36.X
AOpen	CD-924E, CD-932E
Asustek Computer	CD-S340, CD-S400
Behavior Tech Computer	BCD-32XH, BCD-36XH, BCD40XH
Calix Technology	CR-703L, CR-801N
Delta Electronics	OTC-H101
Elite Peripheral	Ultra 24, Ultra 36
Hitachi	CDR-8330, CDR-8430
Hopax Industries	HO-824, HO-832, HO-836
Kenwood Research	Z40X
Leoptics	CDD-1240, CDD-1320
LG Electronics	CRD-8320B, CRD-8322B
Lite-On Technology	LTN-341, LTS-422
Matsushita Electric Industrial	CR-586-B, KXL-810AN, UJDA150
Mitsumi Electric	FX320M, FX332M
Mountain Optech	CS-680
NEC Home Electronics	CDR-2800A, CDR-3000A, CDR-1801A
Norm Pacific	24X, 32X, 36X
Optics Storage	8622 SCSI, 8841
Pan-International(Cyberdrive)	240D, 362D
Philips	PCA 16SC, CD-320
Pioneer	DR-544, DR-A04S
Plextor (Shinano Kenshi)	PX-32CS, PX-32TS
Samsung Electronics	SCR-2437, SCR-3230
Sanyo Electric	CRD-820P, CRD-1332P
Sony	CDU-711, CSD-880E, PRD-650MC
TEAC	CD-320E, CD-524E
Toshiba	XM-6302B, XM-1702B, XM-6102
Ultima Electronics (Artec)	Super-32X, Super-36X
Unitron	UCD36J, UCD24N
USDrives	24DT, 32DY
Wearnes Peripherals	CDS-24x Max, CDS-32x Max
Yung Fu (Lxycon)	CDX-3200, CDX-3600

8 centimeter (3.15") disk diameter

Sony	DD-2001

A standard CD-ROM optical drive is equipped only to read an appropriate optical disk. It does not have a laser capable of developing write power, a method to switch the laser into a writing mode, nor electronics required for writing data. The optical read-only drive is sometimes referred to generically as OROM (Optical Read-Only Memory), but all drives in this product group are of the CD-ROM type and use 12 centimeter (4.72") or 8 centimeter (3.15") media. 12 centimeter drives usually also accept 8 centimeter media. DVD-ROM drives are covered in section DT-21 of this report, and recordable CD format drives (CD-R, CD-RW, DVD-R, DVD-RAM, DVD+RW) are covered in section DT-22 of this report, which follow 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.

CD-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 20,000 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

CD-ROM drive shipments rose sharply in 1997, although short product life cycles continued to reduce profitability for most industry participants, and increasing production from competitors in Taiwan, Korea and southeast Asia caused OEM prices from some producers to dip into the 40 dollar range for desktop ATAPI drives. The speed race has slowed, with 32X apparently the last major stopping point for most OEMs, although 36X and 40X drives have appeared in aftermarket channels and in the product lines of a few OEMs. 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 is continuing its transition to DVD-ROM drives. Though DVD shipments began to ramp up in 1997, current CD-ROM shipments far outnumber DVD-ROM drive shipments. CD-ROM drives capable of reading CD-RW media began production in late 1996 and this capability is now a standard feature.

1997 unit shipments rose 34.2% to over nearly 74.5 million units, but 1997 worldwide sales revenues increased only 8.9% to nearly $5.1 billion. Growth in sales revenue was again limited by competitive pressures, but declining prices also resulted from manufacturing economies obtained through concentration on 32X designs. The rapidly growing market attracted new entrants, notably in Taiwan, and encouraged 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 successful as a computer peripheral due to its low capacity (about 180 megabytes) and lack of published titles.

The Matsushita companies, Mitsumi Electric and Toshiba were the leading 1997 noncaptive CD-ROM drive producers, followed by LG Electronics, Hitachi and Samsung. Toshiba and Sony are the leading captive producers on the strength of sales of their notebook computer and game products, respectively, and if captive production is considered, Toshiba was the largest 1997 producer.

Thin CD-ROM drives, now available from multiple manufacturers for use with notebook computers, have entered the market and accounted for almost 7.2 million units of the 1997 total shipments.

Marketing trends

CD-ROM drive shipment growth is expected to peak at 87.3 million drives in 1999, and then decline as DVD-ROM drive shipments displace CD-ROM drive shipments. 32X is expected to be the last major transition for CD-ROM, although 36X and 40X drives will have a place in aftermarket channels and a limited role in high end personal computer manufacturers' products. Refer to the following product section for a discussion of DVD-ROM trends. In 2001, CD-ROM shipments will have declined to 46 million units, surpassed by DVD-ROM shipments of nearly 80 million units. 1997 was actually the peak year for CD-ROM revenues at $5.08 billion. Rapidly declining prices in 1998 and declining volume in 1999 and after will lead to a decline in revenues to $1.77 billion in 2001. Average OEM prices are expected to drop well below forty dollars due to increasing competition from companies producing in Korea, China, Taiwan and Southeast Asia.

Non-U.S. firms will continue to be the major producers, but Asian countries other than Japan are rapidly increasing their share of the market as Japan shifts its attention to DVD-ROM drives. Some CD-ROM 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 and Samsung Electronics are shipping major quantities. In Taiwan, AOpen, Acer Peripherals, Lite-On, Pan-International (Cyberdrive) and others are in production using purchased mechanisms, with increasing quantities produced by units of the Acer Group, Pan-International, BTC, Lite-On and others.

OEM shipments are expected to decrease as a percentage of total shipments to the 55% level in 1999 as a result of high captive production by notebook computer makers, but subsequently increase to 62% in 2001 as production shifts to DVD. Distributor shipments, 35.4% of 1997 shipments, are expected to increase as a percentage of total as OEM demand shifts to DVD, but decline after 2000. Captive shipments are expected to decline slightly from 7.5% in 1997 to 3.9% in 2001 as a result of a shift to DVD production by notebook computer manufacturers that also produce drives.

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. So far, the introduction of network computers has had minimal impact on CD-ROM 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 technical training, language instruction, and other educational uses. The generic ability to handle text, audio and video data is often referred to as "multimedia". Multimedia is not restricted to any particular type of storage medium, but the large amounts of storage required by digitized audio and video make CD-ROM an appropriate vehicle for distribution of multimedia titles. Widespread acceptance of video on CD awaits the DVD drives that permit a single disk to contain two hours of video.

In 1997, 68.1% of the CD-ROM drives shipped were attached to desktop personal computers, while portable computers accounted for 9.6%. Consumer computer and other applications, notably games such as Sony's Playstation, captured 14% because of growth in lower cost PC shipments. CD-ROM drive use with network servers and workstations claimed 7.1% in 1997. CD-ROM drives used in optical libraries and in CD-ROM towers attached to file servers or directly attached to the network are included in this segment. Many of these servers are used to supply business data across a corporate "Intranet", a local area network supporting Internet addressing conventions. Desktop personal computers are expected to continue as the largest application for CD-ROM drives in 2001, capturing 53.6% of the drive shipments. Consumer applications, led by entertainment, home computing and education uses, are expected to be the second largest application area, with 33.1% of the units sold. Network servers and workstations will use only 1.2% of the drives shipped, as these platforms are expected to shift quickly to DVD-ROM use.

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.

The majority of major software producers preferentially distribute their software and documentation on CD-ROM because the cost of replication and packaging is substantially less than when multiple 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 databases 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, storage and distribution costs. In some cases, it has been possible to make government statistics and documentary information available to the general public that was not previously available due to the cost of distribution. Where governments use CD-ROM to distribute libraries of forms, the process of updating the forms is simpler because only a

new disk needs to be sent and the number of obsolete forms discarded can be reduced. The most widely distributed government produced CD-ROM concerns the management of hazardous materials. This disk is currently distributed to over 7,000 sites. The military services use CD-ROM storage in place of paper operations and maintenance materials, saving substantial weight and space and simplifying logistics.

CD-ROM and DVD-ROM titles that operate with software allowing access to the Internet (or Intranets) are 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 CD-RW media, CD-ROM drives evolved rapidly in 1997, and now handle all types of CD-format media, but not DVD media because of the shorter wavelength laser required. Because CD-ROM drives are nearing the end of their product cycle, new development efforts have shifted to DVD-ROM, except for those concerned with size and cost reduction.

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 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 standards for CD-ROM became the basis for CD-ROM physical disk inter-

changeability 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. Proprietary formats, many developed by companies pursuing multimedia capabilities, have largely been discarded.

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 became the ECMA 168 standard.

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/DVD-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.

Performance: Average access times have dipped to well under 100 milliseconds and seek times have dipped under 80 milliseconds. Users are getting faster data transfer rates by means of faster rotation rates. CD-ROM drive producers routinely manufacture drives with at least 32 times the original 150 KB/second data transfer rate, with the improvement in performance achieved by increasing the rotation rate and moving from constant linear velocity (variable spin rate) to constant angular velocity (fixed spin 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 (CAV) 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. Oak Technology, Cirrus Logic and other controller makers are offering controllers or chip sets that can extend data transfer rates to the 40X-50X range, but CD-ROM drive makers appear to prefer to concentrate on DVD-ROM instead.

The presence of a large buffer is 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 for 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 98, 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. The 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, did not develop general support by PC and disk drive manufacturers.

Future generations of desktop computers will employ serial bus structures such as USB and P1394 for the connection of peripheral devices. Drives with USB 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. Manufacturing in countries with low labor and overhead costs is increasingly common.

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, and 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. CD-ROM drives are frequently mounted externally to the thinnest or least expensive notebook computers, but internally in desktop, server or 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.

Networks, libraries and CD-ROM towers: System integrators are increasingly adding CD-ROM capabilities to file servers. As a result, there is interest in jukeboxes for CD format drives, but the slow access time of the CD-ROM led many server integrators 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 Creative Design Solutions, Axis Communications and Microtest could attach directly to a local area network and be configured to operate with one of several available network protocols. In 1998, tower designers are adding hard disk drives to their towers to cache multiple CD-ROM disk images, providing faster performance, reduced size and lower cost, as fewer drives are required and rigid disk drives are very inexpensive. Buyer interest is shifting towards these network attached cached towers because of their cost, flexibility, Internet compatibility, and ease of installation.

A number of firms have announced autochangers for CD-ROM. The quantity 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 expected to displace CD-ROM in libraries and towers.

Writable CD: Writable CD-format (CD-R and CD-RW) 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 and have largely displaced CD-R drives. See the product section on CD/DVD format writable drives 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. As noted earlier, DVD-ROM has begun rapidly displacing CD-ROM.

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 100-200 megabytes, do not have the capacity required for many applications, and the media is also more expensive. They are not significant competition for CD-ROM.

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 are expected to capture about 10% of the available drive slots in 2001.

Forecasting assumptions

1. CD-ROM drive production capability will more than meet demand, although short-term component shortages may occur after 1998 as the industry infrastructure retools to support DVD.
2. 32X will be the last major CD-ROM generation. 36X and 40X drives will capture only minor shares.
3. Non-U.S. suppliers will continue to dominate the CD-ROM hardware market, with most production in Asia.
4. There will be little impact on CD-ROM shipments from competing technologies throughout the forecast period, except for DVD-ROM.
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 32X and higher operating rates.
7. Cost reduction and strong competitive pressure will continue and result in a continued decline in average drive prices.

TABLE 17

CD-ROM OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	53.4	530.4	61.0	371.4	75.2	337.5	65.7	189.4	62.4	130.4
Distributor	763.6	1,711.6	637.7	1,577.2	607.1	1,565.5	482.9	1,276.2	333.9	602.1
OEM/Integrator	1,314.4	2,835.0	1,076.1	2,419.4	926.3	2,074.4	781.5	1,711.5	480.2	1,038.9
TOTAL NON-U.S. REVENUES	2,131.4	5,077.0	1,774.8	4,368.0	1,608.6	3,977.4	1,330.1	3,177.1	876.5	1,771.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,131.4	5,077.0	1,774.8	4,368.0	1,608.6	3,977.4	1,330.1	3,177.1	876.5	1,771.4
OEM Average Price ($000)		.066		.051		.043		.040		.036

TABLE 18

CD-ROM OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1997 Shipments		Forecast 1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	610.1	5,612.8	812.3	4,327.3	948.0	4,322.0	887.0	2,544.0	891.0	1,863.0
Distributor	11,903.7	26,437.5	12,779.3	31,864.3	13,579.0	34,905.0	11,946.0	31,404.0	8,730.0	15,570.0
OEM/Integrator	19,378.5	42,530.6	20,300.3	47,045.9	21,463.0	48,068.0	19,457.0	42,625.0	13,230.0	28,620.0
TOTAL NON-U.S. SHIPMENTS	31,892.3	74,580.9	33,891.9	83,237.5	35,990.0	87,295.0	32,290.0	76,573.0	22,851.0	46,053.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	31,892.3	74,580.9	33,891.9	83,237.5	35,990.0	87,295.0	32,290.0	76,573.0	22,851.0	46,053.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	96.8	212.5	130.7	295.8	166.7	383.1	199.0	459.6	221.8	505.7

TABLE 19

CD-ROM OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DATA TRANSFER

	1997 Revenues				Forecast 1998				1999			2000		2001	
	<=12X	16X-18X	20-24X	>=32X	<=12X	16X-18X	20-24X	>=32X	16X-18X	20-24X	>=32X	20-24X	>=32X	20-24X	>=32X
U.S. MANUFACTURERS															
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS															
Captive	137.7	15.5	282.2	95.0	14.5	--	228.0	128.9	--	123.4	214.1	--	189.4	--	130.4
Distributor	452.7	342.3	788.9	127.7	7.3	5.1	462.6	1,102.2	.5	183.5	1,381.5	88.3	1,187.9	44.1	558.0
OEM/Integrator	530.2	495.5	1,463.5	345.8	6.0	51.7	929.7	1,432.0	3.5	275.5	1,795.4	53.6	1,657.9	15.8	1,023.1
TOTAL NON-U.S. REVENUES	1,120.6	853.3	2,534.6	568.5	27.8	56.8	1,620.3	2,663.1	4.0	582.4	3,391.0	141.9	3,035.2	59.9	1,711.5
WORLDWIDE RECAP															
Captive	137.7	15.5	282.2	95.0	14.5	--	228.0	128.9	--	123.4	214.1	--	189.4	--	130.4
	-76.3%	+14.8%	--	--	-89.5%	--	-19.2%	+35.7%	--	-45.9%	+66.1%	--	-11.5%	--	-31.2%
Distributor	452.7	342.3	788.9	127.7	7.3	5.1	462.6	1,102.2	.5	183.5	1,381.5	88.3	1,187.9	44.1	558.0
	-49.6%	--	--	--	-98.4%	-98.5%	-41.4%	+763.1%	-90.2%	-60.3%	+25.3%	-51.9%	-14.0%	-50.1%	-53.0%
OEM/Integrator	530.2	495.5	1,463.5	345.8	6.0	51.7	929.7	1,432.0	3.5	275.5	1,795.4	53.6	1,657.9	15.8	1,023.1
	-82.7%	+550.3%	--	--	-98.9%	-89.6%	-36.5%	+314.1%	-93.2%	-70.4%	+25.4%	-80.5%	-7.7%	-70.5%	-38.3%
Total Revenues	1,120.6	853.3	2,534.6	568.5	27.8	56.8	1,620.3	2,663.1	4.0	582.4	3,391.0	141.9	3,035.2	59.9	1,711.5
	-75.3%	+607.5%	--	--	-97.5%	-93.3%	-36.1%	+368.4%	-93.0%	-64.1%	+27.3%	-75.6%	-10.5%	-57.8%	-43.6%
ANNUAL SHARE, BY DIAMETER	22.1%	16.8%	50.0%	11.1%	.6%	1.3%	37.2%	60.9%	.1%	14.6%	85.3%	4.5%	95.5%	3.4%	96.6%

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

TABLE 20

CD-ROM OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DATA TRANSFER

	1997 Shipments				Forecast										
					1998				1999			2000		2001	
	<=12X	16X-18X	20-24X	>=32X	<=12X	16X-18X	20-24X	>=32X	16X-18X	20-24X	>=32X	20-24X	>=32X	20-24X	>=32X
U.S. MANUFACTURERS															
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS															
Captive	1,241.7	199.5	3,392.6	779.0	156.8	--	2,650.5	1,520.0	--	1,645.0	2,677.0	--	2,544.0	--	1,863.0
Distributor	7,569.9	4,988.8	12,143.3	1,735.5	143.4	104.6	9,664.6	21,951.7	12.0	4,588.0	30,305.0	2,263.0	29,141.0	1,260.0	14,310.0
OEM/Integrator	9,122.5	7,164.2	21,216.1	5,027.8	79.8	831.3	17,105.4	29,029.4	77.0	6,405.0	41,586.0	1,448.0	41,177.0	450.0	28,170.0
TOTAL NON-U.S. SHIPMENTS	17,934.1	12,352.5	36,752.0	7,542.3	380.0	935.9	29,420.5	52,501.1	89.0	12,638.0	74,568.0	3,711.0	72,862.0	1,710.0	44,343.0
WORLDWIDE RECAP															
Captive	1,241.7	199.5	3,392.6	779.0	156.8	--	2,650.5	1,520.0	--	1,645.0	2,677.0	--	2,544.0	--	1,863.0
	-73.2%	+173.3%	--	--	-87.4%	--	-21.9%	+95.1%	--	-37.9%	+76.1%	--	-5.0%	--	-26.8%
Distributor	7,569.9	4,988.8	12,143.3	1,735.5	143.4	104.6	9,664.6	21,951.7	12.0	4,588.0	30,305.0	2,263.0	29,141.0	1,260.0	14,310.0
	-34.6%	--	--	--	-98.1%	-97.9%	-20.4%	--	-88.5%	-52.5%	+38.1%	-50.7%	-3.8%	-44.3%	-50.9%
OEM/Integrator	9,122.5	7,164.2	21,216.1	5,027.8	79.8	831.3	17,105.4	29,029.4	77.0	6,405.0	41,586.0	1,448.0	41,177.0	450.0	28,170.0
	-76.1%	+742.7%	--	--	-99.1%	-88.4%	-19.4%	+477.4%	-90.7%	-62.6%	+43.3%	-77.4%	-1.0%	-68.9%	-31.6%
Total Shipments	17,934.1	12,352.5	36,752.0	7,542.3	380.0	935.9	29,420.5	52,501.1	89.0	12,638.0	74,568.0	3,711.0	72,862.0	1,710.0	44,343.0
	-67.0%	+894.2%	--	--	-97.9%	-92.4%	-19.9%	+596.1%	-90.5%	-57.0%	+42.0%	-70.6%	-2.3%	-53.9%	-39.1%
ANNUAL SHARE, BY DIAMETER	24.0%	16.6%	49.4%	10.0%	.5%	1.1%	35.4%	63.0%	.1%	14.5%	85.4%	4.8%	95.2%	3.7%	96.3%

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

TABLE 21

CD-ROM OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1997 Estimate Units (000)	1997 Estimate %	2001 Projection Units (000)	2001 Projection %
SPECIALIZED HIGH PERFORMANCE				
Supercomputers, video and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	44.7	.1	--	--
NETWORK/MIDRANGE SYSTEMS				
Midrange systems, network servers and workstations	5,317.6	7.1	552.6	1.2
DESKTOP PERSONAL COMPUTERS				
Business and professional, single user	50,819.5	68.1	24,684.5	53.6
CONSUMER COMPUTERS				
Desktop PCs, game, and hobby computers	10,441.3	14.0	15,243.5	33.1
PORTABLE COMPUTERS				
Notebook and smaller mobile computers	7,159.8	9.6	5,157.9	11.2
OTHER APPLICATIONS	798.0	1.1	414.5	.9
Total	74,580.9	100.0	46,053.0	100.0

TABLE 22

CD-ROM OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1997 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	<=12X	16-18X	20-24X	>=32X	Total		<=12X	16-18X	20-24X	>=32X	Total	
Matsushita Elec. Ind.	465.0	--	2284.0	104.5	2853.5	9.1	2166.0	--	7080.0	361.0	9607.0	13.9
Mitsumi Electric	1762.4	902.5	1250.0	114.0	4028.9	12.9	3035.8	1505.8	2100.0	190.0	6831.6	9.9
Toshiba	209.0	--	1387.0	2251.5	3847.5	12.3	380.0	--	2103.3	4225.6	6708.9	9.7
LG Electronics	660.3	1437.4	1057.4	17.1	3172.2	10.1	1364.2	2964.9	2172.7	17.1	6518.9	9.5
Hitachi	959.5	1078.3	1137.1	3.7	3178.6	10.2	1771.8	2429.2	1580.7	3.7	5785.4	8.4
Samsung Electronics	347.7	--	470.3	--	818.0	2.6	1966.5	--	2275.3	--	4241.8	6.2
Sony	302.1	929.1	577.6	--	1808.8	5.8	803.7	2095.7	1256.9	--	4156.3	6.0
NEC	--	380.0	1311.0	408.5	2099.5	6.7	--	646.0	2185.0	646.0	3477.0	5.0
Pan International	900.6	146.3	1175.1	--	2222.0	7.1	1073.5	226.1	1992.1	--	3291.7	4.8
TEAC	622.3	465.5	575.7	109.3	1772.8	5.7	1320.7	769.5	959.4	180.6	3230.2	4.7
Other Non-U.S.	960.4	465.8	3755.9	298.3	5480.4	17.5	2810.2	1515.8	9654.0	1139.3	15119.3	21.9
TOTAL	7189.3	5804.9	14981.1	3306.9	31282.2	100.0	16692.4	12153.0	33359.4	6763.3	68968.1	100.0

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

DVD FORMAT READ-ONLY OPTICAL DISK DRIVES

DVD FORMAT READ-ONLY OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter (4.72") disk diameter

AOpen	DVD-9432
Hitachi	GD-2000, GD-3000
LG Electronics	DRD-820B, DRD-840B
Matsushita Electric Industrial	SR-8582B, SR-8583
Mitsumi Electric	DR200M
Pan-International(Cyberdrive)	DM-811D
Philips	DRD-5200
Pioneer	DVD-102, DVD-302
Samsung Electronics	SDR-230, SDR-430
Sony	DDU-220E
TEAC	DV-22E
Toshiba	SD-C2102, SD-M1202

A 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. Drives in this product group are of the DVD-ROM type and accept 12 centimeter (4.72") or 8 centimeter (3.15") media. CD-ROM drives are covered in section DT-20 of this report, and recordable CD/DVD format drives (CD-R, CD-RW, DVD-R, DVD-RAM, DVD+RW) are covered in section DT-22 of this report. DVD consumer video players are not covered in this report, but it is expected that the high cost of TV and audio equipment needed to fully use improved DVD player video and audio capabilities, lack of recording capability, and competition from VCRs will keep DVD video player sales low relative to DVD-ROM sales for several years.

Like CD-ROM, DVD-ROM drives and media create 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 DVD-ROM storage will be driven by the quantity and types of information that publishers provide. Only a few titles are now sold to the public by DVD-ROM publishers, but numerous "titles" are expected to be published by companies for internal use as writable DVD formats become more available. Typical internal titles include catalogs, parts lists, policy/procedure manuals, and equipment maintenance documentation that require more capacity than available

on CD-RW. The desire to publish internally distributed data has spawned a do-it-yourself CD-ROM publishing industry that is expected to replicate itself in a DVD oriented world.

Market status

1997 was the first real growth year for DVD-ROM drives, but acceptance has been restricted by lack of titles, relatively high drive prices, and confusion caused by the writable DVD format war. These restrictions are expected to be partially resolved within the next 12 months. OEM prices have already dipped to the eighty dollar range and are expected to decline further by year end. Computer manufacturers have been reluctant to commit to very large orders of DVD-ROM drives that are not able to read DVD-RAM or other writable DVD formats. However, DVD-ROM drives are expected to acquire the ability to read DVD-RAM media in late 1998.

The bad news is that the industry may be repeating the same "X" race that reduced CD-ROM profitability, producing short product life cycles and inventory problems for industry participants. The rapid evolution from 1X drives, through 2X drives, to 4X/5X drives this year threatens to cause inventory and component procurement problems for manufacturers that can adversely affect profitability. Producers located outside of Japan are particularly likely to experience procurement problems. Personal computer manufacturers are expected to be the greatest demand source for DVD-ROM drives as they are for CD-ROM drives, and the computer industry has begun its transition to DVD-ROM drives.

1997 unit shipments rose to nearly 1.2 million units, while worldwide sales revenues exceeded $178 million. 1998 unit shipments and revenues are continuing fast growth, with sales revenue for 1998 expected to grow 166% while unit shipments more than triple. This rapid transition is attracting new competitors, but newcomers are finding it difficult to obtain adequate supplies of components and mechanisms. Most newcomers purchase optical and mechanical mechanisms, completing the drive by adding their own electronics and packaging.

As with CD-ROM drives, with the exception of Philips, all of the currently active suppliers are Asian companies. Matsushita Electric, Toshiba and Hitachi were the leading 1997 noncaptive DVD-ROM drive producers.

Thin DVD-ROM drives, currently in short supply, are expected to experience a volume ramp and begin displacing thin CD-ROM drives in 1999.

Marketing trends

DVD-ROM drive shipment growth is expected to be rapid for the next few years, with total shipments of DVD-ROM drives exceeding 79.7 million units in 2001 and exceeding CD-ROM drive shipments in that year. 2001 revenues are expected to grow to almost $3.45 billion. The average OEM price is expected to decline to $40 in 2001 as competition increases and cost reductions are achieved.

Non-U.S. firms will continue to be the major DVD-ROM drive producers, with Asian countries other than Japan expected to become significant sources as components become more available. Some production by Japanese manufacturers will probably move from Japan to other Asian locations.

OEM shipments in 2000 are projected at 59.9% of the total, while distributor shipments will account for an anticipated 36.7% share. Captive shipments are expected to capture 3.4% in 2001 as a result of the broadening of the base of suppliers and strong anticipated growth for personal computers.

Applications

DVD-ROM drives, are used with high end microcomputer based systems, including personal computers, multiple user systems and network servers, and consumer systems based upon microcomputers. Consumer applications, including games and home computing, are expected to be among the fastest growing areas of DVD-ROM use, but workstations, especially those used for content preparation, are also anticipated to be a rapidly growing demand category.

In 1997, 87.5% of the DVD-ROM drives shipped were attached to business personal computers, but this is expected to decline to 57.3% in 2001. Portable computers, which accounted for only .8% in 1997, are forecast to capture a 13.8% share in 2001. Consumer computer applications, with 4.8% in 1997, should increase their holdings to 16.2%. DVD-ROM drive use with network servers and workstations, a 6.3% share in 1997, is expected to increase to

11.4%, helped by DVD-ROM minichangers, DVD-ROM towers and libraries attached to file servers or directly attached to the network.

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. Because DVD-ROM drives can also read CD-ROM media, many software publishers will continue to use the less expensive CD-ROM media for distribution until increasing content size makes DVD replication economically attractive.

Business use of DVD-ROM, like that of CD-ROM, is expected to be oriented towards reference and training uses, but is likely to have a higher multimedia content. Reference materials may include purchased data bases or may be internally generated documents such as parts lists or customer data. Education and industrial training, current areas of applications strength for CD-ROM, are expected to be significant users of DVD-ROM multimedia capabilities.

Government use of DVD-ROM is expected to lag other applications, partially because of inertia and partially because of the lead time to prepare suitable content. However, government agencies will probably purchase DVD-ROM drives in 1999 procurements in order to prepare for anticipated future needs.

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

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 evolved rapidly in 1997 to resolve the issues. Manufacturers are expected to be in position to ship DVD-ROM drives that can read CD-ROM, CD-R, CD-RW, DVD-ROM and DVD-RAM media by late 1998.

> Compatibility: Early users of DVD-ROM drives were unpleasantly surprised to discover that their drives were incapable of reading CD-R media because CD-R media has low reflectivity at the shorter laser wavelengths

used in DVD drives. Later DVD drives employ dual lasers in the pickup to provide compatibility. While a more elegant and less costly approach is to modify the media to broaden the high reflectance portion of the reflectivity spectrum, this has proven to be more difficult than originally anticipated. While second generation DVD-ROM drives resolved the CD-R/RW problems, they can not read DVD-RAM media, which has a different format.

Multimedia support: DVD-ROM drives routinely incorporate the necessary support for audio and video content, but the full video capabilities require MPEG-2 compatibility. Currently, this requires an additional module or a very fast processor to do the MPEG-2 decoding via software. The new 450 megahertz processors can handle the processing load without completely saturating the system, but users of older, slower systems may have to pay for the additional MPEG electronics if they want good full screen, high resolution video performance.

Capacity: Data bases, games, system software and documentation may span several CD-ROM disks, and content providers are expected to use the capacity of DVD-ROM to move multiple disk content to a single disk. Game publishers have been the most active in making this move.

IBM developed the 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 have been harder for replicators to produce and have been used mostly for movies (where small signal dropouts are non-critical), and it is expected that 4.7 gigabyte disks will be the mainstream DVD-ROM standard for years to come.

Caddy: DVD-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. It also provides reliability in an optical library, protecting media against debris and damage while being moved. 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: 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. As the standards for DVD writable drives, especially DVD-RAM, are finalized during 1998, manufacturers will be able to manufacture DVD-ROM drives capable of reading DVD-RAM media.

Performance: Average access times for DVD-ROM drives are in the 100-150 millisecond range, and access times in CD-ROM reading mode have dipped under 100 milliseconds. Data transfer rates, now in the 4-5X range for desktop drives (1X is the original DVD-ROM rate of 1.37 megabytes per second), are expected to move to the 7X-8X range by 2001. Data transfer rates for drives used in portable equipment will be lower: Because of the need to conserve power, spin rates are typically less.

When operating in CD-ROM mode, most DVD-ROM drives will provide at least 24X performance. The tendency will be to operate at 24X for notebook drives and 32X for desktop drives.

Interface: SCSI-2 is likely to remain the interface most needed for use with servers because of its ability to handle many devices. IDE/ATAPI interfaces will be used on most drives installed in a PC, while USB and P1394 are expected to be important in the aftermarket.

Packaging: DVD-ROM drive packaging follows that of CD-ROM drives. DVD-ROM drives are mostly half high models, but 17, and 12.7 millimeter high designs are being designed into notebook computers. 12.7 millimeter designs will become prevalent for thin models in 1998 and thereafter. DVD-ROM autochangers have not yet appeared, but are anticipated.

Networks, libraries and DVD-ROM towers: Manufacturers and integrators of optical storage subsystems plan to incorporate DVD-ROM drives into libraries and towers as soon as their customers indicate a demand for such products. Most of the issues involved relate to appropriate software support, with OS qualified drivers and media management tools needed.

Reliability: While there appear to be no blatant reliability issues associated with DVD-ROM drives, the higher areal density compared to CD-ROM makes the drive more vulnerable to dust and other contaminants.

There remains some concern about disk reliability. Accelerated environmental testing shows a wide variety of resistance to temperature and humidity variations, with the major problems 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/RW media that operate correctly on CD-ROM drives but develop unacceptable error rates on DVD-ROM drives. Media replicators and drive producers seem to be overcoming these problems, but the use of multilayer DVD disks and higher spin rates exacerbate the situation.

Writable DVD: Writable DVD-format (DVD-RAM, DVD+RW, DVD-R) media and systems are expensive, but becoming more affordable. Hitachi and

Pioneer are among the first firms shipping, sometimes as part of a complete recording system. Companies exploring the uses of rewritable DVD format recording are hampered by the lack of authoring tools for DVD and the expense of available hardware and software.

Potential competition: At the present time, CD-ROM/DVD-ROM is relatively unchallenged as an inexpensive publishing and data distribution technology. CD-ROM currently has superior economics for most software producers, but this should not affect DVD-ROM sales, since DVD-ROM drives now read all CD format media.

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

Rapidly declining costs and improving performance of 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 DVD-ROM is likely to be writable versions such as DVD-RAM drives.

Forecasting assumptions

1. DVD-ROM drive production capability will substantially meet demand, although short-term component shortages may recur in 1998 and 1999 as rapid demand increases outstrip industry infrastructure capability.
2. DVD-ROM drive producers will undertake the same speed race that occurred in CD-ROM drives, but the number of competitors will be less.
3. Non-U.S. suppliers will continue to dominate the DVD-ROM hardware market, with most production outside the U.S.
4. There will be little impact on DVD-ROM shipments from competing technologies throughout the forecast period.
5. Most consumers will prefer to use DVD-ROM based games and educational materials with personal computers rather than with freestanding players until freestanding equipment acquires a recording capability.
6. Media mastering and replicating capacity will be adequate and will not restrict growth for DVD-ROM optical memory markets.
7. Cost reduction will continue and result in a long-term decline in average drive prices.

TABLE 23

DVD-ROM OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997 Revenues		Forecast							
	1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	16.3	--	32.9	11.9	50.7	32.7	142.1	57.2	218.8
Distributor	28.7	55.6	106.5	203.5	145.0	349.4	279.9	693.1	549.8	1,317.0
OEM/Integrator	56.6	106.2	141.0	237.7	231.1	579.1	408.8	1,019.7	752.5	1,908.9
TOTAL NON-U.S. REVENUES	85.3	178.1	247.5	474.1	388.0	979.2	721.4	1,854.9	1,359.5	3,444.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	85.3	178.1	247.5	474.1	388.0	979.2	721.4	1,854.9	1,359.5	3,444.7
OEM Average Price ($000)		.143		.083		.071		.046		.040

TABLE 24

DVD-ROM OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1997		Forecast							
	Shipments		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	103.0	--	309.6	119.0	516.0	363.0	1,578.0	715.0	2,735.0
Distributor	182.0	355.0	560.3	1,207.1	1,886.0	4,544.0	5,486.0	13,585.0	12,219.0	29,269.0
OEM/Integrator	394.0	741.0	1,697.5	2,848.3	3,220.0	8,060.0	8,882.0	22,157.0	18,812.0	47,723.0
TOTAL NON-U.S. SHIPMENTS	576.0	1,199.0	2,257.8	4,365.0	5,225.0	13,120.0	14,731.0	37,320.0	31,746.0	79,727.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	576.0	1,199.0	2,257.8	4,365.0	5,225.0	13,120.0	14,731.0	37,320.0	31,746.0	79,727.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	.5	1.2	2.8	5.5	8.0	18.6	22.7	56.0	54.5	135.7

TABLE 25

DVD-ROM OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DATA TRANSFER

	1997 Revenues		Forecast								
			1998			1999		2000		2001	
	<2X	2X-3X	<2X	2X-3X	>=4X	2X-3X	>=4X	2X-3X	>=4X	2X-3X	>=4X
U.S. MANUFACTURERS											
NON-U.S. MANUFACTURERS											
Captive	.5	15.8	1.3	20.6	11.0	4.9	45.8	--	142.1	--	218.8
Distributor	1.7	53.9	.6	174.0	28.9	17.2	332.2	4.9	688.2	.8	1,316.2
OEM/Integrator	.3	105.9	--	154.3	83.4	43.1	536.0	5.4	1,014.3	.9	1,908.0
TOTAL NON-U.S. REVENUES	2.5	175.6	1.9	348.9	123.3	65.2	914.0	10.3	1,844.6	1.7	3,443.0
WORLDWIDE RECAP											
Captive	.5	15.8	1.3	20.6	11.0	4.9	45.8	--	142.1	--	218.8
	--	--	+160.0%	+30.4%	--	-76.2%	+316.4%	--	+210.3%	--	+54.0%
Distributor	1.7	53.9	.6	174.0	28.9	17.2	332.2	4.9	688.2	.8	1,316.2
	--	--	-64.7%	+222.8%	--	-90.1%	--	-71.5%	+107.2%	-83.7%	+91.3%
OEM/Integrator	.3	105.9	--	154.3	83.4	43.1	536.0	5.4	1,014.3	.9	1,908.0
	+50.0%	--	--	+45.7%	--	-72.1%	+542.7%	-87.5%	+89.2%	-83.3%	+88.1%
Total Revenues	2.5	175.6	1.9	348.9	123.3	65.2	914.0	10.3	1,844.6	1.7	3,443.0
	--	--	-24.0%	+98.7%	--	-81.3%	+641.3%	-84.2%	+101.8%	-83.5%	+86.7%
ANNUAL SHARE, BY DIAMETER	1.4%	98.6%	.4%	73.7%	25.9%	6.7%	93.3%	.6%	99.4%	--	100.0%

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

TABLE 27

DVD-ROM OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1997 Estimate Units (000)	1997 Estimate %	2001 Projection Units (000)	2001 Projection %
SPECIALIZED HIGH PERFORMANCE Supercomputers, video and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORK/MIDRANGE SYSTEMS Midrange systems, network servers and workstations	75.7	6.3	9,088.9	11.4
DESKTOP PERSONAL COMPUTERS Business and professional, single user	1,048.6	87.5	45,683.6	57.3
CONSUMER COMPUTERS Desktop PCs, game, and hobby computers	57.2	4.8	12,915.8	16.2
PORTABLE COMPUTERS Notebook and smaller mobile computers	9.1	.8	11,002.3	13.8
OTHER APPLICATIONS	8.4	.6	1,036.4	1.3
Total	1,199.0	100.0	79,727.0	100.0

TABLE 26

DVD-ROM OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DATA TRANSFER

	1997 Shipments		Forecast									
			1998			1999		2000		2001		
	<2X	2X-3X	<2X	2X-3X	>=4X	2X-3X	>=4X	2X-3X	>=4X	2X-3X	>=4X
U.S. MANUFACTURERS												
NON-U.S. MANUFACTURERS												
Captive	3.0	100.0	8.4	212.8	88.4	58.0	458.0	--	1,578.0	--	2,735.0
Distributor	14.0	341.0	7.3	886.8	313.0	229.0	4,315.0	90.0	13,495.0	19.0	29,250.0
OEM/Integrator	2.0	739.0	--	1,879.7	968.6	616.0	7,444.0	107.0	22,050.0	23.0	47,700.0
TOTAL NON-U.S. SHIPMENTS	19.0	1,180.0	15.7	2,979.3	1,370.0	903.0	12,217.0	197.0	37,123.0	42.0	79,685.0
WORLDWIDE RECAP												
Captive	3.0	100.0	8.4	212.8	88.4	58.0	458.0	--	1,578.0	--	2,735.0
	--	--	+180.0%	+112.8%	--	-72.7%	+418.1%	--	+244.5%	--	+73.3%
Distributor	14.0	341.0	7.3	886.8	313.0	229.0	4,315.0	90.0	13,495.0	19.0	29,250.0
	--	--	-47.9%	+160.1%	--	-74.2%	--	-60.7%	+212.7%	-78.9%	+116.7%
OEM/Integrator	2.0	739.0	--	1,879.7	968.6	616.0	7,444.0	107.0	22,050.0	23.0	47,700.0
	+300.0%	--	--	+154.4%	--	-67.2%	+668.5%	-82.6%	+196.2%	-78.5%	+116.3%
Total Shipments	19.0	1,180.0	15.7	2,979.3	1,370.0	903.0	12,217.0	197.0	37,123.0	42.0	79,685.0
	--	--	-17.4%	+152.5%	--	-69.7%	+791.8%	-78.2%	+203.9%	-78.7%	+114.7%
ANNUAL SHARE, BY DIAMETER	1.6%	98.4%	.4%	68.4%	31.2%	6.9%	93.1%	.5%	99.5%	.1%	99.9%

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

TABLE 28

DVD-ROM OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1997 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	<2X	2X-3X	Total		<2X	2X-3X	Total	
Matsushita Elec. Ind.	1.0	160.0	161.0	28.0	14.0	425.0	439.0	40.1
Toshiba	--	160.0	160.0	27.8	--	370.0	370.0	33.7
Hitachi	--	255.0	255.0	44.2	--	285.0	285.0	26.0
Other Non-U.S.	--	--	--	--	2.0	--	2.0	.2
TOTAL	1.0	575.0	576.0	100.0	16.0	1080.0	1096.0	100.0

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter disk diameter

Acer Peripherals	CRW-6206A (E)
AOpen	CD-1420C, CRW-622 (E), DVD-520S (D)
Behavior Tech Computer	BCE 621E (E), BCR 6SR
Delta Electronics	ODR-6121, ODE-6121 (E)
Hewlett-Packard	7210e (E), 8110e (E)
Hitachi	GF-1000 (D), GF-1050 (D)
JVC	XR-S240 (E), XR-W2040 (E)
Leoptics	CDD-3620 (E)
LG Electronics	CED-8040B (E)
Lite-On	LTR-511 (E)
Matsushita Electric Industrial	CW-7582, LF-1700 (P), LF-D111 (D)
Mitsumi Electric	CR2801TE, CR4801TE
NEC	ODX-654P (P), ODX-658 (P/CD-R)
Pan-International (Cyberdrive)	CD RW 602 (E)
Philips	PCA 363RW (E), CDD 3600 (E)
Pinnacle Micro	RCDW 226
Pioneer	DW-S114X, DVR-S101 (R)
Plextor	PX-R412CS
Ricoh	MP6200 (E), MP6211S (E)
Samsung Electronics	SCW-230 (E), SDW-130 (D)
Sanyo Electric	CRD-R24S, CRD-R800S
Sony	CDU948S, CRX-100E (E)
TEAC	PD-518E (P), CD-P520E (P/CD-R)
Toshiba	SD-W1001 (D), SD-W1101 (D)
Ultima Electronics (Artec)	Super-RW (E)
Wearnes Technology	CDR-622
Yamaha	CDR400, CRW4416 (E)

(E) indicates CD-RW drive.
(D) indicates DVD-RAM drive
(P) indicates PD drive
(R) indicates DVD-R drive

Drives included in this group use CD-ROM or one of several DVD writable formats, and have the ability to record in either write-once or rewritable mode. This includes CD-R (write-once), CD-RW (rewritable), DVD-R (write-once), PD (rewritable), DVD-RAM (rewritable), and DVD+RW and DVD-RW drives when they appear. CD-RW drives can use less expensive write-once media as well as rewritable media. Writable formats intended for audio/video recording are not

included. Although the writing format of PD drives 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 personal, consumer and midrange computer systems of the mini and micro class, with intelligent workstations, and with network servers. They are also found in storage subsystems such as jukeboxes, towers and media duplicators.

Market status

Overcoming shortages of components, 1997 shipments turned in a stellar performance, rising 140.7% to over 3.4 million units, despite a shortfall in expected PD drive production. However, the group composition is changing. CD-R and CD-RW shipments combined account for 79.5% of 1997 shipments and will exceed 90% of 1998 shipments. CD-R drives were in the majority in 1997, but CD-RW has the largest 1998 share. PD drive shipments reached 704,500 units in 1997, but declined rapidly in 1998, with only 312,000 expected for the year, due to OEM disinterest and displacement by DVD-RAM. DVD-RAM shipments began in earnest in 1998 (Hitachi was the first volume producer), with over 100,000 anticipated for the year. Pioneer is shipping DVD-R drives in low quantities.

NEC and TEAC began significant production of its own PD drive in 1997. A standard for PD drive media was approved in mid-1996 as ECMA-240. CD-RW drive shipments began in 1997, accounting for over 31% of the unit shipments in the product group.

Shipments of CD-R and CD-RW drives have been strengthened by declining prices and easier integration and use in personal computer systems. An increasing number of companies and individual users now publish or back up in CD-ROM formats. The CD-R/RW drives can also be used to transmit finished content to testers and CD-ROM replicators. Although shortages of CD-R media occurred in 1996, CD-R and CD-RW media suppliers now have sufficient capacity.

1997 Sales revenues for the group increased 89.4% to $950.7 million. About 31% of unit shipments were made to the U.S., a decline from earlier years, reflecting captive use of the PD drive in Japan and heavy consumer use in Japan of CD-R and CD-RW for backup and individual use recording of internet, audio and video content. Worldwide OEM activity represented 45.6% of unit shipments, but

only 35.4% of revenues. 45.2% of shipments were to distributors, which provided 48.8% of revenues. The balance was derived from captive sales.

Philips, Yamaha and Ricoh were the leading CD-R/RW drive producers in 1997, accounting for over 52% of overall unit shipments between them. Matsushita Electric was the leading manufacturer supplying PD drives in quantity. Pioneer was first to ship DVD-R, but with a $17,000 drive price and $50 media, the market is limited to serious professional content developers.

Marketing trends

Strong unit shipment growth is forecast through 2001, with revenues nearly doubling and unit shipments increasing five-fold as component restrictions ease and prices decline. Product mix will again change radically as production of CD-RW drives continues to grow, PD drives are displaced by DVD-RAM drives after 1998 and DVD-RAM begins its run to become the expected dominant product. However, until the writable DVD format wars are resolved and 4.7 gigabyte capacity is obtained, DVD writable will be a sideshow to CD-RW's main event.

Shipments for the group are expected to exceed 15 million units in 2001, while revenues climb to nearly $1.8 billion. DVD writable formats of all types are expected to account for almost 43% of unit shipments in 2001. CD-RW drives will hold 57.1% of 2001 shipments. The major uncertainty is the degree to which DVD-RAM will share the DVD writable segment with other formats. Because DVD-RAM is reaching production almost a year ahead of DVD+RW, it is expected to become very well established and remain the dominant DVD writable format, with its major growth beginning in 2000 when 4.7 gigabyte drives and media are anticipated. DVD-R is expected to remain a minor player because of its write-once limitation, high price and limited number of producers.

Applications

CD-R and CD-RW drives are used for short run disk duplication and distribution where volume does not warrant the cost of the replication process, but backup and archiving of files are also significant applications. 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. The drives can also be used for audio/video recording, an increasingly popular consumer application. PD drives have had their greatest success in Japan, where they are used for backup/restore and data interchange.

Applications for DVD writable formats are not fully defined. Content preparation is a viable application (but 4.7 gigabyte capacity is needed), however, it's unclear which other uses will require the large content of DVD. CD-RW is expected to remain viable for an extended period, as many users will find that CD-RW has sufficient capacity for their distribution needs, and lower overall costs.

Users of CD-RW drives are 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 may be preferred over CD-R for routine save/restore uses since the media can be recycled. However, the less expensive CD-R media is preferred for archival and distribution applications.

PD drives have been positioned by Matsushita as backup, archival and save/restore drives that can also read CD-ROM media. 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 some PD manufacturers, such as NEC, have introduced drives that can read CD media, write once on CD-R media, and perform the rewritable function in PD mode.

Attachments to business personal computers accounted for 62.2% of the units shipped in 1997, but this percentage will decrease to 59.7% in 2001 as usage with storage subsystems, servers and workstations increases from 13.5% to 14.4%. Workstations used to prepare CD-ROMs, Web pages and other graphics content are expected to be major users of drives in this group. Use in consumer computers will increase from 14.9% to 18.1%, but use in portable systems is expected to remain relatively low, reaching 6% share in 2001.

Technical trends

Many new product types are entering the market. Production shipments of CD-RW drives began in late 1997, and shipments of the first production DVD-R

drives started in early 1998. Hitachi, first to ship production DVD-RAM drives, also started in the first half of 1998. PD drives are expected to be displaced by DVD-RAM as it enters its ramp-up phase in 1999. Shipments of DVD+RW drives are now expected in mid-1999. DVD-RW, sponsored by Pioneer, has an uncertain shipment schedule, but shipment of production units in 2000 is considered likely. Evaluation units may be available in 1999. Some of the key aspects of this product progression are reviewed below:

Capacity: The capacity of CD-RW drives is the same as CD-R and CD-ROM. However, due to technical limitations, the capacity of DVD-R is limited to 3.95 gigabytes in its initial form, while DVD-RAM drives will be limited to 2.6 gigabytes per side in their initial releases. DVD+RW drives will have 3 gigabyte capacity in their initial forms. All of these formats expect to migrate to 4.7 gigabyte capacity within 2 years. 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 specify a 4.7 gigabyte capacity DVD-R unit in late 1998. Shipment dates are unclear. The DVD-RAM community is expected to produce 4.7 gigabyte versions in 2000.

Write-once recording: The technology used for CD-R recording is dye-based, while the technology used for CD-RW and DVD-R is phase change. In either method, the writing laser causes a change in media reflectivity which can be sensed during the readback process. Unfortunately, CD-R media was not 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. This problem was resolved by putting dual laser pickups in second generation DVD drives.

Rewritability: Phase change technology is used for DVD rewritable and CD-RW drives, and 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 possible write/erase cycles, much lower than MO media.

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. Because of format differences, DVD writable media can not be read by any CD-ROM drives, nor can it be read by DVD-ROM drives produced before the second half of 1998.

Average access times: Average access times (seek plus latency) for products in this group are not fast, with 100 to 200 milliseconds being typical. PD drives are about twice as fast, with some under 100 milliseconds. This slow performance is one of the motivating factors encouraging the development of the MO drives in 12 centimeter formats, 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-RW performance is now 4X write and 24X read, although 6X and 8X write drives are becoming available from more producers. PD drives have a maximum data transfer rate of 1.41 megabytes per second. Write rates will 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.

Standards: In mid-1997, the members of the DVD forum agreed upon the specification for DVD-RAM with 2.6 gigabytes, with a final standard subsequently published. However, a splinter group, which includes Philips, Sony and Hewlett-Packard, announced in mid-1997 that they were supporting a 3 gigabyte capacity version, creating a huge incompatibility problem as DVD rewritable drives come to market. The alternate format, identified as DVD+RW, has been submitted to ECMA as a proposed standard. The three companies indicate that the reason for their action was to produce a drive generating a format closer to that used for DVD-ROM. Ricoh has also since joined the splinter group. This action was followed by an announcement from NEC that they would produce 12 centimeter drives with a 5.2 gigabyte capacity (MMVF, or Multi Media Video Format), but not compatible with DVD-RAM. These are intended for AV use, not as computer peripherals. Pioneer has proposed the DVD-RW rewritable DVD format and appears to be proceeding to fully define it. With everyone promoting their own "standards", it remains for prospective purchasers to select the standard they like.

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. 3.5" MO drives, high capacity floppy drives and rigid cartridge disk drives compare reasonably well in price with drives in this group, supplying equivalent or superior capacity and performance in some

cases. Where CD/DVD 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.

Competition from advanced magneto-optic drives such as the TeraStor products, assuming that they turn out to be price competitive when introduced, is also anticipated. TeraStor has announced 10 and 20 gigabyte drives and indicated its intention to produce a double sided 40 gigabyte drive, but none of these are judged likely to be in production before mid-1999. Again, these drives can compete only where their format incompatibilities are not disadvantageous.

The most immediate performance competition comes from removable cartridge magnetic disk drives such as the Iomega Jaz drive and the SyQuest SyJet, both in the 1-2 gigabyte range, price competitive, with superior performance. However, because they are not CD format compatible and use expensive media, direct competition is not expected. Rather, the existence of these and other high performance competitors limits the expansion potential for the CD format products in this group.

Forecasting assumptions

1. CD-RW drive production will not be limited by component shortages after 1998. Media supplies will be adequate.
2. Components for DVD writable drives will be in relatively short supply until 2000. 4.7 gigabyte DVD-RAM drives will start production in 2000.
3. DVD-RAM drives will not begin to seriously impact CD-RW production until after 2000. DVD-RAM will be the dominant writable DVD format.
4. Advanced magneto-optic drives will not significantly impact this product group within the forecast period.

TABLE 29

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Distributor	.8	1.1	.3	.3	--	--	--	--	--	--
TOTAL U.S. REVENUES	.8	1.1	.3	.3	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	149.4	--	78.4	1.5	62.5	8.9	134.9	11.8	135.0
Distributor	130.7	462.8	179.2	588.3	136.3	438.6	197.3	587.9	239.9	666.7
OEM/Integrator	132.4	337.4	172.5	369.2	180.4	620.4	290.5	817.4	360.8	977.6
TOTAL NON-U.S. REVENUES	263.1	949.6	351.7	1,035.9	318.2	1,121.5	496.7	1,540.2	612.5	1,779.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	263.9	950.7	352.0	1,036.2	318.2	1,121.5	496.7	1,540.2	612.5	1,779.3
OEM Average Price ($000)		.216		.181		.119		.111		.108

TABLE 30

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1997 Shipments		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Distributor	.3	.4	.1	.1	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	.3	.4	.1	.1	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	312.0	--	182.7	10.0	220.0	44.0	614.0	78.0	870.0
Distributor	459.6	1,544.3	804.9	2,567.1	955.0	3,161.0	1,271.0	4,105.0	1,736.0	5,091.0
OEM/Integrator	613.0	1,557.0	937.0	2,040.0	1,475.0	5,204.0	2,380.0	7,318.0	3,123.0	9,044.0
TOTAL NON-U.S. SHIPMENTS	1,072.6	3,413.3	1,741.9	4,789.8	2,440.0	8,585.0	3,695.0	12,037.0	4,937.0	15,005.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,072.9	3,413.7	1,742.0	4,789.9	2,440.0	8,585.0	3,695.0	12,037.0	4,937.0	15,005.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	2.3	5.4	4.0	10.2	6.5	18.8	10.2	30.8	15.1	45.8

TABLE 31

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1997 Revenues			Forecast									
				1998			1999			2000		2001	
	CD R/RW	PD	DVD	CD R/RW	PD	DVD	CD R/RW	PD	DVD	CD R/RW	DVD	CD R/RW	DVD
U.S. MANUFACTURERS													
Distributor	1.1	--	--	.3	--	--	--	--	--	--	--	--	--
TOTAL U.S. REVENUES	1.1	--	--	.3	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS													
Captive	2.0	147.4	--	4.5	48.1	25.8	13.5	9.0	40.0	32.9	102.0	39.0	96.0
Distributor	366.9	91.7	4.2	495.2	44.0	49.1	353.8	20.3	64.5	269.9	318.0	220.7	446.0
OEM/Integrator	304.1	33.3	--	343.7	8.1	17.4	554.4	2.6	63.4	482.3	335.1	378.7	598.9
TOTAL NON-U.S. REVENUES	673.0	272.4	4.2	843.4	100.2	92.3	921.7	31.9	167.9	785.1	755.1	638.4	1,140.9
WORLDWIDE RECAP													
Captive	2.0	147.4	--	4.5	48.1	25.8	13.5	9.0	40.0	32.9	102.0	39.0	96.0
	--	+346.7%	--	+125.0%	-67.4%	--	+200.0%	-81.3%	+55.0%	+143.7%	+155.0%	+18.5%	-5.9%
Distributor	368.0	91.7	4.2	495.5	44.0	49.1	353.8	20.3	64.5	269.9	318.0	220.7	446.0
	+75.2%	+160.5%	--	+34.6%	-52.0%	--	-28.6%	-53.9%	+31.4%	-23.7%	+393.0%	-18.2%	+40.3%
OEM/Integrator	304.1	33.3	--	343.7	8.1	17.4	554.4	2.6	63.4	482.3	335.1	378.7	598.9
	+101.7%	-54.3%	--	+13.0%	-75.7%	--	+61.3%	-67.9%	+264.4%	-13.0%	+428.5%	-21.5%	+78.7%
Total Revenues	674.1	272.4	4.2	843.7	100.2	92.3	921.7	31.9	167.9	785.1	755.1	638.4	1,140.9
	+86.8%	+93.2%	--	+25.2%	-63.2%	--	+9.2%	-68.2%	+81.9%	-14.8%	+349.7%	-18.7%	+51.1%
ANNUAL SHARE, BY DIAMETER	71.0%	28.7%	.3%	81.5%	9.7%	8.8%	82.3%	2.8%	14.9%	51.1%	48.9%	36.0%	64.0%

Note: DVD includes DVD-RAM, DVD+RW, DVD-R and other DVD writeable formats.

TABLE 32

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1997 Shipments			Forecast									
				1998			1999			2000		2001	
	CD R/RW	PD	DVD	CD R/RW	PD	DVD	CD R/RW	PD	DVD	CD R/RW	DVD	CD R/RW	DVD
U.S. MANUFACTURERS													
Distributor	.4	--	--	.1	--	--	--	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	.4	--	--	.1	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS													
Captive	10.0	302.0	--	24.8	126.6	31.3	90.0	30.0	100.0	274.0	340.0	390.0	480.0
Distributor	1,274.5	269.5	.3	2,368.8	146.6	51.7	2,949.0	81.0	131.0	2,991.0	1,114.0	2,759.0	2,332.0
OEM/Integrator	1,424.0	133.0	--	1,964.3	39.6	36.1	5,043.0	13.0	148.0	6,028.0	1,290.0	5,409.0	3,635.0
TOTAL NON-U.S. SHIPMENTS	2,708.5	704.5	.3	4,357.9	312.8	119.1	8,082.0	124.0	379.0	9,293.0	2,744.0	8,558.0	6,447.0
WORLDWIDE RECAP													
Captive	10.0	302.0	--	24.8	126.6	31.3	90.0	30.0	100.0	274.0	340.0	390.0	480.0
	--	+449.1%	--	+148.0%	-58.1%	--	+262.9%	-76.3%	+219.5%	+204.4%	+240.0%	+42.3%	+41.2%
Distributor	1,274.9	269.5	.3	2,368.9	146.6	51.7	2,949.0	81.0	131.0	2,991.0	1,114.0	2,759.0	2,332.0
	+186.2%	+145.0%	--	+85.8%	-45.6%	--	+24.5%	-44.7%	+153.4%	+1.4%	+750.4%	-7.8%	+109.3%
OEM/Integrator	1,424.0	133.0	--	1,964.3	39.6	36.1	5,043.0	13.0	148.0	6,028.0	1,290.0	5,409.0	3,635.0
	+198.5%	-59.8%	--	+37.9%	-70.2%	--	+156.7%	-67.2%	+310.0%	+19.5%	+771.6%	-10.3%	+181.8%
Total Shipments	2,708.9	704.5	.3	4,358.0	312.8	119.1	8,082.0	124.0	379.0	9,293.0	2,744.0	8,558.0	6,447.0
	+193.6%	+42.0%	--	+60.9%	-55.6%	--	+85.5%	-60.4%	+218.2%	+15.0%	+624.0%	-7.9%	+134.9%
ANNUAL SHARE, BY DIAMETER	79.5%	20.5%	--	91.1%	6.5%	2.4%	94.2%	1.4%	4.4%	77.3%	22.7%	57.1%	42.9%

Note: DVD includes DVD-RAM, DVD+RW, DVD-R and other DVD writeable formats.

TABLE 33

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1997 Estimate Units (000)	1997 Estimate %	2001 Projection Units (000)	2001 Projection %
SPECIALIZED HIGH PERFORMANCE Supercomputers, video and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORK/MIDRANGE SYSTEMS Midrange systems, network servers and workstations	461.9	13.5	2,160.7	14.4
DESKTOP PERSONAL COMPUTERS Business and professional, single user	2,122.0	62.2	8,958.0	59.7
CONSUMER COMPUTERS Desktop PCs, game, and hobby computers	508.6	14.9	2,715.9	18.1
PORTABLE COMPUTERS Notebook and smaller mobile computers	98.7	2.9	900.3	6.0
OTHER APPLICATIONS	222.5	6.5	270.1	1.8
Total	3,413.7	100.0	15,005.0	100.0

TABLE 34

CD/DVD FORMAT WRITABLE OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1997 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	CD-R/RW	PD	DVD	Total		CD-R/RW	PD	DVD	Total	
Philips	315.0	--	--	315.0	29.4	795.0	--	--	795.0	25.6
Yamaha	91.0	--	--	91.0	8.5	430.0	--	--	430.0	13.9
Ricoh	182.0	--	--	182.0	17.0	406.0	--	--	406.0	13.1
Matsushita Elec. Ind.	77.0	44.5	--	121.5	11.3	139.0	224.5	--	363.5	11.7
Other U.S.	.3	--	--	.3	--	.4	--	--	.4	--
Other Non-U.S.	336.0	27.0	.1	363.1	33.8	928.5	178.0	.3	1106.8	35.7
TOTAL	1001.3	71.5	.1	1072.9	100.0	2698.9	402.5	.3	3101.7	100.0

READ/WRITE OPTICAL DISK DRIVES LESS THAN 4 GIGABYTES

1998 DISK/TREND REPORT

READ/WRITE OPTICAL DISK DRIVES LESS THAN 4 GIGABYTES

Coverage

Examples of disk drives in this group include:

3.5" disk diameter

Fujitsu	M2512A, M2513A, M2541S
Konica	OMD-9060
Mountain Optech	CS-250 R/W
Olympus	640MO Turbo, MOS330E, MOS341E

5.25" disk diameter

Hitachi	OD-172, OL-F172S
Maxoptix	T5-2600, T6-5200
Mountain Optech	CS-2600 M/F
NEC	N1137-57, ODD-160
Nikon	DD53-B1
Olympus	MOS525E, MOS540E
Pinnacle Micro	Apex
Pioneer	DE-SH7101, DE-SH2200
Sony	RMO-S594, SMO-F541, RMO-S591

This product group is intended to include two types of optical disk drives: 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 product group currently does not include any WORM drives. For this year, the group capacity definition has been expanded to 4 gigabytes to better reflect industry structure and differentiate existing products from those employing newer technologies, which are discussed in the following section.

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. Automated optical libraries (jukeboxes, in industry parlance) used in mass storage subsystems are usually equipped with 5.25" read/write drives.

Market status

Shipments of 3.5" drives did well in 1997, while shipments of 5.25" drives again declined, producing combined growth of 11.2% in unit shipments for the product group. 3.5" drive shipments rose 16.2% to over 1.4 million units. Shipments of 5.25" drives declined to 143,600 units. However, only a few producers of 3.5" drives remain active, and the ranks of companies actively manufacturing 5.25" drives shrank further as MOST, Ricoh and Sharp opted out.

1997 shipments of 3.5" drives through distribution remained high, at over 72% of the worldwide total. Their strength with Japanese distributors and integrators is the major factor influencing the small share of 3.5" drive shipments into the U.S., only 12.9% of the worldwide total. The Apple Macintosh add-on market, with less price sensitivity, remains the healthiest 3.5" market segment in the U.S. Fujitsu was the leading 1997 noncaptive producer of 3.5" drives, (followed by Olympus), again producing more than all other manufacturers combined.

Sony repeated as the leading noncaptive producer of 5.25" drives in 1997. No other producer came even close, giving Sony a very strong position for the time being. All 3.5" drive producers are Japanese firms, but about 18% of 5.25" production was done by U.S. firms.

1997 worldwide sales revenues declined 7.1% to under $590 million. Major price declines caused 3.5" drive revenues to shrink 2.4%, while 5.25" drive revenues dropped 15.5%. U.S. firms accounted for 4.6% of 1997 sales revenues. Further price declines are expected as 3.5" MO drives struggle to meet competition from other recording technologies and information distribution strategies.

Marketing trends

Rewritable 5.25" drives with capacities of over two gigabytes per side are now shipping, but this isn't enough to reverse the downward trend in shipments of 5.25" drives in this product group. Competition from tape drives, 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, and this application has been capped by the greater success of tape libraries. All is not lost, as 5.25" MO

drives with capacities in excess of 4 gigabytes will probably begin shipping in 1999. But in this product group, they will remain a dying product line.

3.5" drives with capacities of 640 megabytes or higher are now in production at several companies and capacities in the gigabyte range are anticipated in a few years. However, the 3.5" MO drive is already challenged by SyQuest's, Castlewood'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. 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 now the DVD-RAM drive, will also compete in the same capacity segment of the market, often with lower prices but also with inferior performance. As Japan becomes increasingly networked, the role of the 3.5" MO drive as a data interchange medium is expected to decline. Competition from alternative technologies is expected to cause 3.5" MO drive shipments to peak in 2000 and subsequently decline.

Shipments for the product group are expected to peak in 2000 at 2.07 million drives and decline slightly to 2.03 million in 2001. Sales revenues for the are expected to peak in 1999 at almost $637 million, declining to $595 million in 2001.

Applications

5.25" optical drives under 4 gigabytes are used primarily to store images in office, medical, design, video editing, security and other specialized systems. When used as an element of an optical library, the 5.25" drive may provide a second tier storage capability in a hierarchical storage subsystem. There is interest in optical library subsystems operating with hierarchical storage management software for use in network attached data and video servers, but tape's lower cost per stored megabyte has limited the penetration of optical libraries.

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. The ability of some 5.25" multifunction drives to use rewritable or write-once media largely meets this need.

Despite recent gains in capacity and performance for optical drives, limitations in performance, packaging, power dissipation and price relative to faster improving rigid magnetic disk drives cause optical drives to compete poorly against rigid drives, unless a combination of high capacity and removability are mandatory. Even so, recent retail prices of 2.1 gigabyte rigid drives approximates the pricing of some 5.25" MO media.

The faster erasable drives, such as the Maxoptix "T" series, have found limited application as system disks in high security applications requiring vault storage of recorded media when the equipment is unattended, and as a project storage disk in video editing applications, but these usages have 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 and capacity increases also encourage their use as high performance backup devices for workstations and personal computers.

In 1997, desktop personal computers again were the largest application platform for this product group, accounting for 67.2% of the units shipped. Consumer systems accounted for an additional 14.4%. This is a slight increase over l996, reflecting increasing consumer acceptance of 3.5" drives outside the U.S.. The share attached to networks and workstations will decline as user interest shifts to higher capacity drives in the over 4 gigabyte range, resulting in share increases for consumer computer and portable system attachment rates. Gigabyte 3.5" drives, when they appear, are expected to receive acceptance in the workstation market, provided they are properly priced.

Technical trends

The technology of optical drives continues to advance, 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. In any event, the next generation of

5.25" optical drives will have capacities high enough to remove them from this product group. While 3.5" drives will continue in the group for the foreseeable future, spinoffs of technology from very high capacity 5.25" designs are expected to eventually "promote" 3.5" drives to the next capacity group.

Capacity: The capacity of 5.25" rewritable drives has reached 2.6 gigabytes per side and is expected to go well beyond that in 1999 when 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), servo improvements permitting reduction of track pitch, the adoption of pulse width modulation, zoned recording, land and groove recording, and variable track pitch. If blue or green 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 shipments, 1.3 gigabyte 3.5" drives are expected to be developed and announced by late 1998, though shipments will probably begin in 1999. The anticipated migration of the new high capacity MO technologies (such as near field recording) to 3.5" form factors is expected to result in the availability of 3.5" MO drives and media with capacities of 5 gigabytes or more at some time during the forecast period of this report, though no company has yet projected a specific timetable for availability.

The blue or violet lasers that many designers believe hold the key to improving optical storage areal density may be available in sample quantities this year, notably from Nichiya Chemical. While the lasers are operable at room temperatures, lifetime may still be an issue.

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. Sony is also marketing a multifunction drive, similar to that once made by IBM, that is capable of using write-once media.

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, but media for the drives has been expensive and scarce.

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. Also, glass is 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 T6-5200 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 and Fujitsu going under the 30 millisecond level. Increasing rotational speed also improves performance. Some Maxoptix drives rotate 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 can be very lengthy in comparison to the drive average 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, especially if the defects are large, 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, but there will always be a tradeoff between performance and the size of the error correction block.

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 use the half-height 5.25" form factor, which is now the standard profile.

Fujitsu was the first company to announce and ship a 25.4 mm high 3.5" optical disk drive, followed by a 17 millimeter drive in late 1995 which is still the thinnest available. 25.4 millimeter height is now standard for 3.5" MO drives.

Standards: Standards exist for 3.5" and 5.25" drives and media currently in production. While standards were a contentious issue in the early days of optical recording, the few surviving companies have largely rallied

around the road maps established by OSTA, the Optical Storage Technology Association, to establish a commonly supported set of goals and timelines. Standards development activity now tends to track the OSTA road map capacity points.

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 MO 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, Castlewood and SyQuest, at prices substantially under current prices for 3.5" MO drives. Fixed magnetic drives with multigigabyte capacities are often advertised at retail prices in the $200 range.

5.25" magnetic disk drives from Seagate with capacities up to 47 gigabytes have impacted 5.25" optical disk drive sales in applications where a removable disk is not mandatory, and 3.5" magnetic disk drives with capacities now up to 18 gigabytes are having a restraining effect on MO drive sales as well.

Ultimately, the competing products most impacting this product group are the higher capacity optical disk drives that are expected to begin shipments in 1999, and which are discussed in the following product group.

Forecasting assumptions

1. 5.25" optical disk drives with over 4 gigabytes of capacity per side will start to divert shipments of 5.25" drives from this product group beginning in 1999.

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 in production in 1999. The impact of new MO technologies will have a beneficial impact on 3.5" drives in this product group, but the timing is too uncertain for the effects to be forecast.
4. No significant new applications for products in this group are expected to appear during the forecast period.

TABLE 35

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 4 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Distributor	10.8	13.4	8.3	10.7	5.8	8.7	5.5	7.3	4.4	6.1
OEM/Integrator	9.2	13.5	7.1	10.0	7.0	9.6	5.7	8.2	4.6	6.1
TOTAL U.S. REVENUES	20.0	26.9	15.4	20.7	12.8	18.3	11.2	15.5	9.0	12.2
Non-U.S. Manufacturers										
Captive	--	61.6	--	64.8	--	69.3	--	68.8	--	67.1
Distributor	57.7	341.9	58.4	381.4	60.4	407.3	57.8	412.4	51.8	395.7
OEM/Integrator	55.7	159.3	49.6	152.6	43.2	152.2	37.6	140.1	30.0	119.6
TOTAL NON-U.S. REVENUES	113.4	562.8	108.0	598.8	103.6	628.8	95.4	621.3	81.8	582.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	133.4	589.7	123.4	619.5	116.4	647.1	106.6	636.8	90.8	594.6
OEM Average Price ($000)		.406		.359		.331		.311		.275

TABLE 36

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 4 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1997 Shipments		Forecast							
	1998		1999		2000		2001			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Distributor	9.7	12.0	8.0	10.3	6.0	9.0	6.0	8.0	5.0	7.0
OEM/Integrator	9.5	13.8	8.0	11.2	8.0	11.0	7.0	10.0	6.0	8.0
TOTAL U.S. SHIPMENTS	19.2	25.8	16.0	21.5	14.0	20.0	13.0	18.0	11.0	15.0
Non-U.S. Manufacturers										
Captive	--	70.6	--	88.4	--	108.0	--	117.0	--	121.0
Distributor	123.0	1,046.4	138.7	1,258.6	147.0	1,405.0	152.0	1,469.0	141.0	1,447.0
OEM/Integrator	58.9	411.8	61.5	441.0	64.0	477.0	59.0	466.0	51.0	448.0
TOTAL NON-U.S. SHIPMENTS	181.9	1,528.8	200.2	1,788.0	211.0	1,990.0	211.0	2,052.0	192.0	2,016.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	201.1	1,554.6	216.2	1,809.5	225.0	2,010.0	224.0	2,070.0	203.0	2,031.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	1.5	5.7	1.7	7.5	2.0	9.5	2.2	11.5	2.4	13.6

TABLE 37

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 4 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1997 Revenues		Forecast 1998		1999		2000		2001	
	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS										
Distributor	13.4	--	10.7	--	8.7	--	7.3	--	6.1	--
OEM/Integrator	13.5	--	10.0	--	9.6	--	8.2	--	6.1	--
TOTAL U.S. REVENUES	26.9	--	20.7	--	18.3	--	15.5	--	12.2	--
NON-U.S. MANUFACTURERS										
Captive	37.7	23.9	36.1	28.7	33.3	36.0	29.8	39.0	27.2	39.9
Distributor	41.1	300.8	37.6	343.8	36.3	371.0	30.7	381.7	26.5	369.2
OEM/Integrator	87.3	72.0	76.8	75.8	71.0	81.2	62.5	77.6	49.4	70.2
TOTAL NON-U.S. REVENUES	166.1	396.7	150.5	448.3	140.6	488.2	123.0	498.3	103.1	479.3
WORLDWIDE RECAP										
Captive	37.7 -28.2%	23.9 +49.4%	36.1 -4.2%	28.7 +20.1%	33.3 -7.8%	36.0 +25.4%	29.8 -10.5%	39.0 +8.3%	27.2 -8.7%	39.9 +2.3%
Distributor	54.5 +8.1%	300.8 -2.7%	48.3 -11.4%	343.8 +14.3%	45.0 -6.8%	371.0 +7.9%	38.0 -15.6%	381.7 +2.9%	32.6 -14.2%	369.2 -3.3%
OEM/Integrator	100.8 -19.7%	72.0 -11.4%	86.8 -13.9%	75.8 +5.3%	80.6 -7.1%	81.2 +7.1%	70.7 -12.3%	77.6 -4.4%	55.5 -21.5%	70.2 -9.5%
Total Revenues	193.0 -15.5%	396.7 -2.4%	171.2 -11.3%	448.3 +13.0%	158.9 -7.2%	488.2 +8.9%	138.5 -12.8%	498.3 +2.1%	115.3 -16.8%	479.3 -3.8%
ANNUAL SHARE, BY DIAMETER	32.7%	67.3%	27.6%	72.4%	24.6%	75.4%	21.7%	78.3%	19.4%	80.6%

TABLE 38

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 4 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1997 Shipments		Forecast							
			1998		1999		2000		2001	
	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS										
Distributor	12.0	--	10.3	--	9.0	--	8.0	--	7.0	--
OEM/Integrator	13.8	--	11.2	--	11.0	--	10.0	--	8.0	--
TOTAL U.S. SHIPMENTS	25.8	--	21.5	--	20.0	--	18.0	--	15.0	--
NON-U.S. MANUFACTURERS										
Captive	17.6	53.0	18.4	70.0	18.0	90.0	17.0	100.0	16.0	105.0
Distributor	28.4	1,018.0	29.6	1,229.0	31.0	1,374.0	29.0	1,440.0	27.0	1,420.0
OEM/Integrator	71.8	340.0	71.0	370.0	71.0	406.0	68.0	398.0	58.0	390.0
TOTAL NON-U.S. SHIPMENTS	117.8	1,411.0	119.0	1,669.0	120.0	1,870.0	114.0	1,938.0	101.0	1,915.0
WORLDWIDE RECAP										
Captive	17.6 -31.2%	53.0 +65.6%	18.4 +4.5%	70.0 +32.1%	18.0 -2.2%	90.0 +28.6%	17.0 -5.6%	100.0 +11.1%	16.0 -5.9%	105.0 +5.0%
Distributor	40.4 -1.2%	1,018.0 +18.3%	39.9 -1.2%	1,229.0 +20.7%	40.0 +.3%	1,374.0 +11.8%	37.0 -7.5%	1,440.0 +4.8%	34.0 -8.1%	1,420.0 -1.4%
OEM/Integrator	85.6 -26.3%	340.0 +5.5%	82.2 -4.0%	370.0 +8.8%	82.0 -.2%	406.0 +9.7%	78.0 -4.9%	398.0 -2.0%	66.0 -15.4%	390.0 -2.0%
Total Shipments	143.6 -21.4%	1,411.0 +16.2%	140.5 -2.2%	1,669.0 +18.3%	140.0 -.4%	1,870.0 +12.0%	132.0 -5.7%	1,938.0 +3.6%	116.0 -12.1%	1,915.0 -1.2%
ANNUAL SHARE, BY DIAMETER	9.2%	90.8%	7.8%	92.2%	7.0%	93.0%	6.4%	93.6%	5.7%	94.3%

TABLE 39

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 4 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

	1997 Estimate		2001 Projection	
APPLICATION	Units (000)	%	Units (000)	%
SPECIALIZED HIGH PERFORMANCE Supercomputers, video and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORK/MIDRANGE SYSTEMS Midrange systems, network servers and workstations	216.1	13.9	154.4	7.6
DESKTOP PERSONAL COMPUTERS Business and professional, single user	1,044.7	67.2	1,145.5	56.4
CONSUMER COMPUTERS Desktop PCs, game, and hobby computers	224.0	14.4	532.1	26.2
PORTABLE COMPUTERS Notebook and smaller mobile computers	26.3	1.7	144.2	7.1
OTHER APPLICATIONS	43.5	2.8	54.8	2.7
Total	1,554.6	100.0	2,031.0	100.0

TABLE 40

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 4 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1997 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	5.25"	3.5"	Total		5.25"	3.5"	Total	
Fujitsu	--	88.0	88.0	43.8	--	782.0	782.0	52.7
Olympus	2.0	32.0	34.0	16.9	10.0	461.0	471.0	31.7
Other U.S.	19.2	--	19.2	9.5	25.8	--	25.8	1.7
Other Non-U.S.	52.9	7.0	59.9	29.8	90.2	115.0	205.2	13.9
TOTAL	74.1	127.0	201.1	100.0	126.0	1358.0	1484.0	100.0

READ/WRITE OPTICAL DISK DRIVES MORE THAN 4 GIGABYTES

1998 DISK/TREND REPORT

READ/WRITE OPTICAL DISK DRIVES MORE THAN 4 GIGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Eastman Kodak	System 2000

12" disk diameter

ATG	GD 9001/S, GD 16000
Philips LMS	LD 6100

5.25" disk diameter

Quinta/Seagate Technology	To be announced (Rewritable)
TeraStor	To be announced (Rewritable)

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

This product group has been redefined to include optical disk drives with over 4 gigabytes of on-line capacity, reflecting increases in drive capacity level. High capacity optical disk drives are read/write drives, either write-once or re-writable. Currently, most drives in this capacity range are 12" write-once types. Although Nikon started shipments of a 12" rewritable drive in 1992, production has ceased. Eastman Kodak produces high capacity 14" drives, but has announced it is exiting this line of business. 1999 shipments of rewritable 5.25" drives are anticipated.

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 usually 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. The anticipated 5.25" drives will be available with both fixed and removable media, and will be used in libraries and large on-line storage arrays.

Market status

For 1997, unit shipments in this product group totaled 2,400 units (all 12" or 14" drives), a 42.9% decrease. The decline is a continuation of a multiyear slide in shipments of 12" drives, and with the departure of Eastman Kodak, leaves only Philips LMS and ATG as surviving producers for coming years. 1997 revenues declined 38.5% to $35.4 million, due to lower shipments of 12" drives. U.S. manufacturers accounted for 22% of worldwide sales revenues, although 82.5% of worldwide revenues were generated in the U.S. market. Over 68% of 1997 revenues were produced by sales to OEMs and integrators, while 23.1% were from distributor channels.

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" MO drives will expand the market for this product group into general industry.

Marketing trends

Shipments of 12" drives are expected to increase in 1999, as users of 12" libraries stock up in anticipation of product end of life. Higher 12" drive capacities in the 20-30 gigabyte per disk range will also help extend user interest, but ultimately growth in 12" drives will succumb to the new 5.25" technologies. Shipments of 5.25" and smaller drives in this group are expected to begin in 1999 and rise sharply as the introduction of drives from Quinta, TeraStor and manufacturers building ASMO or other advanced drives returns life and hope to the MO optical drive industry. U.S. firms are expected to be the earliest participants in the MO revival, with production from most Japanese drive producers following the initiation of U.S. produced drives.

New products anticipated are 6 gigabyte 4.72" MO drives, 10 and 20 gigabyte near field recording drives from TeraStor, and multigigabyte fixed disk 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 include in forecasting. The

competition from 5.25" drives is expected to reverse the tendency of 12" drive prices to climb modestly 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, but that timetable is also not yet forecastable.

As a consequence of the arrival of small diameter drives in this product group, the average OEM unit price will fall sharply during the forecast period from over $13,000 to under $2,000. This will severely stress the 12" market, but shipments to companies already committed to 12" media in their libraries may keep the 12" market alive for a while. But of the over 1.4 million drives in this product group expected to ship in 2001, only .1% will be 12" drives.

2001 sales revenues are projected to exceed $2.3 billion. Driven by usage in libraries and on-line storage arrays (for example, EMC, where fixed optical drives are expected to supplant the Seagate Elite 47 magnetic drive) U.S. markets are expected to generate the majority of worldwide revenues for this product group in the latter part of the forecast period. Most of the U.S. sales revenues will come from sales of 5.25" drives. 12" drive sales should be helped briefly by expanding sales of small optical libraries with a single 12" drive, plus a new generation of higher capacity drives, but ultimately will fall as drive makers cut prices to deal with the onslaught of small diameter drives.

Applications

Networks and multiuser systems remain the major application for drives in this group, but the introduction of 5.25" drives in the group is expected to result in significant usage in mainframe environments as the Seagate Elite magnetic disk drive series is supplanted by drives using technology from Quinta/Seagate and other manufacturers. Quantum is expected to be able to use its manufacturing license with TeraStor to migrate a portion of its DLT tape customer base to optical drives as the TeraStor drives are designed into automated libraries.

The majority of 12" drives were (and will be) installed in optical libraries. Libraries attached to mainframes used enough drives to account for 26.3% of group shipments in 1997. With the arrival of next generation 5.25" (or smaller)

drives in this group, mainframe applications are expected to capture 12.2% of the 2001 total. Midrange systems, networks and workstations will capture 79.6% of 2001 shipments, with the rest scattered among other platforms. If 3.5" drives materialize as expected, business personal computers might do better than the 3.2% share forecasted, and the 1.1% share of notebook computers might also be improved.

High capacity optical drives will probably 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. Not only is TeraStor's business plan predicated upon these characteristics, but with Quantum's investment in TeraStor and Seagate's acquisition of Quinta, a startup less than 2 years old at the time, there is ample evidence that the strategic planners at major disk drive producers see the potential.

Major applications for 12" optical disk drives 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. Data warehousing, 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.

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.

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" standalone drive applications in this product group have been impacted by lower capacity 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.

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 30 gigabytes per cartridge.

Technical trends

Many of the technical issues discussed in the section on optical disk drives under 4 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 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 lower degree of standardization, since the drives expected in 1998 and 1999 represent completely new designs. 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, such as Quinta's fixed media design, will not require much beyond compliance with standard logical interfaces such as SCSI, Ultra-SCSI and FC AL, and with industry form factor and packaging requirements. And if successful, the newcomers will probably create de facto standards prior to formal standards generation.

System design: Many large capacity optical disk storage systems will incorporate an automated library. Several firms, including ATG, 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. Optical drives intended to replace tape drives or magnetic disk drives are expected to contain controllers that will enable direct replacement and not require extensive changes in system software.

Capacity: The family of 12" drives that started its introduction cycle in late 1994 offers over 16 gigabytes per disk, much improved from a typical capacity of 2 gigabytes per disk in earlier models, and is being extended to the 30 gigabyte range. More recent 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 been announced as 10 gigabytes, 20 gigabytes and 40 gigabytes per disk. Quinta's drive capacity remains unannounced, but it is widely expected to be in the 100 gigabyte range, using multiple disks.

Interface: SCSI is the most commonly encountered interface family 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 ATAPI, USB and P1394 interfaces (assuming they do 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: Most drive producers are making the transition from infra-red lasers to red laser diodes in order to improve areal density. Blue-green,

blue and violet lasers will be adopted as they become available, providing that they can meet price, output power, operating temperature and operating life requirements. Blue-green lasers may be in use toward the end of the forecast period, but it will probably take another few years to get blue or violet lasers acceptable for writable optical drive use into production.

Heads: Head design for advanced small optical drives is borrowing techniques from the magnetic drive design world, adopting rotary positioners and flying heads at microinch levels above the disk surface. In the case of near field recording, spacing must be minimized to get adequate energy coupling from the head to the media. Fly height control is critical in obtaining adequate and stable signal to noise ratios. In some designs, the laser is mounted off the slider itself, with energy routed through the use of optical fibers between laser and head. Linear positioning is used in 12" and in older 5.25" designs.

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 hopes of achieving higher 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 3,000 RPM or higher.

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 has largely gone to plastic, while 4.72" media will use only plastic substrates. Surface irregularities and dimensional instabilities in plastic media create difficulties for drive designs requiring low flying heads, and it remains to be seen how acceptable plastic will be for these designs in actual practice.

Forecasting assumptions

1. 5.25" optical drives will become major participants in this product group in 1999. Both fixed and removable media types will be shipped. Both the Quinta/Seagate and TeraStor programs are assumed to have successful outcomes. 4.72" ASMO drives will be introduced in late 1998 for 1999 delivery.
2. There will continue to be an adequate supply of media and components for drives in this product group.
3. There will be no generally accepted single standard for 12" drives and media through 2001. 30 gigabyte drives will be available in 1999.
4. 3.5" drives will appear in this product group during the forecast period, but the timing is too uncertain to permit forecasting.

TABLE 41

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	3.0	3.0	--	--	--	--	--	--	--	--
Distributor	2.4	4.8	2.0	4.0	14.0	20.2	47.8	77.5	169.8	264.3
OEM/Integrator	--	--	--	--	28.5	39.0	195.3	294.5	920.0	1,689.6
TOTAL U.S. NONCAPTIVE	2.4	4.8	2.0	4.0	42.5	59.2	243.1	372.0	1,089.8	1,953.9
TOTAL U.S. REVENUES	5.4	7.8	2.0	4.0	42.5	59.2	243.1	372.0	1,089.8	1,953.9
Non-U.S. Manufacturers										
Distributor	2.6	3.4	2.5	3.3	3.8	11.3	10.9	51.5	19.7	97.2
OEM/Integrator	21.2	24.2	20.9	25.4	24.2	39.3	45.6	95.2	112.0	297.2
TOTAL NON-U.S. REVENUES	23.8	27.6	23.4	28.7	28.0	50.6	56.5	146.7	131.7	394.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	29.2	35.4	25.4	32.7	70.5	109.8	299.6	518.7	1,221.5	2,348.3
OEM Average Price ($000)		13.444		12.700		2.256		1.659		1.618

TABLE 42

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1997 Shipments		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.1	.1	--	--	--	--	--	--	--	--
Distributor	.1	.2	.1	.2	9.0	13.0	29.0	47.0	97.0	151.0
OEM/Integrator	--	--	--	--	19.0	26.0	126.0	190.0	575.0	1,056.0
TOTAL U.S. SHIPMENTS	.2	.3	.1	.2	28.0	39.0	155.0	237.0	672.0	1,207.0
Non-U.S. Manufacturers										
Distributor	.2	.3	.2	.3	1.2	5.3	6.1	30.2	11.1	56.2
OEM/Integrator	1.6	1.8	1.7	2.0	3.9	8.7	18.0	44.8	61.4	171.8
TOTAL NON-U.S. SHIPMENTS	1.8	2.1	1.9	2.3	5.1	14.0	24.1	75.0	72.5	228.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2.0	2.4	2.0	2.5	33.1	53.0	179.1	312.0	744.5	1,435.0
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	53.0	104.1	55.0	106.6	88.1	159.6	267.2	471.6	1,011.7	1,906.6

TABLE 43

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1997 Revenues 12"-14"	Forecast 1998 12"-14"	1999 12"-14"	1999 5.25"	2000 12"-14"	2000 5.25"	2001 12"-14"	2001 5.25"
U.S. MANUFACTURERS								
Captive	3.0	--	--	--	--	--	--	--
Distributor	4.8	4.0	--	20.2	--	77.5	--	264.3
OEM/Integrator	--	--	--	39.0	--	294.5	--	1,689.6
TOTAL U.S. REVENUES	7.8	4.0	--	59.2	--	372.0	--	1,953.9
NON-U.S. MANUFACTURERS								
Distributor	3.4	3.3	3.3	8.0	2.0	49.5	2.0	95.2
OEM/Integrator	24.2	25.4	30.0	9.3	28.0	67.2	16.7	280.5
TOTAL NON-U.S. REVENUES	27.6	28.7	33.3	17.3	30.0	116.7	18.7	375.7
WORLDWIDE RECAP								
Captive	3.0 -65.9%	-- --	-- --	-- --	-- --	-- --	-- --	-- --
Distributor	8.2 -59.0%	7.3 -11.0%	3.3 -54.8%	28.2 --	2.0 -39.4%	127.0 +350.4%	2.0 --	359.5 +183.1%
OEM/Integrator	24.2 -16.0%	25.4 +5.0%	30.0 +18.1%	48.3 --	28.0 -6.7%	361.7 +648.9%	16.7 -40.4%	1,970.1 +444.7%
Total Revenues	35.4 -38.5%	32.7 -7.6%	33.3 +1.8%	76.5 --	30.0 -9.9%	488.7 +538.8%	18.7 -37.7%	2,329.6 +376.7%
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	30.3%	69.7%	5.8%	94.2%	.8%	99.2%

Note: 5.25 inch drive totals include 4.72 inch drives.

TABLE 44

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1997 Shipments	Forecast						
		1998	1999		2000		2001	
	12"-14"	12"-14"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"
U.S. MANUFACTURERS								
Captive	.1	--	--	--	--	--	--	--
Distributor	.2	.2	--	13.0	--	47.0	--	151.0
OEM/Integrator	--	--	--	26.0	--	190.0	--	1,056.0
TOTAL U.S. SHIPMENTS	.3	.2	--	39.0	--	237.0	--	1,207.0
NON-U.S. MANUFACTURERS								
Distributor	.3	.3	.3	5.0	.2	30.0	.2	56.0
OEM/Integrator	1.8	2.0	2.7	6.0	2.8	42.0	1.8	170.0
TOTAL NON-U.S. SHIPMENTS	2.1	2.3	3.0	11.0	3.0	72.0	2.0	226.0
WORLDWIDE RECAP								
Captive	.1	--	--	--	--	--	--	--
	-75.0%	--	--	--	--	--	--	--
Distributor	.5	.5	.3	18.0	.2	77.0	.2	207.0
	-61.5%	--	-40.0%	--	-33.3%	+327.8%	--	+168.8%
OEM/Integrator	1.8	2.0	2.7	32.0	2.8	232.0	1.8	1,226.0
	-28.0%	+11.1%	+35.0%	--	+3.7%	+625.0%	-35.7%	+428.4%
Total Shipments	2.4	2.5	3.0	50.0	3.0	309.0	2.0	1,433.0
	-42.9%	+4.2%	+20.0%	--	--	+518.0%	-33.3%	+363.8%
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	5.7%	94.3%	1.0%	99.0%	.1%	99.9%

Note: 5.25 inch drive totals include 4.72 inch drives.

TABLE 45

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

WORLDWIDE SHIPMENTS (000)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1997		Forecast							
	--Shipments--		-----1998----		-----1999----		-----2000----		-----2001----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	.1		--		--		--		--	
Write-Once	.1	100.0%	--	--	--	--	--	--	--	--
Noncaptive Total	.2		.2		39.0		237.0		1,207.0	
Write-Once	.2	100.0%	.2	100.0%	--	--	--	--	--	--
Rewritable	--	--	--	--	39.0	100.0%	237.0	100.0%	1,207.0	100.0%
Total U.S.	.3		.2		39.0		237.0		1,207.0	
Write-Once	.3	100.0%	.2	100.0%	--	--	--	--	--	--
Rewritable	--	--	--	--	39.0	100.0%	237.0	100.0%	1,207.0	100.0%
NON-U.S. MANUFACTURERS										
Noncaptive Total	2.1		2.3		14.0		75.0		228.0	
Write-Once	2.1	100.0%	2.3	100.0%	3.0	21.4%	3.0	4.0%	2.0	.9%
Rewritable	--	--	--	--	11.0	78.6%	72.0	96.0%	226.0	99.1%
Total Non-U.S.	2.1		2.3		14.0		75.0		228.0	
Write-Once	2.1	100.0%	2.3	100.0%	3.0	21.4%	3.0	4.0%	2.0	.9%
Rewritable	--	--	--	--	11.0	78.6%	72.0	96.0%	226.0	99.1%
WORLDWIDE SHIPMENTS										
Total Shipments	2.4		2.5		53.0		312.0		1,435.0	
	-72.9%		+4.2%		--		+488.7%		+359.9%	
Write-Once	2.4	100.0%	2.5	100.0%	3.0	5.7%	3.0	1.0%	2.0	.1%
	-42.8%		+4.2%		+20.0%		--		-33.2%	
Rewritable	--	--	--	--	50.0	94.3%	309.0	99.0%	1,433.0	99.9%
	--		--		--		+518.0%		+363.8%	

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

TABLE 46

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1997 Estimate Units (000)	1997 Estimate %	2001 Projection Units (000)	2001 Projection %
SPECIALIZED HIGH PERFORMANCE				
Supercomputers, video and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	.6	26.3	175.1	12.2
NETWORK/MIDRANGE SYSTEMS				
Midrange systems, network servers and workstations	1.3	52.5	1,142.3	79.6
DESKTOP PERSONAL COMPUTERS				
Business and professional, single user	.1	5.0	45.9	3.2
CONSUMER COMPUTERS				
Desktop PCs, game, and hobby computers	--	--	25.8	1.8
PORTABLE COMPUTERS				
Notebook and smaller mobile computers	--	--	15.8	1.1
OTHER APPLICATIONS	.4	16.2	30.1	2.1
Total	2.4	100.0	1,435.0	100.0

TABLE 47

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 4 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1997 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	12-14"	5.25"	Total		12-14"	5.25"	Total	
Philips LMS	1.7	--	1.7	89.4	1.8	--	1.8	78.3
Other U.S.	.1	--	.1	5.3	.2	--	.2	8.7
Other Non-U.S.	.1	--	.1	5.3	.3	--	.3	13.0
TOTAL	1.9	--	1.9	100.0	2.3	--	2.3	100.0

CD FORMAT OPTICAL DISK LIBRARIES

1998 DISK/TREND REPORT

CD FORMAT OPTICAL DISK LIBRARIES

Coverage

Examples of optical disk libraries in this group include:

12 centimeter (4.72") disk diameter

Asaca	AC-600, AM-1450 DVD
ASM	CDR 100, CDR 1400
Cygnet Storage Solutions	INF250/4, id100, id100/DVD
DISC	D300, D600, D1260
DSM GmbH & Co.	CDR 40, CDR 53, CDR 71
Eastman Kodak	CD ADL-150, CD Library 144
Grundig	GMS 1035CD, GMS 3280CD
Hitachi	DL-F111-50
JVC	MC-1200, MC-2600P
Kubik Enterprises	CDR240M, CD Tower
Matsushita Electric Industrial	LF-J50A2, LF-J100A2
Nakamichi	MJ5.16Se
Nippon Columbia (Denon)	DRD-1400
Nistec	ALW-501
NSM	Mercury-40, Satellite, SERVEready TK
Pioneer	DRM-624X, DRM-1804X, DRM-5002R2W
Plasmon Data	D120-40, D240-P6, D480-6
Sony	CDL 2100, CDL 2200-22, CDL 5000
TEAC	CD-C68E, CD-C624E

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 typically store five disks and fit into a half-high slot.

Market status

Because of drastically decreased OEM consumption of minichangers, unit shipments in this product group declined 80.3% in 1997 to about 134,200 units. The only category displaying year on year growth was libraries with over 100 disks. Because the larger libraries have higher prices, 1997 sales revenue for the entire product group shrank only 47.3%, dropping to $74.6 million. The drop in

minichanger unit shipments precipitated a shakeout, with only Nakamichi and Pioneer remaining as manufacturers. Non-U.S. suppliers had over 87% of the worldwide market, and 49% of the units were shipped to the U.S., a sharp increase from the 1996 share, due to the fall in shipments of small autochangers to Asian personal computer manufacturers. Low cost autochangers and towers negatively impacted shipments of 10 to 100 disk units. Many minichangers are used in towers containing multiple minichangers, competing effectively with midsize libraries.

The average OEM price in the product group rose as a result of the smaller percentage of inexpensive autochangers in the mix, and is expected to peak in 1998, after which normal price decline patterns are anticipated.

Almost 96% of the units shipped in 1997 held fewer than 10 disks, 1.7% had from 10 to 100 disks, and 2.5% of the units shipped used over 100 disks. However, only 34.6% 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 14.2% and 51.2%, respectively.

Shipments of small autochangers began dropping in early 1997 because system manufacturers found that product prices were too high and performance too slow relative to conventional CD-ROM drives. Shipments of the small autochangers are expected to resume growth in 1999 as the result of growing demand from CD tower producers, but growth will be nominal, since the tower makers are shifting to hard drive cached configurations requiring fewer drives and changers. As a result, the revenue share of the under 10 disk segment is expected to decline over the next few years, dropping to about 24% of sales in 2001. New, lower price products in the 10 to 100 disk segment have begun to stimulate growth in that segment, and the larger capacity libraries are benefiting from the growth in storage server markets.

NSM, Sony, Plasmon Data, DISC, Pioneer, JVC, Cygnet Storage Solutions and others are shipping libraries with 100 disk or greater capacity, with NSM achieving the highest 1997 unit shipment volume in this category. Matsushita has announced 50 and 100 disk libraries incorporating its PD drive. Several other companies are using karaoke system libraries to which have been added appropriate controller logic and software support.

As noted earlier, 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 becoming more prominent as the smaller systems are displaced by hard drive cached configurations. CD towers are discussed in detail in the following section.

Marketing trends

Unit shipments are forecasted to grow to 173,300 units in 2001, the majority (over 94%) of which will remain minichangers. Revenues are expected to dip through 1999, and then recover to $75.6 million in 2001, much less than anticipated earlier, because of quickly decreasing prices and smaller than anticipated shipments for small autochangers. 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 8.4% by the end of the forecast period.

Most computer manufacturers now incorporate single CD-ROM or DVD drives with their file servers, increasing the opportunity for upgrades to a library subsystem. The availability of inexpensive server modules 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 without the need for an additional server.

Applications

The major applications for CD-ROM format optical libraries continue to be in network file servers, 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 documentation for many users located at diverse sites. Low-end libraries, such as the Pioneer and Nakamichi units, are used primarily with single-user computers and workstations or 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. While DVD-ROM drives will be able to eliminate some need for minichangers by virtue of their larger capacity, the desire to have multiple DVD-ROM applications accessible by computer control is expected to create a demand for DVD based minichangers.

The coming generation of DVD drives is expected to create new applications for libraries in selected video-on-demand applications, but the higher capacity of the drives is not judged likely to decrease the size of the required library in applications currently requiring multiple disks.

The availability of CD-R and CD-RW drives is also a positive stimulus for CD-ROM libraries, which enable users to back up large sections of multigigabyte rigid disk drives or duplicate CD disks automatically. Some larger CD-ROM libraries have been used as CD-R duplicators, but most companies doing quantity duplication prefer dedicated systems writing multiple CD-R disks 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 and DISC. Kubik's and Nippon Columbia's rotary carousel designs provide 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, direct network attachment, 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.

Libraries will increasingly substitute DVD-ROM drives for CD-ROM drives after 1998, by which time third generation DVD-ROM drives capable of reading DVD-RAM media will be widely available and considerably less expensive.

As noted earlier, there is 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 and DVD-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. The use of DVD-ROM drives in libraries will increase markedly after 1998.
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/DVD-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 48

CD FORMAT OPTICAL LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997 Revenues		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Distributor	2.4	3.2	2.4	3.6	2.4	3.7	2.4	3.7	2.5	3.9
OEM/Integrator	10.5	18.9	9.8	13.2	10.9	13.9	10.9	13.9	11.6	14.8
TOTAL U.S. REVENUES	12.9	22.1	12.2	16.8	13.3	17.6	13.3	17.6	14.1	18.7
Non-U.S. Manufacturers										
Captive	--	.6	--	.9	--	.9	--	.8	--	.8
Distributor	16.5	29.9	18.1	29.4	17.8	28.3	18.7	29.6	19.8	31.4
OEM/Integrator	11.5	22.0	11.4	21.7	12.3	22.0	13.4	23.5	14.4	24.7
TOTAL NON-U.S. REVENUES	28.0	52.5	29.5	52.0	30.1	51.2	32.1	53.9	34.2	56.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	40.9	74.6	41.7	68.8	43.4	68.8	45.4	71.5	48.3	75.6
OEM Average Price ($000)		.926		1.014		.888		.794		.733

TABLE 49

CD FORMAT OPTICAL LIBRARIES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1997 Shipments		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Distributor	535	908	262	437	274	456	283	470	295	490
OEM/Integrator	3,167	16,301	594	745	640	804	682	856	727	919
TOTAL U.S. SHIPMENTS	3,702	17,209	856	1,182	914	1,260	965	1,326	1,022	1,409
Non-U.S. Manufacturers										
Captive	--	80	--	120	--	110	--	106	--	100
Distributor	47,751	89,070	60,652	95,715	66,890	104,635	72,245	111,935	77,130	118,840
OEM/Integrator	14,585	27,849	19,795	33,668	25,121	39,632	30,502	46,258	35,883	52,988
TOTAL NON-U.S. SHIPMENTS	62,336	116,999	80,447	129,503	92,011	144,377	102,747	158,299	113,013	171,928
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	66,038	134,208	81,303	130,685	92,925	145,637	103,712	159,625	114,035	173,337
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	466	1,254	547	1,385	640	1,531	743	1,690	858	1,864

TABLE 50

CD FORMAT OPTICAL LIBRARIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY LIBRARY SIZE

	1997 Revenues			Forecast											
	1998			1999			2000			2001					
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
Distributor	.2	.2	2.8	--	.5	3.1	--	.5	3.2	--	.5	3.2	--	.5	3.4
OEM/Integrator	2.8	--	16.1	--	.3	12.9	--	.3	13.6	--	.3	13.6	--	.3	14.5
TOTAL U.S. REVENUES	3.0	.2	18.9	--	.8	16.0	--	.8	16.8	--	.8	16.8	--	.8	17.9
NON-U.S. MANUFACTURERS															
Captive	--	.6	--	--	.9	--	--	.9	--	--	.8	--	--	.8	--
Distributor	16.6	5.7	7.6	15.4	5.3	8.7	13.3	5.7	9.3	13.0	6.2	10.4	12.6	6.7	12.1
OEM/Integrator	6.1	4.1	11.8	5.0	5.1	11.6	4.7	6.2	11.1	5.1	6.9	11.5	5.3	7.1	12.3
TOTAL NON-U.S. REVENUES	22.7	10.4	19.4	20.4	11.3	20.3	18.0	12.8	20.4	18.1	13.9	21.9	17.9	14.6	24.4
WORLDWIDE RECAP															
Captive	--	.6	--	--	.9	--	--	.9	--	--	.8	--	--	.8	--
	--	--	--	--	+50.0%	--	--	--	--	--	-11.1%	--	--	--	--
Distributor	16.8	5.9	10.4	15.4	5.8	11.8	13.3	6.2	12.5	13.0	6.7	13.6	12.6	7.2	15.5
	-47.5%	+25.5%	-28.3%	-8.3%	-1.7%	+13.5%	-13.6%	+6.9%	+5.9%	-2.3%	+8.1%	+8.8%	-3.1%	+7.5%	+14.0%
OEM/Integrator	8.9	4.1	27.9	5.0	5.4	24.5	4.7	6.5	24.7	5.1	7.2	25.1	5.3	7.4	26.8
	-87.2%	-48.7%	+119.7%	-43.8%	+31.7%	-12.2%	-6.0%	+20.4%	+.8%	+8.5%	+10.8%	+1.6%	+3.9%	+2.8%	+6.8%
Total Revenues	25.7	10.6	38.3	20.4	12.1	36.3	18.0	13.6	37.2	18.1	14.7	38.7	17.9	15.4	42.3
	-74.7%	-16.5%	+40.8%	-20.6%	+14.2%	-5.2%	-11.8%	+12.4%	+2.5%	+.6%	+8.1%	+4.0%	-1.1%	+4.8%	+9.3%
ANNUAL SHARE, BY DIAMETER	34.6%	14.2%	51.2%	29.7%	17.6%	52.7%	26.2%	19.8%	54.0%	25.3%	20.6%	54.1%	23.7%	20.4%	55.9%

Note: Headings define number of disks stored per library.

TABLE 51

CD FORMAT OPTICAL LIBRARIES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY LIBRARY SIZE

	1997 Shipments			Forecast											
				1998			1999			2000			2001		
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
Distributor	600	33	275	--	120	317	--	129	327	--	136	334	--	143	347
OEM/Integrator	15,700	--	601	--	85	660	--	90	714	--	97	759	--	105	814
TOTAL U.S. SHIPMENTS	16,300	33	876	--	205	977	--	219	1,041	--	233	1,093	--	248	1,161
NON-U.S. MANUFACTURERS															
Captive	--	80	--	--	120	--	--	110	--	--	106	--	--	100	--
Distributor	86,850	1,313	907	93,205	1,345	1,165	101,800	1,440	1,395	108,700	1,605	1,630	115,100	1,860	1,880
OEM/Integrator	25,300	919	1,630	30,640	1,228	1,800	36,000	1,677	1,955	42,100	2,038	2,120	48,300	2,403	2,285
TOTAL NON-U.S. SHIPMENTS	112,150	2,312	2,537	123,845	2,693	2,965	137,800	3,227	3,350	150,800	3,749	3,750	163,400	4,363	4,165
WORLDWIDE RECAP															
Captive	--	80	--	--	120	--	--	110	--	--	106	--	--	100	--
	--	--	--	--	+50.0%	--	--	-8.3%	--	--	-3.6%	--	--	-5.7%	--
Distributor	87,450	1,346	1,182	93,205	1,465	1,482	101,800	1,569	1,722	108,700	1,741	1,964	115,100	2,003	2,227
	-47.6%	+27.5%	-26.1%	+6.6%	+8.8%	+25.4%	+9.2%	+7.1%	+16.2%	+6.8%	+11.0%	+14.1%	+5.9%	+15.0%	+13.4%
OEM/Integrator	41,000	919	2,231	30,640	1,313	2,460	36,000	1,767	2,669	42,100	2,135	2,879	48,300	2,508	3,099
	-91.9%	-47.4%	+86.7%	-25.3%	+42.9%	+10.3%	+17.5%	+34.6%	+8.5%	+16.9%	+20.8%	+7.9%	+14.7%	+17.5%	+7.6%
Total Shipments	128,450	2,345	3,413	123,845	2,898	3,942	137,800	3,446	4,391	150,800	3,982	4,843	163,400	4,611	5,326
	-81.0%	-16.3%	+22.1%	-3.6%	+23.6%	+15.5%	+11.3%	+18.9%	+11.4%	+9.4%	+15.6%	+10.3%	+8.4%	+15.8%	+10.0%
ANNUAL SHARE, BY DIAMETER	95.8%	1.7%	2.5%	94.9%	2.2%	2.9%	94.7%	2.4%	2.9%	94.6%	2.5%	2.9%	94.4%	2.7%	2.9%

Note: Headings define number of disks stored per library.

CD FORMAT DISK TOWERS

1998 DISK/TREND REPORT

CD FORMAT DISK TOWERS

Coverage

Examples of CD format disk towers in this group include:

Host attached

Advanced Media Services	MAX Tower
Boffin	91-CDX77MJ5, 91-CDRT77
CD International	CDJ2800, CDT4000
Compaq Computer	CD Storage
Cutting Edge	ShareStor-CD/DVD
Excel Computer	CDD-7, CDD-14
JES	2bay, 7bay, 14bay
Kintronics	CDR-P7724-PC, CDR-T1432X-PC
Legacy Storage Systems	LVU07N04X
Meridian Data	CD NetROM 7/7, CD NetROM 28/28
Micro Design International	SECD32XST
Optical Access International	Maxtet/CD, Maxtet/CD Mini
Plextec	CDT-7XX, IDMAX-14XX
Plextor	PT-IXS-32CS-X7, CD-20X7
Procom Technology	7 Plus, 14 Plus, 28 Plus
Rexas	CDRS100, CDRS402
Smart and Friendly	CD Tower, CDJ 35016
SMS Data Products	1070 Tower, 10700P Tower, S70028
TAC Systems	CD Tower, CD MiniTower
Todd Enterprises	VL4, VL14, VL28
Vision Computers	STRADUS

Network attached

Advanced Media Services	CD Server
Allion Computer	CD-Serv/Tower
Atronics	IDEal CDServer
Axonix	CD-Sharer
Boffin	91-IS77, 91-IS2828
CD International	CDS4900, CDS8400, Admiral
Chia Shin	CD-Serve Tower
CMS Enhancements	CD14-32XE
Cutting Edge	AccessStor-CD/DVD
DTS Computer	DP300
Excel Computer	EX-7, Twister 105
Hewlett-Packard	J3277A, J3278A
Kintronics	CDR-P1424-NS, CDR-T5632X-NS
Legacy Storage Systems	Vantage, LKCU07M02F
Meridian Data	TNT Server 2000
Micro Design International	USS-CD17, CD Express Connect
Microtest	DiscPort Enterprise Server
Open Storage Solutions	OpenNet
Optical Access International	Netserve/33X, Netserve/CD

Network attached (continued)

Optics Storage	OPTICS-SERVE
Plextec	CD-LAN-14XX, CDJA-7XX
Plextor	NPA-32-CS-7, PS-20TS-2
Procom Technology	CD FORCE Rax-63, Hyper CD, CCA35-E2
Rexas	CDRS212
SciNet	Series 5000, LS Series
Smart and Friendly	CDD 14032, CD-SmartNet
SMS Data Products	S7007NOV, 1070DP Tower-7
TAC Systems	LANRedi, TowerDrive
TEAC	CD-SERVER
Tekram Technololgy	CS700
Ten X Technology	TenXpert-2/30p
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, now the majority 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. Cached towers, which also include a rigid disk drive to contain multiple CD-ROM images, are a rapidly growing product segment.

Market status

1997 worldwide shipments of CD towers grew 9.8% to 41,197 units, while revenue grew 20.3% to $157.6 million due to the shift to more expensive network attached towers. Shipment growth has slowed in 1998, and revenues are shrinking slightly under competitive pressure and lackluster non-U.S. shipments due to slowing economic conditions outside the U.S. While new entrants are appearing outside the U.S., a period of consolidation among U.S. suppliers seems likely, given the relatively moderate growth and strong competitive pricing.

70.2% of the towers shipped in 1997 had less than 10 drives, followed by the 10 to 25 drive segment with a 22.5% share. Only 7.6% had more than 25 drives. 44.9% of the units shipped in 1997 were host attached, while 55.1% were network

attached. The network attached portion includes cached towers, which accounted for 5.2% of unit shipments. These figures do not include products intended solely or primarily for CD-R duplication, which are not included in this analysis. Captive shipments include towers integrated by Compaq and Hewlett-Packard and sold to end users as part of a complete system.

The U.S. market accounted for 77.2% of the towers shipped and 77.4% of 1997 revenues, down slightly from 1996. U.S. firms accounted for 86.5% of revenues and 84.7% of unit shipments overall, but tended to increase their participation share for the largest subsystems.

Network server modules are provided to tower manufacturers by multiple manufacturers, including Axis Communications, Meridian Data, Creative Design, 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 54,800 units in 2001, while revenues are expected to increase to $204.8 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 implemented in host systems using software. The United States is expected to remain the largest market through 2001, accounting for over 70% of unit shipments.

As expected, unit shipments of network attached towers moved past the host attached segment in 1997, and are expected to account for 83.2% of the towers shipped in 2001. Cached towers (included in the network attached figure) will account for 44.7% of shipments. User demand for better performance, the lower cost and space requirements of cached towers, and the desire of tower manufacturers to generate higher value added content are fueling these shifts.

DVD-ROM drives are beginning to make their appearance in towers, and will appear in an increasing percentage. Some 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.

Because the cost of entry into the tower business is relatively low, suppliers of towers are finding growth more difficult to realize. Since integrators can configure and customize a tower from easily obtained hardware and software components, much of the growth expected by tower makers is being siphoned off by their anticipated customer base.

Applications

CD/DVD 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 significant technical trends are the rapid shift in tower interfaces from host attached to network attached and the ability of the cached tower to displace smaller tower configurations. The changes are driven by the desire to simultaneously improve performance, reduce cost, lower complexity and 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 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 47 gigabyte capacities and new models will be available in the future at an ever decreasing cost per megabyte. A Seagate Elite 47 rigid drive will store the content of over 60 CD-ROM disks or 9 DVD-ROM disks. A computer system equipped with such a drive and a single CD-ROM drive for use as a mailbox device can easily replace a library or tower.

Forecasting assumptions

1. Towers will continue their shift to network attached and cached 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 ever larger capacity rigid disk drives will have a limiting effect on growth during the forecast period.

TABLE 52

CD FORMAT DISK TOWERS

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997 Revenues		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	1.1	2.0	2.8	4.9	2.8	4.8	3.0	5.3	3.9	7.1
Distributor	84.9	98.7	78.5	91.1	86.1	101.0	81.5	99.7	89.0	113.7
OEM/Integrator	45.3	51.2	41.9	45.3	38.2	42.5	43.0	47.6	45.0	49.5
TOTAL U.S. REVENUES	131.3	151.9	123.2	141.3	127.1	148.3	127.5	152.6	137.9	170.3
Non-U.S. Manufacturers										
Distributor	3.8	15.5	3.8	15.5	4.6	16.9	8.0	25.9	7.3	24.3
OEM/Integrator	.8	8.2	.9	8.5	1.0	8.8	.9	8.6	1.0	10.2
TOTAL NON-U.S. REVENUES	4.6	23.7	4.7	24.0	5.6	25.7	8.9	34.5	8.3	34.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	135.9	175.6	127.9	165.3	132.7	174.0	136.4	187.1	146.2	204.8
OEM Average Price ($000)		4.587		4.410		3.898		3.870		3.655

TABLE 53

CD FORMAT DISK TOWERS

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1997 Shipments		Forecast 1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	295	540	830	1,420	843	1,445	900	1,590	980	1,780
Distributor	20,155	23,453	21,549	25,185	23,239	27,206	22,895	27,923	22,850	29,035
OEM/Integrator	9,842	10,923	9,099	9,972	9,745	10,820	11,050	12,218	12,690	13,976
TOTAL U.S. SHIPMENTS	30,292	34,916	31,478	36,577	33,827	39,471	34,845	41,731	36,520	44,791
Non-U.S. Manufacturers										
Distributor	1,331	4,255	1,681	4,943	1,841	5,251	2,303	6,728	2,746	7,681
OEM/Integrator	183	2,026	252	2,228	295	2,340	300	2,305	250	2,360
TOTAL NON-U.S. SHIPMENTS	1,514	6,281	1,933	7,171	2,136	7,591	2,603	9,033	2,996	10,041
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	31,806	41,197	33,411	43,748	35,963	47,062	37,448	50,764	39,516	54,832
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	62	78	95	122	131	169	169	220	208	275

TABLE 54

CD FORMAT DISK TOWERS

WORLDWIDE REVENUES ($M)

BREAKDOWN BY TOWER SIZE

	1997 Revenues			Forecast											
	1998			1999			2000			2001		
	<10	10-25	>25	<10	10-25	>25	<10	10-25	>25	<10	10-25	>25	<10	10-25	>25
U.S. MANUFACTURERS															
Captive	2.0	--	--	4.9	--	--	4.8	--	--	5.3	--	--	7.1	--	--
Distributor	42.7	31.1	24.9	46.0	25.9	19.2	55.1	26.7	19.2	55.6	23.6	20.5	69.9	21.5	22.3
OEM/Integrator	27.3	10.9	13.0	27.0	6.4	11.9	23.7	7.2	11.6	28.1	8.2	11.3	27.3	10.8	11.4
TOTAL U.S. REVENUES	72.0	42.0	37.9	77.9	32.3	31.1	83.6	33.9	30.8	89.0	31.8	31.8	104.3	32.3	33.7
NON-U.S. MANUFACTURERS															
Distributor	6.9	6.2	2.4	7.3	5.6	2.6	8.6	5.5	2.8	14.7	8.2	3.0	12.1	9.1	3.1
OEM/Integrator	2.6	3.5	2.1	2.4	3.8	2.3	2.7	3.7	2.4	2.2	4.0	2.4	3.0	4.8	2.4
TOTAL NON-U.S. REVENUES	9.5	9.7	4.5	9.7	9.4	4.9	11.3	9.2	5.2	16.9	12.2	5.4	15.1	13.9	5.5
WORLDWIDE RECAP															
Captive	2.0	--	--	4.9	--	--	4.8	--	--	5.3	--	--	7.1	--	--
	--	--	--	+145.0%	--	--	-2.0%	--	--	+10.4%	--	--	+34.0%	--	--
Distributor	49.6	37.3	27.3	53.3	31.5	21.8	63.7	32.2	22.0	70.3	31.8	23.5	82.0	30.6	25.4
	+5.1%	-11.2%	-9.3%	+7.5%	-15.5%	-20.1%	+19.5%	+2.2%	+.9%	+10.4%	-1.2%	+6.8%	+16.6%	-3.8%	+8.1%
OEM/Integrator	29.9	14.4	15.1	29.4	10.2	14.2	26.4	10.9	14.0	30.3	12.2	13.7	30.3	15.6	13.8
	+135.4%	+77.8%	+155.9%	-1.7%	-29.2%	-6.0%	-10.2%	+6.9%	-1.4%	+14.8%	+11.9%	-2.1%	--	+27.9%	+.7%
Total Revenues	81.5	51.7	42.4	87.6	41.7	36.0	94.9	43.1	36.0	105.9	44.0	37.2	119.4	46.2	39.2
	+36.1%	+3.2%	+17.8%	+7.5%	-19.3%	-15.1%	+8.3%	+3.4%	--	+11.6%	+2.1%	+3.3%	+12.7%	+5.0%	+5.4%
ANNUAL SHARE, BY DIAMETER	46.5%	29.4%	24.1%	53.1%	25.2%	21.7%	54.6%	24.8%	20.6%	56.7%	23.5%	19.8%	58.4%	22.6%	19.0%

Note: Headings refer to number of CD/DVD drives installed per tower.

TABLE 55

CD FORMAT DISK TOWERS

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY TOWER SIZE

	1997 Shipments			Forecast											
				1998			1999			2000			2001		
	<10	10-25	>25	<10	10-25	>25	<10	10-25	>25	<10	10-25	>25	<10	10-25	>25
U.S. MANUFACTURERS															
Captive	540	--	--	1,420	--	--	1,445	--	--	1,590	--	--	1,780	--	--
Distributor	16,157	5,516	1,780	17,632	5,848	1,705	19,455	5,933	1,818	20,678	5,315	1,930	22,245	4,760	2,030
OEM/Integrator	8,007	1,904	1,012	7,586	1,383	1,003	8,260	1,490	1,070	9,465	1,675	1,078	10,780	2,110	1,086
TOTAL U.S. SHIPMENTS	24,704	7,420	2,792	26,638	7,231	2,708	29,160	7,423	2,888	31,733	6,990	3,008	34,805	6,870	3,116
NON-U.S. MANUFACTURERS															
Distributor	2,964	1,077	214	3,485	1,176	282	3,690	1,235	326	4,485	1,895	348	5,270	2,045	366
OEM/Integrator	1,196	657	173	1,190	801	237	1,195	875	270	1,160	875	270	1,135	960	265
TOTAL NON-U.S. SHIPMENTS	4,160	1,734	387	4,675	1,977	519	4,885	2,110	596	5,645	2,770	618	6,405	3,005	631
WORLDWIDE RECAP															
Captive	540	--	--	1,420	--	--	1,445	--	--	1,590	--	--	1,780	--	--
	--	--	--	+163.0%	--	--	+1.8%	--	--	+10.0%	--	--	+11.9%	--	--
Distributor	19,121	6,593	1,994	21,117	7,024	1,987	23,145	7,168	2,144	25,163	7,210	2,278	27,515	6,805	2,396
	-3.6%	-10.8%	-11.9%	+10.4%	+6.5%	-.4%	+9.6%	+2.1%	+7.9%	+8.7%	+.6%	+6.3%	+9.3%	-5.6%	+5.2%
OEM/Integrator	9,203	2,561	1,185	8,776	2,184	1,240	9,455	2,365	1,340	10,625	2,550	1,348	11,915	3,070	1,351
	+59.0%	+55.7%	+101.5%	-4.6%	-14.7%	+4.6%	+7.7%	+8.3%	+8.1%	+12.4%	+7.8%	+.6%	+12.1%	+20.4%	+.2%
Total Shipments	28,864	9,154	3,179	31,313	9,208	3,227	34,045	9,533	3,484	37,378	9,760	3,626	41,210	9,875	3,747
	+12.6%	+1.3%	+11.5%	+8.5%	+.6%	+1.5%	+8.7%	+3.5%	+8.0%	+9.8%	+2.4%	+4.1%	+10.3%	+1.2%	+3.3%
ANNUAL SHARE, BY DIAMETER	70.2%	22.2%	7.6%	71.7%	21.0%	7.3%	72.4%	20.3%	7.3%	73.7%	19.2%	7.1%	75.3%	18.0%	6.7%

Note: Headings refer to number of CD/DVD drives installed per tower.

TABLE 56

CD FORMAT DISK TOWERS

WORLDWIDE SHIPMENTS (SINGLE UNITS)

HOST/NETWORK ATTACHMENT ANALYSIS

	1997 --Shipments--		Forecast							
			1998		1999		2000		2001	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	540.0		1,420.0		1,445.0		1,590.0		1,780.0	
Host	490.0	90.7%	1,320.0	93.0%	1,205.0	83.4%	1,050.0	66.0%	900.0	50.6%
Network	50.0	9.3%	100.0	7.0%	240.0	16.6%	540.0	34.0%	880.0	49.4%
Noncaptive Total	34,376.0		35,157.0		38,026.0		40,141.0		43,011.0	
Host	14,364.0	41.8%	11,556.0	32.9%	9,485.0	24.9%	7,938.0	19.8%	6,286.0	14.6%
Network	17,873.0	52.0%	18,643.0	53.0%	20,175.0	53.1%	18,200.0	45.3%	16,520.0	38.4%
Cached	2,139.0	6.2%	4,958.0	14.1%	8,366.0	22.0%	14,003.0	34.9%	20,205.0	47.0%
Total U.S.	34,916.0		36,577.0		39,471.0		41,731.0		44,791.0	
Host	14,854.0	42.5%	12,876.0	35.2%	10,690.0	27.1%	8,988.0	21.5%	7,186.0	16.0%
Network	17,923.0	51.4%	18,743.0	51.2%	20,415.0	51.7%	18,740.0	44.9%	17,400.0	38.8%
Cached	2,139.0	6.1%	4,958.0	13.6%	8,366.0	21.2%	14,003.0	33.6%	20,205.0	45.2%
NON-U.S. MANUFACTURERS										
Noncaptive Total	6,281.0		7,171.0		7,591.0		9,033.0		10,041.0	
Host	3,628.0	57.8%	2,930.0	40.9%	2,605.0	34.3%	2,305.0	25.5%	2,005.0	20.0%
Network	2,653.0	42.2%	3,877.0	54.0%	4,366.0	57.5%	4,113.0	45.6%	3,711.0	37.0%
Cached	--	--	364.0	5.1%	620.0	8.2%	2,615.0	28.9%	4,325.0	43.0%
Total Non-U.S.	6,281.0		7,171.0		7,591.0		9,033.0		10,041.0	
Host	3,628.0	57.8%	2,930.0	40.9%	2,605.0	34.3%	2,305.0	25.5%	2,005.0	20.0%
Network	2,653.0	42.2%	3,877.0	54.0%	4,366.0	57.5%	4,113.0	45.6%	3,711.0	37.0%
Cached	--	--	364.0	5.1%	620.0	8.2%	2,615.0	28.9%	4,325.0	43.0%
WORLDWIDE SHIPMENTS										
Total Shipments	41,197.0		43,748.0		47,062.0		50,764.0		54,832.0	
	+9.8%		+6.2%		+7.6%		+7.9%		+8.0%	
Host	18,482.0	44.9%	15,806.0	36.1%	13,295.0	28.3%	11,293.0	22.2%	9,191.0	16.8%
	-2.1%		-14.4%		-15.8%		-15.0%		-18.5%	
Network	20,576.0	49.9%	22,620.0	51.7%	24,781.0	52.7%	22,853.0	45.1%	21,111.0	38.5%
	+10.4%		+9.9%		+9.6%		-7.7%		-7.5%	
Cached	2,139.0	5.2%	5,322.0	12.2%	8,986.0	19.1%	16,618.0	32.7%	24,530.0	44.7%
	--		+148.8%		+68.8%		+84.9%		+47.6%	

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

READ/WRITE OPTICAL DISK LIBRARIES, 1-39 CARTRIDGES

1998 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	M2532B1

5.25" disk diameter

ASM	MO 20
Fujitsu	F6448/JX, M2522/AX
Hewlett-Packard	C1100F, 80ex, 160ex
Hitachi	OL172S-20A
IBM	3995-C20, 3995-C40
Kubota	K2020
Maxoptix	MX620
NEC	N1137-58, OL5120, OL5220
Plasmon Data Systems	M20-520, M32-520
Sony	OSL 2500-15, OSL 2500-25

12" disk diameter

ATG	AC 16000, GF 6910
Cygnet Storage Solutions	1602, ASM-123W
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 are available as of mid-1998. The 12" library segment in this group ranges from the 6 disk Philip LMS unit to Cygnet's 29 disk model. 5.25" libraries are mostly deskside or rack mounted units. They are used with servers, workstations, high end personal computers and in local area networks.

The Philips LMS library, which incorporates a dual head optical drive, enables 16% of its 72 gigabyte capacity to be on-line at all times. Drives included in libraries of this group are largely rewritable or multifunction for 5.25" types, but 12" types are still limited to write-once drives.

Market status

1997 unit shipments declined 20.3% to 8,355 libraries, with all categories falling short of 1996 totals, as manufacturers in this product group struggled against competition from high capacity 5.25" magnetic rigid disk drives capable of storing up to 47 gigabytes at selling prices only a fraction of optical library prices. Competition from automated tape libraries is also a factor in depressing shipments in this product group. Sales revenues for the product group were even more severely impacted in 1997, falling 26.5% to $48.9 million. 62.9% of 1997 revenues and 59% of 1997 shipments were generated by U.S. manufacturers, a slight revenue increase over 1996, but a small shipment decline.

In 1997, Hewlett-Packard was the leading 5.25" library supplier in this product group, while Philips LMS was again the dominant 12" library supplier. 61.9% of 1997 unit shipments were made to U.S. destinations. 34.5% of the unit shipments were made to OEMs, which accounted for 30.7% of total 1997 revenue. Distributors accounted for 52.4% of 1997 revenue. U.S. distributors accounted for over 71% of 1997 distribution revenue, but non-U.S. OEMs were the OEM revenue leaders, capturing 66% of the annual total.

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, and it appears that manufacturers are abandoning the product category pending availability of drives offering more appropriate price, capacity and performance features.

Marketing trends

Because of competition from alternative technologies, unit shipments are expected to decline through 1999, after which time the availability of very high capacity optical drives is expected to revitalize this product group and stimulate shipment increases to nearly 10,700 units in 2001. Revenues are expected to display a similar pattern, closing out the forecast period at $58.8 million. Shipments at the low capacity end of this product group will be increasingly negatively impacted in the future by fixed media magnetic and optical disk drives capable of storing even higher capacities than today's drives offer. This product group

will also see future competition from libraries employing DVD-RAM drives. Because of the unique features of the Philips LMS libraries and future drive capacity increases, only minor year on year shipment erosion is anticipated for 12" libraries.

OEM sales are expected to account for approximately 30% of annual revenues during the forecast period. The OEM price trend is generally downward, but a momentary reversal in 1998 will occur as the result of introduction of new products and manufacturer price increases compensating for reduced shipment levels. Of total worldwide sales revenues of $58.8 million in 2001, 54.3% is expected to be generated by U.S. manufacturers. U.S. manufacturers will generate 49% of unit shipments in the same year. About 62% of the 2001 worldwide library revenues in this group are expected to be generated in the U.S. market, matched by an approximately equal share of unit shipments to the U.S. market.

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 until the new high capacity MO drives can be designed into this product group. Libraries with fewer than 10 cartridges are gone for the time being, and the price/performance capabilities of the Seagate Elite 47 and a horde of high capacity 3.5" drives will only reinforce this trend.

Applications

Optical libraries with single drives, regardless of diameter, are being used in applications where their superior performance relative to tape storage justifies the higher cost per stored megabyte associated with optical disk storage. 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 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.

Technical trends

Libraries in this product group will continue to use 5.25" or 12" drives and media. The impact of the 10 and 20 gigabyte per side 5.25" drives anticipated in 1999 is expected to reignite significant growth, once the libraries are redesigned to accommodate the unconventional cartridge formats anticipated. 3.5" libraries are also likely to reappear, once the new MO technologies are applied to that form factor, but the timing is too uncertain to permit a definite forecast.

The new MO technologies, when available in 3.5" drives, could also create a possible market for a tabletop library with 5 gigabyte or larger media volumes for use in video editing and technical workstation applications. As noted earlier, the major competition to this product group comes from high capacity rigid magnetic disk drives such as the Seagate Elite 47, which offers the capacity of a small optical library at a lower price and with better performance, and from libraries based upon DVD-RAM drives as they become available in 1998 and thereafter.

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.

Network attached libraries, while not yet a major factor in this product group, are anticipated as part of the general trend to network-centric computing systems. Direct network attachment would probably be helpful in increasing the attractiveness of this product group and offsetting its trend to shipment decline. It also seems likely that 3.5" libraries in this group will lean heavily toward direct network attachment when they reappear.

Forecasting assumptions

1. Very high capacity MO drives will not influence this product group until 1999, at which time they will have a positive impact on shipments.

2. The 5.25" format will remain the most commonly used. The reappearance of a 3.5" library in this product group during the forecast period is likely, but its timing and impact cannot be forecasted.

3. Library redesign required to use advanced MO drives and media will be accomplished in a timely manner and will not delay introduction of libraries using the advanced drive technology.

TABLE 57

OPTICAL LIBRARIES, 1-39 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997 Revenues		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	4.6	7.4	3.4	5.7	3.5	5.8	4.2	6.9	4.9	7.9
Distributor	10.8	18.3	9.3	15.9	8.5	14.4	9.0	15.6	9.9	17.4
OEM/Integrator	3.1	5.1	3.1	4.7	2.7	3.9	3.0	4.5	4.2	6.6
TOTAL U.S. REVENUES	18.5	30.8	15.8	26.3	14.7	24.1	16.2	27.0	19.0	31.9
Non-U.S. Manufacturers										
Captive	--	.9	--	1.1	--	1.2	--	1.3	--	1.6
Distributor	5.1	7.3	5.5	8.1	6.4	9.4	7.4	10.9	8.5	12.9
OEM/Integrator	6.9	9.9	7.1	9.7	7.1	9.7	7.9	10.9	8.9	12.4
TOTAL NON-U.S. REVENUES	12.0	18.1	12.6	18.9	13.5	20.3	15.3	23.1	17.4	26.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	30.5	48.9	28.4	45.2	28.2	44.4	31.5	50.1	36.4	58.8
OEM Average Price ($000)		5.203		5.314		4.919		4.843		4.828

TABLE 58

OPTICAL LIBRARIES, 1 - 39 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1997 Shipments		Forecast							
			1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	532	820	484	791	455	760	490	810	565	930
Distributor	976	1,619	952	1,581	955	1,615	1,040	1,740	1,260	2,130
OEM/Integrator	609	841	559	810	540	800	560	845	655	990
TOTAL U.S. SHIPMENTS	2,117	3,280	1,995	3,182	1,950	3,175	2,090	3,395	2,480	4,050
Non-U.S. Manufacturers										
Captive	--	153	--	158	--	160	--	170	--	205
Distributor	660	1,134	720	1,299	790	1,385	880	1,555	1,050	1,855
OEM/Integrator	615	1,295	635	1,331	780	1,600	860	1,755	1,040	2,115
TOTAL NON-U.S. SHIPMENTS	1,275	2,582	1,355	2,788	1,570	3,145	1,740	3,480	2,090	4,175
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,392	5,862	3,350	5,970	3,520	6,320	3,830	6,875	4,570	8,225
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	20	35	23	41	27	48	31	54	35	63

TABLE 59

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1997 Revenues			Forecast							
				1998		1999		2000		2001	
	12-14"	5.25"	3.5"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS											
Captive	--	7.4	--	--	5.7	--	5.8	--	6.9	--	7.9
Distributor	--	18.3	--	--	15.9	--	14.4	--	15.6	--	17.4
OEM/Integrator	--	5.1	--	--	4.7	--	3.9	--	4.5	--	6.6
TOTAL U.S. REVENUES	--	30.8	--	--	26.3	--	24.1	--	27.0	--	31.9
NON-U.S. MANUFACTURERS											
Captive	--	.9	--	--	1.1	--	1.2	--	1.3	--	1.6
Distributor	1.1	6.0	.2	1.1	7.0	1.1	8.3	1.1	9.8	.8	12.1
OEM/Integrator	2.2	7.1	.6	1.9	7.8	1.7	8.0	1.6	9.3	1.4	11.0
TOTAL NON-U.S. REVENUES	3.3	14.0	.8	3.0	15.9	2.8	17.5	2.7	20.4	2.2	24.7
WORLDWIDE RECAP											
Captive	-- --	8.3 -26.5%	-- --	-- --	6.8 -18.1%	-- --	7.0 +2.9%	-- --	8.2 +17.1%	-- --	9.5 +15.9%
Distributor	1.1 -83.6%	24.3 +1.7%	.2 -89.5%	1.1 --	22.9 -5.8%	1.1 --	22.7 -.9%	1.1 --	25.4 +11.9%	.8 -27.3%	29.5 +16.1%
OEM/Integrator	2.2 -77.8%	12.2 -3.2%	.6 +500.0%	1.9 -13.6%	12.5 +2.5%	1.7 -10.5%	11.9 -4.8%	1.6 -5.9%	13.8 +16.0%	1.4 -12.5%	17.6 +27.5%
Total Revenues	3.3 -80.2%	44.8 -6.3%	.8 -60.0%	3.0 -9.1%	42.2 -5.8%	2.8 -6.7%	41.6 -1.4%	2.7 -3.6%	47.4 +13.9%	2.2 -18.5%	56.6 +19.4%
ANNUAL SHARE, BY DIAMETER	6.7%	91.7%	1.6%	6.6%	93.4%	6.3%	93.7%	5.4%	94.6%	3.7%	96.3%

TABLE 60

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1997 Shipments			Forecast							
				1998		1999		2000		2001	
	12-14"	5.25"	3.5"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS											
Captive	--	1,087	--	--	850	--	830	--	980	--	1,130
Distributor	--	2,950	--	--	2,400	--	2,200	--	2,600	--	3,000
OEM/Integrator	--	890	--	--	750	--	650	--	750	--	1,100
TOTAL U.S. SHIPMENTS	--	4,927	--	--	4,000	--	3,680	--	4,330	--	5,230
NON-U.S. MANUFACTURERS											
Captive	--	94	--	--	110	--	115	--	130	--	160
Distributor	59	1,262	20	60	1,484	60	1,660	60	1,960	50	2,400
OEM/Integrator	119	1,644	230	110	1,850	105	2,010	100	2,330	90	2,745
TOTAL NON-U.S. SHIPMENTS	178	3,000	250	170	3,444	165	3,785	160	4,420	140	5,305
WORLDWIDE RECAP											
Captive	--	1,181	--	--	960	--	945	--	1,110	--	1,290
	--	-11.5%	--	--	-18.7%	--	-1.6%	--	+17.5%	--	+16.2%
Distributor	59	4,212	20	60	3,884	60	3,860	60	4,560	50	5,400
	-79.6%	-21.8%	-92.0%	+1.7%	-7.8%	--	-.6%	--	+18.1%	-16.7%	+18.4%
OEM/Integrator	119	2,534	230	110	2,600	105	2,660	100	3,080	90	3,845
	-73.7%	-6.5%	+360.0%	-7.6%	+2.6%	-4.5%	+2.3%	-4.8%	+15.8%	-10.0%	+24.8%
Total Shipments	178	7,927	250	170	7,444	165	7,465	160	8,750	140	10,535
	-76.2%	-15.9%	-16.7%	-4.5%	-6.1%	-2.9%	+.3%	-3.0%	+17.2%	-12.5%	+20.4%
ANNUAL SHARE, BY DIAMETER	2.1%	95.0%	2.9%	2.2%	97.8%	2.2%	97.8%	1.8%	98.2%	1.3%	98.7%

TABLE 61

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1997		Forecast							
	--Shipments--		-----1998----		-----1999----		-----2000----		-----2001----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	1,087.0		850.0		830.0		980.0		1,130.0	
Rewritable	1,087.0	100.0%	850.0	100.0%	830.0	100.0%	980.0	100.0%	1,130.0	100.0%
Noncaptive Total	3,840.0		3,150.0		2,850.0		3,350.0		4,100.0	
Rewritable	3,840.0	100.0%	3,150.0	100.0%	2,850.0	100.0%	3,350.0	100.0%	4,100.0	100.0%
Total U.S.	4,927.0		4,000.0		3,680.0		4,330.0		5,230.0	
Rewritable	4,927.0	100.0%	4,000.0	100.0%	3,680.0	100.0%	4,330.0	100.0%	5,230.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	94.0		110.0		115.0		130.0		160.0	
Rewritable	94.0	100.0%	110.0	100.0%	115.0	100.0%	130.0	100.0%	160.0	100.0%
Noncaptive Total	3,334.0		3,504.0		3,835.0		4,450.0		5,285.0	
Write-Once	178.0	5.3%	170.0	4.9%	165.0	4.3%	160.0	3.6%	140.0	2.6%
Rewritable	3,156.0	94.7%	3,334.0	95.1%	3,670.0	95.7%	4,290.0	96.4%	5,145.0	97.4%
Total Non-U.S.	3,428.0		3,614.0		3,950.0		4,580.0		5,445.0	
Write-Once	178.0	5.2%	170.0	4.7%	165.0	4.2%	160.0	3.5%	140.0	2.6%
Rewritable	3,250.0	94.8%	3,444.0	95.3%	3,785.0	95.8%	4,420.0	96.5%	5,305.0	97.4%
WORLDWIDE SHIPMENTS										
Total Shipments	8,355.0		7,614.0		7,630.0		8,910.0		10,675.0	
	-20.2%		-8.8%		+.2%		+16.8%		+19.8%	
Write-Once	178.0	2.1%	170.0	2.2%	165.0	2.2%	160.0	1.8%	140.0	1.3%
	-76.1%		-4.4%		-2.8%		-2.9%		-12.4%	
Rewritable	8,177.0	97.9%	7,444.0	97.8%	7,465.0	97.8%	8,750.0	98.2%	10,535.0	98.7%
	-15.9%		-8.9%		+.3%		+17.2%		+20.4%	

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

READ/WRITE OPTICAL DISK LIBRARIES, 40 OR MORE CARTRIDGES

1998 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
40 OR MORE CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Asaca	AOL-626, AO-560
ASM	MO 50, PD 100, MO 1000
DISC	D1050-2, D50, D60
DSM GmbH & Co.	5300, 7100
EMASS	AML/J
Fujitsu	F6445/A2X2, M2522/BX
Hewlett-Packard	320ex, 1200ex, C1160F
Hitachi	OL172-48, OL500-270
IBM	3995-C12, 3995-C48
Kubota	K4020
NEC	N7925-84, OL5260, N3661-XX
Plasmon Data Systems	M52-520-X, M104-520
Sony	OSL 6000-25

12"-14" disk diameter

Cygnet Storage Solutions	1800/A2, CASS
DSM GmbH & Co.	48
Eastman Kodak	2000E
FileNet	OSAR 50 GTL

The optical disk libraries in this group are mainstream products for classical library uses in imaging and archiving systems, usually attached to mainframe and midrange/network platforms. The 12" library models are frequently used in multi-user and networked systems because of their ability to keep large amounts of data accessible in minimal time. For the 1998 DISK/TREND Report, this group is the result of combining two previous groups: 40-69 disk libraries and 70 disk or more libraries.

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

1997 Optical disk library shipments in this product group rose .6% to 5,862 units worldwide. The U.S. market accounted for 57.9% of unit shipments and 61.4% of revenues. Overall sales revenues actually grew 7.9% to $173 million, reflecting a larger proportion of higher priced large configuration libraries in the mix. Shipment growth in this product group is difficult to maintain because of the lower cost per megabyte available with tape libraries.

1997 shipments of 5.25" libraries exceeded shipments of 12" libraries by a wide margin, with 5.25" libraries capturing 91.3% of the worldwide total. Although shipments of 12" libraries declined slightly because of customer preferences for larger 5.25" libraries, improved captive shipments of 5.25" libraries more than offset the 12" shipment decline. 12" libraries, only 8.7% of 1997 unit shipments, generated over 34% of product group revenues, as a result of their higher price tags and shipment growth. Hewlett Packard was the leading supplier in this optical disk library product group, followed by Plasmon Data and Hitachi.

Marketing trends

Moderate shipment growth is projected for this product group during the current forecast period, resulting in unit shipments of 8,225 in 2001 and worldwide revenues of $159.6 million, although weakness in revenues is expected until shipment growth is resumed in 2000. Shipments of 12" optical disk libraries are expected to steadily erode, impacted by decreasing participation in the 12" drive and library manufacturing community and increasing capacities available in 5.25" drives. OEM prices will fall steadily as the more expensive 12" libraries form a decreasing share of annual shipments.

Shipment and revenue growth during the forecast interval are heavily weighted towards the end of the period, by which time advanced technology MO drives should be available in quantity and designed into libraries, allowing this product group to compete much more effectively with tape libraries.

Unit shipments to the U.S. in 2001 are expected to represent 55.6% of total worldwide unit shipments, while the U.S. market is forecasted to produce 55.1% of revenues. U.S. firms are expected to capture 49.2% of unit shipments, and 66% of revenues, benefiting from the chance to be early users of new MO drives.

Applications

Archival storage and on-line retrieval of document images are the two primary application areas for these large 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 adoption of advanced MO drives by libraries in this product group starting in 1999 is probably the most significant event anticipated. The new drives, with 10 to 20 gigabyte per side capacity, will increase on-line capacity, permitting the use of fewer drives for a given capacity and reducing the number of required disk mounts. However, libraries will require some degree of redesign to accommodate the protective cartridges used by the new media. Also anticipated are more 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. The libraries in this group will increasingly be available with network attachment capability, a trend to be accelerated by the developing interest in storage area networks and storage servers.

There may be future competition for 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 transaction rates are relatively low and a high degree of data rewriting is not required. 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 existing 5.25" MO drives shipping in 1998, and is expected to move to 4.7 gigabytes in 2000.

Specialized internal controllers are often being 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. Direct attachment of an optical disk library to a local area network and the incorporation of hard disk drive caching 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, though multifunction 5.25" drives using write-once media will tend to displace them over time. 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 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 1999 will restimulate customer interest for products in this group, resulting in stronger growth after a period of marginal gains.
5. DVD-RAM based libraries will have only minor impact on shipments of libraries in this group.

TABLE 62

OPTICAL LIBRARIES, 40 OR MORE CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1997		Forecast							
	Revenues		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	39.8	53.2	27.6	43.2	22.6	36.8	20.5	32.6	19.3	30.1
Distributor	23.9	39.6	22.0	36.4	21.3	36.1	22.9	38.2	27.1	45.7
OEM/Integrator	28.7	37.1	23.5	31.4	20.4	28.8	19.5	28.2	20.1	29.5
TOTAL U.S. REVENUES	92.4	129.9	73.1	111.0	64.3	101.7	62.9	99.0	66.5	105.3
Non-U.S. Manufacturers										
Captive	--	10.4	--	10.3	--	10.0	--	10.3	--	12.1
Distributor	8.0	16.0	8.6	15.5	9.2	15.8	9.9	17.0	11.4	19.6
OEM/Integrator	5.9	16.7	5.6	15.9	8.6	18.6	9.2	19.6	10.7	22.6
TOTAL NON-U.S. REVENUES	13.9	43.1	14.2	41.7	17.8	44.4	19.1	46.9	22.1	54.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	106.3	173.0	87.3	152.7	82.1	146.1	82.0	145.9	88.6	159.6
OEM Average Price ($000)		25.187		22.092		19.750		18.385		16.779

TABLE 63

OPTICAL LIBRARIES, 40 OR MORE CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1997		Forecast							
	Shipments		1998		1999		2000		2001	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	532	820	484	791	455	760	490	810	565	930
Distributor	976	1,619	952	1,581	955	1,615	1,040	1,740	1,260	2,130
OEM/Integrator	609	841	559	810	540	800	560	845	655	990
TOTAL U.S. NONCAPTIVE	1,585	2,460	1,511	2,391	1,495	2,415	1,600	2,585	1,915	3,120
TOTAL U.S. SHIPMENTS	2,117	3,280	1,995	3,182	1,950	3,175	2,090	3,395	2,480	4,050
Non-U.S. Manufacturers										
Captive	--	153	--	158	--	160	--	170	--	205
Distributor	660	1,134	720	1,299	790	1,385	880	1,555	1,050	1,855
OEM/Integrator	615	1,295	635	1,331	780	1,600	860	1,755	1,040	2,115
TOTAL NON-U.S. SHIPMENTS	1,275	2,582	1,355	2,788	1,570	3,145	1,740	3,480	2,090	4,175
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,392	5,862	3,350	5,970	3,520	6,320	3,830	6,875	4,570	8,225
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	20	35	23	41	27	48	31	54	35	63

TABLE 64

OPTICAL LIBRARIES, 40 OR MORE CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1997 Revenues		Forecast							
			1998		1999		2000		2001	
	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS										
Captive	38.0	15.2	29.4	13.8	23.9	12.9	18.6	14.0	13.7	16.4
Distributor	--	39.6	--	36.4	--	36.1	--	38.2	--	45.7
OEM/Integrator	20.3	16.8	14.5	16.9	11.8	17.0	9.6	18.6	7.3	22.2
TOTAL U.S. REVENUES	58.3	71.6	43.9	67.1	35.7	66.0	28.2	70.8	21.0	84.3
NON-U.S. MANUFACTURERS										
Captive	--	10.4	--	10.3	--	10.0	--	10.3	--	12.1
Distributor	.1	15.9	--	15.5	--	15.8	--	17.0	--	19.6
OEM/Integrator	.8	15.9	.6	15.3	.5	18.1	.5	19.1	.5	22.1
TOTAL NON-U.S. REVENUES	.9	42.2	.6	41.1	.5	43.9	.5	46.4	.5	53.8
WORLDWIDE RECAP										
Captive	38.0 +10.1%	25.6 +63.1%	29.4 -22.6%	24.1 -5.9%	23.9 -18.7%	22.9 -5.0%	18.6 -22.2%	24.3 +6.1%	13.7 -26.3%	28.5 +17.3%
Distributor	.1 -88.9%	55.5 +18.3%	-- --	51.9 -6.5%	-- --	51.9 --	-- --	55.2 +6.4%	-- --	65.3 +18.3%
OEM/Integrator	21.1 --	32.7 -20.6%	15.1 -28.4%	32.2 -1.5%	12.3 -18.5%	35.1 +9.0%	10.1 -17.9%	37.7 +7.4%	7.8 -22.8%	44.3 +17.5%
Total Revenues	59.2 +4.8%	113.8 +9.6%	44.5 -24.8%	108.2 -4.9%	36.2 -18.7%	109.9 +1.6%	28.7 -20.7%	117.2 +6.6%	21.5 -25.1%	138.1 +17.8%
ANNUAL SHARE, BY DIAMETER	34.3%	65.7%	29.1%	70.9%	24.8%	75.2%	19.7%	80.3%	13.5%	86.5%

TABLE 65

OPTICAL LIBRARIES, 40 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1997 Shipments		Forecast							
			1998		1999		2000		2001	
	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS										
Captive	233	587	201	590	170	590	140	670	110	820
Distributor	--	1,619	--	1,581	--	1,615	--	1,740	--	2,130
OEM/Integrator	267	574	204	606	175	625	145	700	115	875
TOTAL U.S. SHIPMENTS	500	2,780	405	2,777	345	2,830	285	3,110	225	3,825
NON-U.S. MANUFACTURERS										
Captive	--	153	--	158	--	160	--	170	--	205
Distributor	3	1,131	1	1,298	--	1,385	--	1,555	--	1,855
OEM/Integrator	8	1,287	6	1,325	5	1,595	5	1,750	5	2,110
TOTAL NON-U.S. SHIPMENTS	11	2,571	7	2,781	5	3,140	5	3,475	5	4,170
WORLDWIDE RECAP										
Captive	233	740	201	748	170	750	140	840	110	1,025
	-8.3%	+45.1%	-13.7%	+1.1%	-15.4%	+.3%	-17.6%	+12.0%	-21.4%	+22.0%
Distributor	3	2,750	1	2,879	--	3,000	--	3,295	--	3,985
	-62.5%	+9.7%	-66.7%	+4.7%	--	+4.2%	--	+9.8%	--	+20.9%
OEM/Integrator	275	1,861	210	1,931	180	2,220	150	2,450	120	2,985
	+9.6%	-19.1%	-23.6%	+3.8%	-14.3%	+15.0%	-16.7%	+10.4%	-20.0%	+21.8%
Total Shipments	511	5,351	412	5,558	350	5,970	290	6,585	230	7,995
	-.4%	+.7%	-19.4%	+3.9%	-15.0%	+7.4%	-17.1%	+10.3%	-20.7%	+21.4%
ANNUAL SHARE, BY DIAMETER	8.7%	91.3%	6.9%	93.1%	5.5%	94.5%	4.2%	95.8%	2.8%	97.2%

TABLE 66

OPTICAL LIBRARIES, 40 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

ERASABLE/WRITE-ONCE DRIVE ANALYSIS

	1997		Forecast							
	--Shipments--		-----1998----		-----1999----		-----2000----		-----2001----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	162.0		180.0		190.0		220.0		270.0	
Rewritable	162.0	100.0%	180.0	100.0%	190.0	100.0%	220.0	100.0%	270.0	100.0%
Noncaptive Total	584.0		627.0		660.0		720.0		925.0	
Rewritable	584.0	100.0%	627.0	100.0%	660.0	100.0%	720.0	100.0%	925.0	100.0%
Total U.S.	746.0		807.0		850.0		940.0		1,195.0	
Rewritable	746.0	100.0%	807.0	100.0%	850.0	100.0%	940.0	100.0%	1,195.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	110.0		108.0		105.0		110.0		130.0	
Rewritable	110.0	100.0%	108.0	100.0%	105.0	100.0%	110.0	100.0%	130.0	100.0%
Noncaptive Total	901.0		1,129.0		1,205.0		1,355.0		1,635.0	
Write-Once	4.0	.4%	5.0	.4%	5.0	.4%	5.0	.4%	5.0	.3%
Rewritable	897.0	99.6%	1,124.0	99.6%	1,200.0	99.6%	1,350.0	99.6%	1,630.0	99.7%
Total Non-U.S.	1,011.0		1,237.0		1,310.0		1,465.0		1,765.0	
Write-Once	4.0	.4%	5.0	.4%	5.0	.4%	5.0	.3%	5.0	.3%
Rewritable	1,007.0	99.6%	1,232.0	99.6%	1,305.0	99.6%	1,460.0	99.7%	1,760.0	99.7%
WORLDWIDE SHIPMENTS										
Total Shipments	1,757.0		2,044.0		2,160.0		2,405.0		2,960.0	
	+18.4%		+16.3%		+5.7%		+11.3%		+23.1%	
Write-Once	4.0	.2%	5.0	.2%	5.0	.2%	5.0	.2%	5.0	.2%
	--		+25.0%		--		--		--	
Rewritable	1,753.0	99.8%	2,039.0	99.8%	2,155.0	99.8%	2,400.0	99.8%	2,955.0	99.8%
	+18.1%		+16.3%		+5.7%		+11.4%		+23.1%	

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

CD FORMAT DISK DRIVE SPECIFICATIONS

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.

1998 DISK/TREND optical disk product groups

For the 1998 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: DVD format read-only optical disk drives.
Group 22: CD/DVD format writable optical disk drives.

Read/write optical disk drives:

Group 23: Read/write optical disk drives, less than 4 gigabytes.
Group 24: Read/write optical disk drives, more than 4 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 or more cartridge capacity.

MANUFACTURER		ACER PERIPHERALS	ACER PERIPHERALS	ACER PERIPHERALS	ACER PERIPHERALS	ACER PERIPHERALS
CD FORMAT DRIVE		CD-620A	CD-624A	CD-632A	CD-636A	CD-840A
DISK/TREND GROUP		20	20	20	20	20
MARKET		OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA:	Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE:	Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
	Relative speed: Read	8X-20X	12X-24X	32X	36X	40X
	Relative speed: Write	--	--	--	--	--
	Rotational speed (RPM)	3800	5600			
	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	CAV	CAV
CAPACITY/RECORDING DENSITY						
	Nominal capacity (Gigabytes)	.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)					
	Average access time (msec)	125	125	100	85	85
	Data transfer rate (MBytes/sec) Internal External	1.2-3.0 16.7 PIO Mode 4	1.8-3.6 16.7 PIO Mode 4	4.8 max. 33.3 Ultra DMA	5.4 max. 33.3 Ultra DMA	6.0 max.
SIZE (mm: H x W x D)		42 x 146 x 198	42 x 146 x 198	42 x 146 x 198	42 x 146 x 198	42 x 146 x 198
FIRST CUSTOMER SHIPMENT		3/97	5/97			3Q98
COMMENTS		Philips mechanism.	Philips mechanism.		Philips mechanism.	

MANUFACTURER	ACER PERIPHERALS	ACTIMA	ACTIMA	ACTIMA	AOPEN
CD FORMAT DRIVE	CRW-6206A	24.X	32.X	36.X	CD-924E
DISK/TREND GROUP	22	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	CAPT,OEM,DIST
MEDIA: Recording technology	Phase Change	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-RW	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	6X	24X max.	32X max.	36X max.	24X
Relative speed: Write	2X	--	--	--	--
Rotational speed (RPM)	3180-400				6000
Interface	IDE/ATAPI	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 (Gigabytes)	F: .65	F: .65	F: .65	F: .65	.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)	512				128
Average positioning time (msec)					
Average access time (msec)	300	120	120	120	86
Data transfer rate (MBytes/sec) Internal External	.6 WR/.9 RD	3600 max.	4800 max.	5400 max.	1.8-3.6
SIZE (mm: H x W x D)	42 x 146 x 210	42 x 146 x 197	42 x 146 x 197	42 x 146 x 197	42 x 149 x 196.5
FIRST CUSTOMER SHIPMENT		4Q97	3/98	3Q98	3Q97
COMMENTS					Can read CD-RW media.

MANUFACTURER	AOPEN	AOPEN	AOPEN	AOPEN	AOPEN
CD FORMAT DRIVE	CD-932E	CD-936E	CD-940E	CDS-924E	DVD-9432
DISK/TREND GROUP	20	20	20	20	21
MARKET	CAPT,OEM,DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	DVD-ROM
Relative speed: Read	32X	36X	40X	24X	4X/32X*
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	8000	8000	8700		--
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.782 Mode 2 F: .656 Mode 1	.782 Mode 2 F: .656 Mode 1	.782 Mode 2 F: .656 Mode 1	.748 Mode 2 F: .656 Mode 1	8.5 F: 4.7
Data surfaces per spindle	1	1	1	1	1, 2
Track density (TPI)	15875	15875	15875	15875	34324
Maximum linear density (BPI)	27600	27600	27600	27600	96000
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	128	128	
Average positioning time (msec)					
Average access time (msec)	85	85	85		
Data transfer rate (MBytes/sec) Internal External	4.8	2.4-5.4	2.4-6.0	1.8-3.6	5.52/4.8*
SIZE (mm: H x W x D)	42 x 149 x 196.5	42 x 149 x 196.5	42 x 149 x 196.5	12.7 x 128.7 x 142	41.3 x 146 x 196
FIRST CUSTOMER SHIPMENT	4Q97	1Q98	3Q98	4Q98	4Q98
COMMENTS	Can read CD-RW media.	Can read CD-RW media.		MultiRead.	*CD-ROM mode.

MANUFACTURER	AOPEN	AOPEN	AOPEN	AOPEN	AOPEN
CD FORMAT DRIVE	CD-1420C	CRW-620	CRW-622	CRW-9420	DVD-520S
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Recording technology	Dye Polymer	Phase Change	Phase Change	Phase Change	Phase Change
DRIVE: Drive type	CD-R	CD-RW	CD-RW	CD-RW	DVD-RAM
Relative speed: Read	4X	6X	6X	20X	2X/20X
Relative speed: Write	2X	2X	2X	4X	1X
Rotational speed (RPM)	2120-400			--	--
Interface	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI	SCSI-2
Disk insertion	Caddy	Tray	Tray	Tray	Caddy
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.748 Mode 2 F: .656 Mode 1	.782 Mode 2 F: .656 Mode 1	.782 Mode 2 F: .656 Mode 1	.782 Mode 2 F: .656 Mode 1	F: 2.6/5.2
Data surfaces per spindle	1	1	1	1	1, 2
Track density (TPI)	15875	15875	15875	15875	34324
Maximum linear density (BPI)	27600	27600	27600	27600	62000
PERFORMANCE					
Buffer/cache size (KBytes)	512	1000	1000	1024	2048
Average positioning time (msec)	--/363				
Average access time (msec)	--/390	--/350 RD	--/350 RD		85/120
Data transfer rate (MBytes/sec) Internal External	.3/.6	.3 WR/.9 RD	.3 WR/.9 RD	.6/3.6	10
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	41.3 x 146 x 203	41.3 x 146 x 196
FIRST CUSTOMER SHIPMENT	1996	3Q97	3Q97	4Q98	3Q98
COMMENTS	Ricoh mechanism.	Ricoh mechanism.	Ricoh mechanism.	Ricoh mechanism.	Panasonic mechanism.

MANUFACTURER	ASUSTEK COMPUTER	ASUSTEK COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER
CD FORMAT DRIVE	CD-S340	CD-S400	BCD 24Xmax	BCD 32XH	BCD 36XH
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	34X max.	40X max.	24X	32X	36X max.
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)		8900	5000-200	6800-200	7700-200
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	PCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .650	F: .650	F: .650	.742 Mode 2 F: .650 Mode 1	F: .650
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	128
Average positioning time (msec)					
Average access time (msec)	80	75	105	100	100
Data transfer rate (MBytes/sec) Internal External	2.4-5.1	2.8-6.0	1.6-3.58 16.6 PIO Mode 4	1.9-4.8 16.6 PIO Mode 4	5.4 max. 16.6 PIO Mode 4
SIZE (mm: H x W x D)	41.5 x 149 x 197	41.5 x 149 x 197	42 x 146.5 x 210	42 x 149 x 202	41.3 x 146 x 202
FIRST CUSTOMER SHIPMENT	1Q98	3Q98	1997	1Q98	3Q98
COMMENTS				MultiRead.	MultiRead.

MANUFACTURER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	CALIX TECHNOLOGY
CD FORMAT DRIVE	BCD 40XH	BCD 8X	BCE 621E	BCR 6SR	CR-703L
DISK/TREND GROUP	20	20	22	22	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Phase Change	Dye Polymer	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-RW	CD-R	CD-ROM
Relative speed: Read	40X max.	8X	6X	6X	24X
Relative speed: Write	--	--	2X	2X	--
Rotational speed (RPM)	8500-200	4240-1600			
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
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .650	.635 Mode 2 F: .553 Mode 1	F: .650	.635 Mode 2 F: .553 Mode 1	F: .650
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	1000	1000	128
Average positioning time (msec)		150			
Average access time (msec)	100	180	350	290	100
Data transfer rate (MBytes/sec) Internal External	6.0 16.6 PIO Mode 4	1.2 11.1 PIO Mode 3	.3/.9	.35/1.05	3.6 16.7 PIO Mode 4
SIZE (mm: H x W x D)	42 x 149 x 202	42 x 146 x 201.8	42 x 149 x 213	42 x 149 x 210.5	42 x 146.5 x 204
FIRST CUSTOMER SHIPMENT	3Q98	1996	1997	4Q96	1998
COMMENTS					Manufacturing by Hanpin Electronic Co.

MANUFACTURER	CALIX TECHNOLOGY	CALIX TECHNOLOGY	DELTA ELECTRONICS	DELTA ELECTRONICS	DELTA ELECTRONICS
CD FORMAT DRIVE	CR-703M	CR-801N	OTC-H101	ODE-6121	ODR-6121
DISK/TREND GROUP	20	20	20	22	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Phase Change	Dye Polymer
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-RW	CD-R
Relative speed: Read	32X	36X	32X	6X	4X
Relative speed: Write	--	--	--	2X	2X
Rotational speed (RPM)			6360-6400		3180-400
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .650	F: .650	.740 Mode 2 F: .650 Mode 1	.740 Mode 2 F: .650 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	128, 256 option	1000	
Average positioning time (msec)		100			
Average access time (msec)	100		100	320	370
Data transfer rate (MBytes/sec) Internal External	4.8 16.7 PIO Mode 4	5.4 16.7 PIO Mode 4	4.8 16.7 PIO Mode 4	.3 WR/.9 RD	.9/.3
SIZE (mm: H x W x D)	42 x 146.5 x 204	42 x 146 x 204	41 x 146 x 203	41 x 146 x 203	41 x 146 x 203
FIRST CUSTOMER SHIPMENT	1998	1998	4Q97	1998	3Q97
COMMENTS	Manufacturing by Hanpin Electronic Co.	Manufacturing by Hanpin Electronic Co.	MultiRead.		Philips mechanism.

MANUFACTURER	ELITE PERIPHERAL, INC.	ELITE PERIPHERAL, INC.	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI
CD FORMAT DRIVE	Ultra 24	Ultra 36	C4380A 7210e 7210i CD-Writer +	C4392 8110e 8110i CD-Writer +	CDR-8130
DISK/TREND GROUP	20	20	22	22	20
MARKET	OEM, DIST	OEM, DIST	CAPT,OEM,DIST	CAPT,OEM,DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Phase Change	Phase Change	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-R, CD-RW	CD-R, CD-RW	CD-ROM
Relative speed: Read	24X max.	36X max.	6X	24X	16X
Relative speed: Write	--	--	2X	4X/2X	--
Rotational speed (RPM)			3180-400		4200-3200
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CLV	CLV/CAV	CAV/CLV (PCAV)
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.748 Mode 2 F: .656 Mode 1	.748 Mode 2 F: .656 Mode 1	.682 F: .581	.682 F: .581	.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	1000	1000	128
Average positioning time (msec)	110		290	125/150	82
Average access time (msec)		100	345 WR/310 RD		90
Data transfer rate (MBytes/sec) Internal External	3.8	5.4 max.	.30 WR/.900 RD	.6/.3 WR,3.6 RD	1.2-2.4
SIZE (mm: H x W x D)	42 x 146 x 203	42 x 149 x197	41.5 x 146 x 206	41.5 x 146 x 206	41.3 x 146 x 190
FIRST CUSTOMER SHIPMENT	1998	1998	1Q98	3Q98	1Q97
COMMENTS			7210e is external mount.	8110e is external mount.	MultiRead.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
CD FORMAT DRIVE	CDR-8330	CDR-8430	CDR-S100	GD-2000	GD-3000
DISK/TREND GROUP	20	20	20	21	21
MARKET	OEM, DIST	OEM, DIST	OEM	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM
Relative speed: Read	24X	14X-32X	20X	2X/20X*	5X/
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	5500	7490	4240	3056-1149**	
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	EIDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CLV/CAV*	CAV*/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.742 Mode 2 F: .650 Mode 1	.742 Mode 2 F: .650 Mode 1	.742 Mode 2 F: .650 Mode 1	4.760 F: 8.500	8.5 F: 4.7
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	512/256*	512/256*
Average positioning time (msec)			--	150/100*	
Average access time (msec)	85	80	150	210/130*	
Data transfer rate (MBytes/sec) Internal External	1.5-3.6 16.6 PIO Mode 4	2.1-4.8 16.6 PIO Mode 4	1.2-3.0	2.76/3.0* 16.6	6.9 16.6 PIO Mode 4
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	3Q97	4Q97	3Q97	5/97	1Q99
COMMENTS	MultiRead.			*CD-ROM mode. Dual laser pick up. **4600 CAV for CD-ROM.	DVD-RAM compatible. *CD-ROM mode.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HOPAX INDUSTRIES	HOPAX INDUSTRIES
CD FORMAT DRIVE	GF-1000	GF-1050	GF-1055	HO-824	HO-832
DISK/TREND GROUP	22	22	22	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
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: Read	2X*/8X**	2X*/8X**	2X*/8X**	8X-24X	18X-32X
Relative speed: Write	1X	1X	1X	--	--
Rotational speed (RPM)	1536-582	1536-582	1536-582	4240-4800	4240-6400
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 (Gigabytes)	2.600/ F: 4.700/8.800*	2.600/ F: 4.700/8.800*	2.600/ F: 4.700/8.800*	.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)	34324	34324	34324	15875	15875
Maximum linear density (BPI)	62000	62000	62000	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	1000	1000	1000	256	256
Average positioning time (msec)				110	
Average access time (msec)	210/150**	210/150**	210/150**	120	110
Data transfer rate (MBytes/sec) Internal	1.38/2.76*	1.38/2.76*	1.38/2.76*	1.2-3.6	2.5-4.7
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	50 x 180 x 343	41.5 x 146 x 208	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	3Q98	3Q98	4/98	3Q97	1Q98
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	HOPAX INDUSTRIES	JVC	JVC	KENWOOD	LEOPTICS
CD FORMAT DRIVE	HO-836	XR-S240	XR-W2040 XR-W2042	Z40X	CDD-1240
DISK/TREND GROUP	20	22	22	20	20
MARKET	OEM, DIST	DIST, OEM	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Phase Change	Phase Change	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-RW	CD-RW	CD-ROM	CD-ROM
Relative speed: Read	18X-36X	6X	6X	40X	24X max.
Relative speed: Write	--	2X	2X	--	--
Rotational speed (RPM)	4240-7200	3180-400	3180-400	4500-1800	
Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.650 Mode 2 F: .553 Mode 1	F: .650	F: .580/.680	F: .65	.63 Mode 2 F: .55 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	1000	1000	2000	128
Average positioning time (msec)				70	
Average access time (msec)	85			85	100
Data transfer rate (MBytes/sec) Internal External	2.7-5.4	.9 RD, .3 WR	.3 RD/.9 WR 10.0 synch.	6.0	3.6 max. 16.6 PIO Mode 4
SIZE (mm: H x W x D)	41.5 x 146 x 208	67 x 220 x 265	43 x 149.1 x 208	43 x 149 x 200	41 x 146 x 198
FIRST CUSTOMER SHIPMENT	3Q98	4Q97	4Q97	3Q98	1998
COMMENTS	Purchased mechanisms.	Sold only in Japan.		Zen Research 7 track parallel read head.	MultiRead.

MANUFACTURER	LEOPTICS	LEOPTICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS
CD FORMAT DRIVE	CDD-1320	CDD-3620	CRD-8160B	CRD-8161B	CRD-8240B
DISK/TREND GROUP	20	22	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Phase Change	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-RW	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	32X max.	6x	16X	16X	24X
Relative speed: Write	--	2X	--	--	--
Rotational speed (RPM)		3180-400	4240-3200	4240-3200	5230
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Slot	Tray
Speed control	CAV	CLV	CAV/CLV	CAV/CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.63 Mode 2 F: .55 Mode 1	.63 Mode 2 F: .55 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)	256	1000	128	128	128
Average positioning time (msec)			100	100	90
Average access time (msec)	100	290			
Data transfer rate (MBytes/sec) Internal External	4.8 max. 16.6 PIO Mode 4	.3 WR/.9 RD	2.4	2.4	3.6
SIZE (mm: H x W x D)	41 x 146 x 208	41.5 x 146 x 206	41.5 x 146 x 201	41.5 x 146 x 201	41.5 x 146 x 201
FIRST CUSTOMER SHIPMENT		1998	11/96	3/97	5/97
COMMENTS					

MANUFACTURER	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS
CD FORMAT DRIVE	CRD-8241B	CRN-8241B	CRD-8320B	CRD-8321B	CRD-8322B
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM,DIST,CAPT	OEM, DIST	OEM,DIST,CAPT	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	24X	24X max.	32X max.	32X max.	32X max.
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	5230	5230	6420	6420	6420
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Slot	Powered Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.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	128
Average positioning time (msec)	90	100	80	70	
Average access time (msec)		110	90	80	80
Data transfer rate (MBytes/sec) Internal External	3.6	3.6 max.	4.8 max.	4.8 max.	4.8 max. 16.7 PIO Mode 4
SIZE (mm: H x W x D)	41.5 x 146 x 201	12.7 x 128 x 129	41.4 x 146 x 201	41.4 x 146 x 201	42 x 149 x 208
FIRST CUSTOMER SHIPMENT	8/97	3Q98	11/97	6/98	
COMMENTS		MultiRead.	MultiRead.	MultiRead.	

MANUFACTURER	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS
CD FORMAT DRIVE	CRN-8240B	CRN-8240E	DRD-820B	DRD-840B	CED-8040B
DISK/TREND GROUP	20	20	21	21	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM,DIST,CAPT	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Phase Change
DRIVE: Drive type	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM	CD-RW
Relative speed: Read	24X	12X/7X**	2X/24X*	4X/32X	12X
Relative speed: Write	--	--	--	--	4X/2X (RW)
Rotational speed (RPM)	4240-1600				4230-2400 Read
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CLV/CAV*	CLV/CAV	CLV/CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.690 Mode 2 F: .540 Mode 1	F: .650	F: 4.700/8.750	F: 4.7/8.5	F: .650
Data surfaces per spindle	1	1	1, 2	1, 2	1
Track density (TPI)	15875	15875	34324	34324	15875
Maximum linear density (BPI)	27600	27600	96000	96000	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	256	256	2000
Average positioning time (msec)				100/80	
Average access time (msec)	150	130	150/100*	110/90	150
Data transfer rate (MBytes/sec) Internal External	3.5	1.8/1.05**	2.7/3.6* 16.7 PIO Mode 4	5.4/4.8	.3/.6/1.8*
SIZE (mm: H x W x D)	12.7 x 128 x 129	22.9 x 132.8 x 159	41.5 x 146 x 206	41.5 x 146 x 206	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	11/97	6/98		3Q98	3Q98
COMMENTS	Toshiba connector type. MultiRead.	*With PC card adapter. **Using Notebook power.	*CD-ROM mode. MultiRead.	MultiRead.	*CD-ROM mode. MultiRead.

MANUFACTURER	LITE-ON TECHNOLOGY	LITE-ON TECHNOLOGY	LITE-ON TECHNOLOGY	LITE-ON TECHNOLOGY	LITE-ON TECHNOLOGY
CD FORMAT DRIVE	LTN-301	LTN-341	LTN-382	LTS-422	LTR-511
DISK/TREND GROUP	20	20	20	20	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Phase Change
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-RW
Relative speed: Read	14X-32X	12X-24X	16X-40X	12X-24X	6X
Relative speed: Write	--	--	--	--	2X
Rotational speed (RPM)		6360-4800	8000	6360-4800	3180-400
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	PCAV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.650 Mode 2 F: .553 Mode 1	.650 Mode 2 F: .553 Mode 1	F: .650	F: .650	F: .65
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	1000
Average positioning time (msec)	80	100			
Average access time (msec)			80	100	350
Data transfer rate (MBytes/sec)					
Internal	1950-4800	1.8-3.6	2.4	1.8	.9 RD/.3 WR
External	33 Ultra DMA		6.0	3.6	
SIZE (mm: H x W x D)	41.3 x 145.8 x 190.5	42 x 146 x 191	41.3 x 145.8 x 190.5	12.7 x 128 x 126.9	41.5 x 146 x 203
FIRST CUSTOMER SHIPMENT	12/97	12/97	3Q98	2Q98	1Q98
COMMENTS					

MANUFACTURER	LITE-ON TECHNOLOGY	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LTR-521	CR-172	CR-173-B	CR-505	CR-506
DISK/TREND GROUP	22	20	20	20	20
MARKET	OEM, DIST	OEM	OEM	OEM	OEM
MEDIA: Recording technology	Phase Change	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-RW	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	24X	8.6X-20X	10.4X-24X	8X	8X
Relative speed: Write	4X	--	--	--	--
Rotational speed (RPM)		4240	5460	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	CAV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .650	.748 Mode 2 F: .656 Mode 1	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)	1000	128	128	128	256
Average positioning time (msec)					
Average access time (msec)	300	150	140	193	150
Data transfer rate (MBytes/sec) Internal External	3.6/.6	1.275-3.0 13.3	1.55-3.6 13.3	.914	1.2 5.0
SIZE (mm: H x W x D)	12.7 x 128 x 126.9	12.7 x 128 x 129	12.7 x 128 x 129	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q98	2Q97	2Q98	2Q96	2Q96
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	CR-508-B	CR-582	CR-583	CR-585-B	CR-5850
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	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: Read	10.3X-24X	6X	8X	10.3X-24X	10.3X-24X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	5460	3180-1200	4240-1600	4800	5670
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Slot
Speed control	CAV	CLV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .656	F: .682 Mode 2	F: .656	.748 Mode 2 F: .656 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)	512	128	128	128	128
Average positioning time (msec)					
Average access time (msec)	85	175	150	85	85
Data transfer rate (MBytes/sec)					
Internal	1.55-3.6	.914	1.2	1.55-3.6	1.55-3.6
External	10.0	13.3 PIO Mode 3	13.3 PIO Mode 3	13.3 DMA Mode 1	13.3 PIO Mode 3
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 190	41.3 x 146 x 190
FIRST CUSTOMER SHIPMENT	2Q97	2Q96	2Q96	1Q97	2Q97
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	CR-586-B	CR-587	CR-588	KXL-810AN KXL-810MN	LK-MC606BP LK-MC606BQ
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM	OEM	DIST	DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	14X-32X	10.3X-24X	14X-32X	20X	24X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	7420				
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Top	Tray
Speed control	CAV	CAV	CAV		CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .656 Mode 1	F: .656	F: .656	F: .650	.682 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	128	128		
Average positioning time (msec)					
Average access time (msec)	65	100	100		85
Data transfer rate (MBytes/sec) Internal External	2.1-4.8 16.6 PIO Mode 4	1.55-3.6 13.3 DMA Mode 1	2.1-4.8 16.6 PIO Mode 4	3.0	3.6
SIZE (mm: H x W x D)	41.3 x 146 x 190	41.3 x 146 x 190	41.3 x 146 x 190	24.3 x 130 x 162.8	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q97	1Q98	2Q98	4Q97	2Q97
COMMENTS				MN model is for Macintosh.	

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LK-MC682BP	LK-MC686B LK-MC86BP	LK-RC824AT	LK-RC832TZ	LK-RC924ZZ
DISK/TREND GROUP	20	20	20	20	20
MARKET	DIST	DIST	DIST	DIST	DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	32X	24X	10.3X-24X	32X	10.3X-24X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)					
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV/CLV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .682	.682 Mode 2 F: .540 Mode 1	F: .650	F: .650	F: .650
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
Average positioning time (msec)	65	85		65	
Average access time (msec)			85		85
Data transfer rate (MBytes/sec) Internal External	4.8 16.6 PIO Mode 4	3.6		2.06-4.8	
SIZE (mm: H x W x D)	41.3 x 146 x 190	41.3 x 146 x 203	41.3 x 146 x 196	41.3 x 146 x 196	41.3 x 146 x 196
FIRST CUSTOMER SHIPMENT	4Q97	2Q97	3Q97	2Q98	3Q97
COMMENTS				MultiRead.	External mount.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	UJDA110	UJDA130	UJDA150	LK-RV8581AT	SR-8171
DISK/TREND GROUP	20	20	20	21	21
MARKET	OEM	OEM	OEM	DIST	OEM
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM
Relative speed: Read	20X	20X	24X	1X/6X*	2X/20X*
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)					
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .540	F: .65	F: .540	F: 8.500 F: 4.700	8.500 F: 4.700
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	128	512
Average positioning time (msec)					
Average access time (msec)	150	150	150	270/180*	180/120*
Data transfer rate (MBytes/sec) Internal External	3.0 max.	3.0	3.6 max.	1.38/.9*	1.4-2.8/1.3-3*
SIZE (mm: H x W x D)	12.7 x 128 x 132	9.5 x 128 x 129	12.7 x 128 x 130	41.3 x 146 x 209	12.7 x 128 x 129
FIRST CUSTOMER SHIPMENT	2Q97	7/98	1Q98	1Q97	2Q98
COMMENTS	Pin connector.		Pin connector.	For DOSV PC. *CD-ROM mode. MPEG2 kit. Sold in Japan.	*CD-ROM mode.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	SR-8183-B	SR-8573	SR-8581B	SR-8582B	SR-8583
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM	OEM	OEM	OEM	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	DVD-ROM	DVD-ROM	DVD-ROM	DVD-ROM	DVD-ROM
Relative speed: Read	1.5X/20X*	4X/32X*	1X/6X*	2X/8.6X-20X	5X/
Relative speed: Write	--		--	--	--
Rotational speed (RPM)					
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
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	8.500 F: 4.700	8.500 F: 4.700	8.500 F: 4.700	8.500 F: 4.700	8.5 F: 4.7
Data surfaces per spindle	1, 2	1,2	1, 2	1, 2	1, 2
Track density (TPI)	34324	34324	34324	34324	34324
Maximum linear density (BPI)	96000	96000	96000	96000	96000
PERFORMANCE					
Buffer/cache size (KBytes)	512	512	128	512	512
Average positioning time (msec)					
Average access time (msec)	270/250*	140/90*	270/180*	170/100*	150/100
Data transfer rate (MBytes/sec) Internal External			1.38/.9*	2.76/1.293-3.0* 16.7 PIO Mode 4	6.9 16.7 PIO Mode 4
SIZE (mm: H x W x D)	17.3 x 128 x 137	41.3 x 146 x 190	41.3 x 146 X 209	41.3 x 146 X 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q97			4Q97	4Q98
COMMENTS	*CD-ROM mode. MultiRead.	*CD-ROM mode.	*CD-ROM Mode.	*CD-ROM mode. CD-R & CD-RW compatible.	DVD-RAM compatible. *CD-ROM mode.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	CW-7501	CW-7502-B	CW-7582	LF-1097 LF-1007	LF-1106 LF-1196
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM	OEM	CAPT,DIST,OEM	OEM, DIST
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Phase Change	Ph.Chg.,Replic.
DRIVE: Drive type	CD-R	CD-R	CD-R	PD	PD
Relative speed: Read	4X	8X	8X	24X*	--/8X*
Relative speed: Write	2X	4X	4X	--	
Rotational speed (RPM)	2120-400	4240-800	4240-800	2026	2026/4240-800*
Interface	SCSI-2	SCSI-2	IDE/ATAPI	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 (Gigabytes)	F: .682	F: .656 Mode 1	F: .656 Mode 1	.668 PD F: .540 CD-ROM	.668 PD F: .540 CD-ROM
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	21166/15875*	21166/15875*
Maximum linear density (BPI)	27600	27600	27600	29195/27600*	29195/27600*
PERFORMANCE					
Buffer/cache size (KBytes)	1000/256	1000	1000	640	512
Average positioning time (msec)	222				88/195*
Average access time (msec)	272/250	--/175	1.75	82/78*	102.8
Data transfer rate (MBytes/sec) Internal External	.3 WR/.6 RD	.6 WR/1.2 RD 10.0 synch.	.6 WR/1.2 RD	.52-1.14/.6-.3*	.518-1.41/1.2* 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		41.3 x 146.1 x 196
FIRST CUSTOMER SHIPMENT	1Q96	2Q97	2Q98	1Q98	3Q97
COMMENTS				*For CD-ROM mode.	*For CD-ROM mode.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
CD FORMAT DRIVE	LF-1500EBP	LF-1500J LF-1500JDN	LF-1600	LF-1700	LF-D101 LF-D100J
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, DIST	DIST	CAPT, DIST	CAPT, DIST	OEM, DIST
MEDIA: Recording technology	Phase Change	Ph.Chg.,Replic.	Phase Change	Phase Change	Phase Change
DRIVE: Drive type	PD	PD	PD	PD	DVD-RAM/PD
Relative speed: Read	--/8X*	--/8X*	20X*	24X*	2X/--/20X**
Relative speed: Write	--		--	--	1X*/--
Rotational speed (RPM)	2026/4240-1600*	2026/4240-1600*	2026/5000	2026	
Interface	Parallel	SCSI-2, PCMCIA	SCSI-2	SCSI-2	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Cartridge
Speed control	ZCAV	ZCAV	ZCAV/CLV*	ZCAV/CLV*	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.668 PD F: .650 CD-ROM	.668 PD F: .650	F: .668 PD	F: .668 PD	.668 PD F: 2.600
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	21166/15875*	21166/15875*	21166/15875*	21166/15875*	34324
Maximum linear density (BPI)	29195/27600*	29195/27600*	29195/27600*	29195/27600*	62000
PERFORMANCE					
Buffer/cache size (KBytes)	512	512	640	640	2000
Average positioning time (msec)	88/195*	88			
Average access time (msec)	102.8	1028	82/78*	82/78*	120*/85**/85
Data transfer rate (MBytes/sec) Internal External	.518-1.41/1.2* --	.518-1.141/1.2* 5.0	.52-1.14/.6-.3*	.52-1.14/.6-.3*	1.37/1.41/3.0** 10.0 synch.
SIZE (mm: H x W x D)	35 x 143 x 218	35 x 143 x 218	35 x 143 x 218	35 x 143 x 218	41.3 x 146 x 196
FIRST CUSTOMER SHIPMENT	4Q97	1997	4Q97	2Q98	1Q98
COMMENTS	*For CD-ROM mode.	*For CD-ROM mode. -JDN has PCMCIA interface.	*For CD-ROM mode.	*For CD-ROM mode.	*DVD-RAM mode. **CD-ROM mode. MultiRead.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
CD FORMAT DRIVE	LF-D111	LK-MW602B LK-MW602BP LK-RW602	FX320M	FX332M	SR240S
DISK/TREND GROUP	22	22	20	20	20
MARKET	OEM, DIST	DIST	DIST	OEM	OEM
MEDIA: Recording technology	Phase Change	Dye Polymer	Replication	Replication	Replication
DRIVE: Drive type	DVD-RAM/PD	CD-R	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	2X/--/20X**	4X	13X-32X	15X-32X	24X
Relative speed: Write	1X*/--	2X	--	--	--
Rotational speed (RPM)		2120-200			
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Cartridge	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	PCAV	PCAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.668 PD F: 2.600	.682 Mode 2 .F: 540 Mode 1	F: .540 Mode 1	F: .650	F: .650
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	34324	15875	15875	15875	15875
Maximum linear density (BPI)	62000	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	2000	1000/256	256	256	1000
Average positioning time (msec)		222			
Average access time (msec)	120*/85**/85	270/250	85	75	120
Data transfer rate (MBytes/sec) Internal External	1.37/1.41/3** 16.7 PIO Mode 4	.300/.600 5.0	2.06-4.8	2.25-4.8	3.6
SIZE (mm: H x W x D)	41.3 x 146 x 196	41.3 x 146 x 203	41.3 x 148 x 201	41.3 x 148 x 201	12.7 x 128 x 129
FIRST CUSTOMER SHIPMENT	1Q98	1995	1/98	5/98	5/98
COMMENTS	*DVD-RAM mode. **CD-ROM mode. MultiRead.	--RW602 sold only in Japan.			

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MOUNTAIN OPTECH
CD FORMAT DRIVE	DR200M	CR-2600TE	CR-2801TE	CR-4801TE	CS-680
DISK/TREND GROUP	21	22	22	22	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM
MEDIA: Recording technology	Replication	Dye Polymer	Dye Polymer	Dye Polymer	Replication
DRIVE: Drive type	DVD-ROM	CD-R	CD-R	CD-R	CD-ROM
Relative speed: Read	2X/24X*	6X	8X	8X	8X
Relative speed: Write	--	2X	2X	4X	--
Rotational speed (RPM)		3180-400			2120-800
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control		CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	8.750 F: 4.700	.650 Mode 2 F: .580 Mode 1	.650 Mode 2 F: .580 Mode 1	.650 Mode 2 F: .580 Mode 1	.640 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	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)		1000	512	1000	256
Average positioning time (msec)		220 RD			
Average access time (msec)	150/90*	238	200	200	
Data transfer rate (MBytes/sec) Internal External	2.7/3.8* 16.7 PIO Mode 4	.9 RD/.3 WR	.6 WR/1.2 RD 11.1 PIO Mode 3	.6 WR/1.2 RD 11.1 PIO Mode 3	1.2
SIZE (mm: H x W x D)	41.3 x 146 x 201	41.3 x 146 x 205	41.3 x 146 x 201	41.3 x 146 x 201	
FIRST CUSTOMER SHIPMENT	1Q98	4Q96	1Q98	1Q98	4Q95
COMMENTS	*CD-ROM mode.				

MANUFACTURER	MOUNTAIN OPTECH	NEC	NEC	NEC	NEC
CD FORMAT DRIVE	SE-680 SI-680 ST-680	ODX-658 Multi CD-R	ODX-653P	ODX-654P	ODX-656
DISK/TREND GROUP	20	22	22	22	22
MARKET	OEM	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Phase Change	Phase Change	Phase Change	Phase Change
DRIVE: Drive type	CD-ROM	PD/CD-R	PD	PD	PD
Relative speed: Read	5X	--/20X*	--/6X*	--/6X*	--/8X*
Relative speed: Write	--	--/2X**			
Rotational speed (RPM)	2120-800	2027/1060/4000*	2026/3180-1200*	2026/3180-1200*	2027/4240-1600*
Interface	SCSI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	ZCAV/CAV/CLV	ZCAV/CLV*	ZCAV/CLV*	ZCAV/CLV*
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.640 Mode 2 F: .540 Mode 1	.664 PD F: .650 CD-ROM	.664 PD F: .650 CD-ROM	.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	21116/15875*	21116/15875*	21116/15875*	21116/15875*
Maximum linear density (BPI)	27600	29195/27600*	29195/27600*	29195/27600*	29195/27600*
PERFORMANCE					
Buffer/cache size (KBytes)	256	512/1000*	256	256	256
Average positioning time (msec)			125/160*	125/160*	110/120*
Average access time (msec)		79			150/150*
Data transfer rate (MBytes/sec) Internal External	.75	1.14/.3**/3.0* 5.3/16.4*	.518-1.14/.9*	.518-1.14/.9*	.518-1.14/1.2* 5.1/3.4*
SIZE (mm: H x W x D)		41.3 x 146 x 192	41.3 x 146 x 196	41.3 x 146 x 196	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q95	2Q98	3Q96	3Q96	1Q97
COMMENTS	Ruggedized CD-ROM.	*CD-ROM mode. **CD-R mode. MultiRead.	*CD-ROM mode.	*CD-ROM mode.	*CD-ROM mode.

MANUFACTURER	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS
CD FORMAT DRIVE	CDR-1801A	CDR-1900A	CDR-1901A	CDR-1910A	CDR-2700A
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM,DIST,CAPT	OEM,DIST,CAPT	OEM,DIST,CAPT	OEM,DIST,CAPT
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	10X-24X	14X-32X	14X-32X	14X-32X	8X-20X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	5300	6486	6750	6750	4250
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	Ultra SCSI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.680 Mode 2 F: .540 Mode 1	.680 Mode 2 F: .540 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)	256	256	128	256	128
Average positioning time (msec)	--				
Average access time (msec)	95	75	90	75	150
Data transfer rate (MBytes/sec) Internal External	1.5-3.6 16.6 PIO Mode 4	2.1-4.92	2.1-4.8	2.1-4.8	1.2-3.0
SIZE (mm: H x W x D)	42.8 x 149 x 210	42 x 148 x 209	42 x 148 x 209	42 x 148 x 209	13.8 x 128 x 129
FIRST CUSTOMER SHIPMENT		4Q97	3Q98	1Q98	1Q98
COMMENTS	MultiRead.				

MANUFACTURER	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NORM PACIFIC AUTOMATION	NORM PACIFIC AUTOMATION	NORM PACIFIC AUTOMATION
CD FORMAT DRIVE	CDR-2800A	CDR-3000A	Ultra 24X	Ultra 32X	Ultra 36X
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM,DIST,CAPT	OEM	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	10X-24X	17X-40X	24X	32X	36X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	5300	8350			
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.680 Mode 2 F: .540 Mode 1	.680 Mode 2 F: .540 Mode 1	F: .650	F: .650	F: .650
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)		--			
Average access time (msec)	130	75	110-130	80-90	80-90
Data transfer rate (MBytes/sec) Internal External	1.5-3.6	1.2-3.0 16.6/33.2	3.8 max.	4.8 max.	5.4 max.
SIZE (mm: H x W x D)	13.8 x 128 x 129	42.8 x 149 x 210	42 x 146 x 203	42 x 149 x 202	42 x 149 x 202
FIRST CUSTOMER SHIPMENT	3Q98	1Q98			
COMMENTS		MultiRead.			

MANUFACTURER	OPTICS STORAGE	OPTICS STORAGE	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)
CD FORMAT DRIVE	8622 SCSI Maverick 12X	8841	240D	240S	320D
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	12X	16X max.	24X max.	24X max.	33.3X max.
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	6360-2400		5000-4800	5000-4800	6800
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CAV	ZCLV	ZCLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.635 Mode 2 F: .553 Mode 1	.635 Mode 2 F: .553 Mode 1	.630 Mode 2 F: .540 Mode 1	.630 Mode 2 F: .540 Mode 1	.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)	256*	128	128	128	128
Average positioning time (msec)	150				
Average access time (msec)	160	150	110	110	85
Data transfer rate (MBytes/sec) Internal External	1.8 10.0 synch.	2.4	3.6 max.	3.6 max. 10.0 synch.	5.0 max.
SIZE (mm: H x W x D)	41 x 146 x 195	42.2 x 148.5 x 195	42.5 x 148.5 x 202.5	42.5 x 148.5 x 202.5	42 x 148 x 208.8
FIRST CUSTOMER SHIPMENT	3Q96		3Q97	3Q97	1Q98
COMMENTS	*1 MB option. Purchased mechanism.	Purchased mechanism.			

MANUFACTURER	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)
CD FORMAT DRIVE	321D	322D	361D	362D	CS200D
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	32X max.	32X max.	36X max.	36X max.	20X max.
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	6600	6800	7500	7600	4150-4000
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV	CAV	ZCLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.630 Mode 2 F: .540 Mode 1	.630 Mode 2 F: .540 Mode 1	.630 Mode 2 F: .540 Mode 1	.630 Mode 2 F: .540 Mode 1	.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	128	128	128	128
Average positioning time (msec)					
Average access time (msec)	95	90	95	90	130
Data transfer rate (MBytes/sec) Internal External	4.8 max.	4.8 max.	5.4 max.	5.4 max.	3.0 max.
SIZE (mm: H x W x D)	42 x 148 x 195	42 x 148 x 202.5	42 x 148 x 195	42 x 148 x 202.5	12.7 x 128 x 126.9
FIRST CUSTOMER SHIPMENT	1Q98	3Q98	3Q98	3Q98	2Q98
COMMENTS					

MANUFACTURER	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)	PAN-INTERNATIONAL (CYBERDRIVE)	PHILIPS	PHILIPS
CD FORMAT DRIVE	CS240D	DM-811D	CD RW 602	CD-320	PCA 16SC
DISK/TREND GROUP	20	21	22	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Recording technology	Replication	Replication	Phase Change	Replication	Replication
DRIVE: Drive type	CD-ROM	DVD-ROM	CD-RW	CD-ROM	CD-ROM
Relative speed: Read	24X max.	2X/24X* max.	6.4X max.	32X	12X/16X
Relative speed: Write	--	--	2X	--	--
Rotational speed (RPM)	5000-4800	3200/5500* max.			
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	ZCLV/CAV*	CLV/ZCLV*	CLV		CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.630 Mode 2 F: .540 Mode 1	8.500 F: 4.700	.630 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, 2	1	1	1
Track density (TPI)	15875	34324	15875	15875	15875
Maximum linear density (BPI)	27600	96000	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	512	1024	256	256
Average positioning time (msec)					
Average access time (msec)	125	170/100*	310		110
Data transfer rate (MBytes/sec) Internal External	3.6 max.	2.7/3.6* max.	.3 WR/.96RD max	4.8 max.	1.8-2.4 5.0
SIZE (mm: H x W x D)	12.7 x 128 x 126.9	43 x 146 x 208	41.5 x 146 x 209.5	41.5 x 146 x 198	41.5 x 146 x 198
FIRST CUSTOMER SHIPMENT	3Q98	3Q98	4Q97	4Q97	2Q97
COMMENTS	*New release.	*CD-ROM mode.	MultiRead.	MultiRead.	External mount option.

MANUFACTURER	PHILIPS	PHILIPS	PHILIPS	PHILIPS	PHILIPS
CD FORMAT DRIVE	DRD-5200	CDD 3600	CDD 3610	PCA 362RW	PCA 363RW
DISK/TREND GROUP	21	22	22	22	22
MARKET	DIST	OEM	OEM	DIST	DIST
MEDIA: Recording technology	Replication	Phase Change	Phase Change	Phase Change	Phase Change
DRIVE: Drive type	DVD-ROM	CD-RW	CD-RW	CD-RW	CD-RW
Relative speed: Read	2X/24X*	6X	6X	6X	6X
Relative speed: Write	--	2X	2X	2X	2X
Rotational speed (RPM)		3180-400	3180-400	3180-400	3180-400
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI	Parallel Port
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	8.500 F: 4.700	F: .650 Mode 1	F: .650 Mode 1	F: .650 Mode 1	F: .650 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)	256	1000	1000	1000	1000
Average positioning time (msec)		290	290	290	290
Average access time (msec)	116/110*	345 WR/310 RD	345 WR/310 RD	345 WR/310 RD	345 WR/310 RD
Data transfer rate (MBytes/sec) Internal External	2.7/3.6*	.307 WR/.921 RD 5.0 synch.	.307 WR/.921 RD	.307 WR/.921 RD	.307 WR/.921 RD
SIZE (mm: H x W x D)		41.5 x 146 x 206	41.5 x 146 x 206	41.5 x 146 x 206	
FIRST CUSTOMER SHIPMENT	4Q97	4Q97	2Q97	3Q98	3Q98
COMMENTS	*CD-ROM mode. Bundled MPEG-2 decoder. MultiRead.	Incremental packet writing.	Incremental packet writing.	Incremental packet writing.	Incremental packet writing.

MANUFACTURER	PINNACLE MICRO	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	RCDW 226	DR-316 DR-U16	DR-316S DR-U16S	DR-501S DR-511	DR-504
DISK/TREND GROUP	22	20	20	20	20
MARKET	DIST	DIST, OEM	DIST, OEM	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	6X	14X-36X	14X-36X	24X	32X
Relative speed: Write	2X	--	--	--	--
Rotational speed (RPM)	3180-400	7300	7300		7300
Interface	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Slot	Tray	Tray
Speed control	CLV	CAV	CAV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.681 Mode 2 F: .580 Mode 1	F: .65	F: .65	.650 Mode 2 F: .553 Mode 1	F: .550
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	128	128
Average positioning time (msec)	220	60	60	65	60
Average access time (msec)	225	70	70	75	70
Data transfer rate (MBytes/sec) Internal External	.300/.900 5.0 synch.	2.1-5.4 10.0 synch.	2.1-5.4 10.0 synch.	1.2-3.6	4.8 16.6
SIZE (mm: H x W x D)	41.3 x 146 x 211	41.3 x 148 x 207.5	41.3 x 148 x 207.5	41.3 x 146 x 202	42.3 x 148 x 208.5
FIRST CUSTOMER SHIPMENT	1996	3Q98	3Q98	5/97	1Q98
COMMENTS	Purchased mechanism. External mount option.			Can read CD-RW media.	Can read CD-RW media.

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	DR-506S DR-U06S	DR-533	DR-544 DR-A32X	DR-566	DR-A014S
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	14X-33X	24X	14X-33X	14X-33X	14X-36X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	7420		7420	7420	7300
Interface	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2	IDE/ATAPI
Disk insertion	Slot	Tray	Tray	Tray	Slot
Speed control	CAV	CAV/CLV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.635 Mode 2 F: .540 Mode 1	.650 Mode 2 F: .553 Mode 1	F: .550	F: .550	F: .65
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)	60	65	60	60	60
Average access time (msec)	70	75	70	70	70
Data transfer rate (MBytes/sec) Internal External	4.95 10.0 synch.	1.8-3.6	4.95 10.0	4.95 10.0	2.1-5.4 13.3 PIO Mode 3
SIZE (mm: H x W x D)	41.3 x 146 x 202.5	42.3 x 148 x 208.5	42.3 x 148 x 208.5	42.3 x 148 x 208.5	41.3 x 148 x 207.5
FIRST CUSTOMER SHIPMENT	1Q98		1Q98	1Q98	3Q98
COMMENTS	MultiRead. DR-566 can vertical mount.				

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	DR-A14	DR-U24X	DR-A04S	DRD-134X	DRM-1804X
DISK/TREND GROUP	20	20	20	20	20
MARKET	DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	14X-36X	24X	14X-33X	4.4X	4X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	7300		7420	2332-880	2120-200
Interface	IDE/ATAPI	SCSI	IDE/ATAPI	SCSI-2	SCSI
Disk insertion	Tray	Tray	Slot		
Speed control	CAV	CAV/CLV	CAV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .65	.635 Mode 2 F: .540 Mode 1	.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)	128	128	128	1000	256
Average positioning time (msec)	60	70	60	110	300
Average access time (msec)	70	90	70	128.7	328
Data transfer rate (MBytes/sec) Internal External	2.1-5.4 13.3 PIO Mode 3	3.6	4.95	.66	.614
SIZE (mm: H x W x D)	41.3 x 148 x 207.5	41.3 x 146 x 203	41.3 x 146 x 202.5	41.3 x 146 x 203	198 x 262 x 422
FIRST CUSTOMER SHIPMENT	3Q98	3Q97	1Q98		1994
COMMENTS		Can read CD-RW.	MultiRead.	For use with CD library.	Integral with 18 disk changer

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
CD FORMAT DRIVE	DRM-624X	PCP-PR24	DVD-102 DVD-A02	DVD-302 DVD-U02	DR-R504X
DISK/TREND GROUP	20	20	21	21	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Drive type	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM	CD-R
Relative speed: Read	4.4X	24X	2.6X/20X*	2.6X/20X*	4X
Relative speed: Write	--	--	--	--	
Rotational speed (RPM)	2332-880	5300-2000			2120-800
Interface	SCSI-2	SCSI/EIDE	IDE/ATAPI	SCSI-2	
Disk insertion	Tray	Tray	Slot	Slot	
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .540	F: .540 Mode 1	8.500 F: 4.700	8.500 F: 4.700	F: .550
Data surfaces per spindle	1	1	1, 2	1, 2	1
Track density (TPI)	15875	15875	34424	34424	15875
Maximum linear density (BPI)	27600	27600	96000	96000	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128		512	512	1000
Average positioning time (msec)	70	90	120/80*	120/80*	110
Average access time (msec)	150		150/90*	150/90*	137
Data transfer rate (MBytes/sec) Internal External	.676	1.5	3.51/3.0*	3.51/3.0*	.614
SIZE (mm: H x W x D)	88.3 x 210 x 370		41.3 x 146 x 202.5	41.3 x 146 x 202.5	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	3Q95	2Q98	4Q97		1Q95
COMMENTS		Portable drive.	*CD-ROM mode. Can read CD-RW media.	*CD-ROM mode. Can read CD-RW media.	For use with CD library.

MANUFACTURER	PIONEER	PIONEER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT DRIVE	DVR-S101	DW-S114X	PX-32CS	PX-32TS	PX-R412Ce PX-R412Ci
DISK/TREND GROUP	22	22	20	20	22
MARKET	OEM, DIST	OEM	OEM, DIST	OEM, DIST	DIST
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Replication	Replication	Dye Polymer
DRIVE: Drive type	DVD-R	CD-R	CD-ROM	CD-ROM	CD-R
Relative speed: Read	1X	4X	14X-32X	14X-32X	8X-12X
Relative speed: Write	1X		--	--	4X
Rotational speed (RPM)		2120-800	6890	6890	6360-800
Interface	SCSI-2	SCSI-2	Ultra SCSI	Ultra SCSI	SCSI-2
Disk insertion	Tray	Tray	Caddy	Tray	Caddy*
Speed control	CLV	CLV	CAV	CAV	CLV/PCAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: 3.95	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)	31750	15875	15875	15875	15875
Maximum linear density (BPI)	56000	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	4000	1000	512	512	2000
Average positioning time (msec)		603	80	80	
Average access time (msec)		630	85	85	190
Data transfer rate (MBytes/sec) Internal External	1.428	.614	2.1-4.8 20.0 synch.	2.1-4.8 20.0 synch.	.6 WR/1.8 RD 10.0 synch.
SIZE (mm: H x W x D)	115 x 210 x 399	41.3 x 146 x 203	41.3 x 146 x 202	41.3 x 146 x 202	41.3 x 146 x 205
FIRST CUSTOMER SHIPMENT	1Q98	3Q95	1998	1998	1Q98
COMMENTS			MultiRead.	MultiRead.	Ce model is external mount. *With tray adapter.

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	RICOH	RICOH	RICOH	RICOH
CD FORMAT DRIVE	PX-R412CS	MP6200A	MP6200S	MP6201S	MP6211S
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Dye Polymer	Dye,Phase Chng.	Dye,Phase Chng.	Phase Change	Dye,Phase Chng.
DRIVE: Drive type	CD-R	CD-RW	CD-RW	CD-RW	CD-RW
Relative speed: Read	12X	6X	6X	6X	6X
Relative speed: Write	4X	2X	2X	2X	2X
Rotational speed (RPM)	6360-800	3180-400	3180-400	3180-400	3180-400
Interface	SCSI-2	ATAPI	SCSI-2		SCSI-2
Disk insertion	Caddy	Tray	Tray/Caddy	Caddy	Caddy
Speed control	CLV/PCAV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.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	.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)	2000	2000	2000	2000	2000
Average positioning time (msec)		350 RD	350 RD		350 RD
Average access time (msec)	190	368	368		368
Data transfer rate (MBytes/sec) Internal External	.6 WR/1.8 RD 10.0 synch.	.3 WR/.9 RD 5.0 synch.	.3 WR/.9 RD 5.0 synch.	.3 WR/.9 RD	.3 WR/.9 RD 5.0 synch.
SIZE (mm: H x W x D)	41.3 x 146 x 205	41.3 x 101.6 x 203	41.3 x 101.6 x 203		41.3 x 101.6 x 203
FIRST CUSTOMER SHIPMENT	1998	3/97	3/97	3Q97	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-2431	SCR-2437
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	12X	8X-16X	8X-20X	10X-24X	10X-24X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	6360-2400	NA	NA		
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CAV	CAV		CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .680	F: .680	F: .680	F: .650 Mode 1	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)	256	128	512	512	256
Average positioning time (msec)			90	90	130
Average access time (msec)	150	150			
Data transfer rate (MBytes/sec) Internal	1.8	1.2-2.4	1.2-3.0	1.5-3.6	1.5-3.6
External			16.7 PIO Mode 4	16.7 PIO Mode 4	16.7 PIO Mode 4
SIZE (mm: H x W x D)	42 x 149 x 200	12.7 x 128 x 129	41.3 x 149 x 202	41.5 x 149 x 202	12.7 x 128 x 129
FIRST CUSTOMER SHIPMENT				3Q97	1Q98
COMMENTS			MultiRead.	MultiRead.	MultiRead.

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
CD FORMAT DRIVE	SCR-3230	SCR-831	SDR-230	SDR-430	SCW-230
DISK/TREND GROUP	20	20	21	21	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Phase Change
DRIVE: Drive type	CD-ROM	CD-ROM	DVD-ROM	DVD-ROM	CD-RW
Relative speed: Read	12.8X-32X	8X	2X/20X*	4X/32X*	6X
Relative speed: Write	--	--	--	--	2X
Rotational speed (RPM)		4240-1600			3180-400
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	
Disk insertion	Tray	Tray	Tray	Tray	
Speed control	CAV	CLV			CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .650 Mode 1	F: .680	8.500 F: 4.700	8.500 F: 4.700	F: .650
Data surfaces per spindle	1	1	1, 2	1, 2	1
Track density (TPI)	15875	15875	34324	34324	15875
Maximum linear density (BPI)	27600	27600	96000	96000	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	256	512	512	1000
Average positioning time (msec)	80		150/100	150/100	
Average access time (msec)		150			350
Data transfer rate (MBytes/sec) Internal External	1.92-4.8 16.7 PIO Mode 4	1.2	2.76/3.0* 16.7 PIO Mode 4	5.4/4.8*	.9 RD/.3 WR
SIZE (mm: H x W x D)	41.3 x 149 x 202	42 x 149 x 200	41.5 x 149 x 199	41.5 x 149 x 199	41.5 x 146 x 206
FIRST CUSTOMER SHIPMENT	1Q98	4Q96	2Q98	1998	1Q98
COMMENTS	MultiRead.		*CD-ROM. MultiRead.	*CD-ROM. MultiRead.	

MANUFACTURER	SAMSUNG ELECTRONICS	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC
CD FORMAT DRIVE	SDW-130	CRD-1332P	CRD-820P	CRD-S352	CRD-R24S CRD-RS2000
DISK/TREND GROUP	22	20	20	20	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM
MEDIA: Recording technology	Phase Change	Replication	Replication	Replication	Dye Polymer
DRIVE: Drive type	DVD-RAM	CD-ROM	CD-ROM	CD-ROM	CD-R
Relative speed: Read	1X	13X-32X	20X	10X-24X	4X
Relative speed: Write	1X	--	--	--	2X
Rotational speed (RPM)		6890		5300	2120-800
Interface		IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Disk insertion		Tray	Tray	Tray	Tray
Speed control		CAV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: 2.6	F: .640	F: .640	F: .640	F: .640
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	34324	15875	15875	15875	15875
Maximum linear density (BPI)	62000	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)		128	128	128	
Average positioning time (msec)		100	80	150	300
Average access time (msec)	200				327
Data transfer rate (MBytes/sec) Internal External	1.385 16.6	1.95-4.8	1.2-3.0	1.5-3.6	.600
SIZE (mm: H x W x D)		41 x 146 x 190	41 x 146 x 190	12.7 x 128 x 126.1	41.3 x 146 x 188.5
FIRST CUSTOMER SHIPMENT	2Q98	4Q97	1997	4Q97	
COMMENTS					RS2000 is external mount.

MANUFACTURER	SANYO ELECTRIC	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	CRD-R800S	CDU611	CDU701	CDU711	CSD-880E
DISK/TREND GROUP	22	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM
MEDIA: Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	20X	10X-24X	32X	32X	8X
Relative speed: Write	8X	--	--	--	--
Rotational speed (RPM)		5200	7000	7000	4240-1600
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion		Tray	Tray	Tray	Tray
Speed control		CAV	CAV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .640	F: .656 Mode 1	F: .65	F: .65	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	256	256
Average positioning time (msec)	150				160
Average access time (msec)		90	90	80	174
Data transfer rate (MBytes/sec) Internal	1.2 WR/3.0 RD	3.6-1.5	4.8 16.7PIO/33U.DMA	4.8 16.7PIO/33U.DMA	1.2
External					
SIZE (mm: H x W x D)	42.3 x 148.5 x 191.1	41.4 x 146 x 203	41.4 x 146 x 203	41.4 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1Q98	2Q97	2Q98	4Q97	7/96
COMMENTS					

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	DD-2001 Data Discman	DD-75 Data Discman	PRD-250WN	PRD-650MC PRD-650WN CD-ROM Discman	SCPH1000 Playstation
DISK/TREND GROUP	20	20	20	20	20
MARKET	DIST	DIST	DIST	DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	1X	1X	4X	6X	--
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	500-300	500-300	2120-800	3180-1200	NS
Interface			PCMCIA	PCMCIA	Proprietary
Disk insertion					
Speed control	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .184	F: .184	F: .540	.650 Mode 2 F: .553 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)			128	128	
Average positioning time (msec)	NS	NS	250	280/128*	NS
Average access time (msec)	NS	NS	277		NS
Data transfer rate (MBytes/sec) Internal External	NS	NS	.600	.6/.9*	.300
SIZE (mm: H x W x D)	39 x 160 x 110	39 x 160 x 110	27 x 132 x 172		60 x 270 x 188
FIRST CUSTOMER SHIPMENT	1996	1996	1996	4Q96	4Q94
COMMENTS				Portable. *With PC adapter.	

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
CD FORMAT DRIVE	DDU-100E	DDU-220E DDU-220E/H	CDU526R	CDU924S	CDU928E
DISK/TREND GROUP	21	21	22	22	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Dye Polymer	Dye Polymer	Dye Polymer
DRIVE: Drive type	DVD-ROM	DVD-ROM	CD-R	CD-R	CD-R
Relative speed: Read	1X/8X*	5X/32X*	6X	4X	8X
Relative speed: Write	--	--	2X	2X	2X
Rotational speed (RPM)		7000-2800		1160-400 WR	4240-400
Interface	IDE/ATAPI	IDE/ATAPI		SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray			Caddy
Speed control	CLV	PCAV/CAV*	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: 4.700/8.500	8.5 F: 4.7	F: .650	.650 Mode 2 F: .553 Mode 1	F: .540 Mode 1
Data surfaces per spindle	1, 2	1, 2	1	1	1
Track density (TPI)	34324	34284	15875	15875	15875
Maximum linear density (BPI)	96000	96000	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512	512		1000	512
Average positioning time (msec)				223 RD/245 WR	250
Average access time (msec)		100/75*		250 RD/300 WR	
Data transfer rate (MBytes/sec) Internal External	1.35/1.2* 16.7 PIO Mode 4	6.75/4.8*	.9/.3	.600 4.0 synch.	.3 WR/1.2 RD 16.6 PIO Mode 4
SIZE (mm: H x W x D)	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	1Q97	6/98	3/97	2Q96	2Q97
COMMENTS	*CD-ROM mode. Dual laser pickup.	*CD-ROM mode. E/H model includes MPEG card.	CD-RFS file system.		Packet writing.

MANUFACTURER	SONY	SONY	SONY	SONY	TEAC
CD FORMAT DRIVE	CDU948S CDU948S/CH	CRX-110E/CH CRX-100E/CH Spressa CD-RW	CRX100E/CH Spressa	CSP-9611S Spressa 9611	CD-211PE
DISK/TREND GROUP	22	22	22	22	20
MARKET	OEM, DIST	OEM, DIST	DIST	OEM, DIST	OEM
MEDIA: Recording technology	Dye Polymer	Phase Change	Phase Change	Dye Polymer	Replication
DRIVE: Drive type	CD-R	CD-RW	CD-RW	CD-R	CD-ROM
Relative speed: Read	8X	24X max.	24X	6X	10X
Relative speed: Write	4X	4X CD-R/2X CDRW	2X RW/4X R	2X	--
Rotational speed (RPM)	4240-800	2120/5400		3180-400	4240-2300
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	SCSI-2	PC Card Type 2
Disk insertion	Caddy	Tray	Tray	Caddy	Top
Speed control	CLV	CLV/CAV	CAV*/CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .65	F: .65	F: .65	F: .540 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	27600	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	2000	1000		512	128
Average positioning time (msec)		--			
Average access time (msec)	220	150 (24X)	150		200
Data transfer rate (MBytes/sec) Internal External	4.8	.6/.3/3.6 16.6 PIO Mode 4	3.6*/.6/.3 16.6 PIO Mode 4	.3 WR/.9 RD 10.0 synch.	1.5 16.6 PIO Mode 4
SIZE (mm: H x W x D)				70 x 210 x 293	41.3 x 150.4 x 152.4
FIRST CUSTOMER SHIPMENT		3Q98	3Q98		1997
COMMENTS	CH model includes PCI interface card.	UDF packet writing.	*CD-ROM mode. UDF packet writing.	Packet writing. External mount.	

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
CD FORMAT DRIVE	CD-220E	CD-224E	CD-316E	CD-320E	CD-38E
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	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: Read	8X-20X	24X	8X-16X	8X-20X	8X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	4240-4000		4240-3200		4240-1600
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CAV	CAV/CLV	CAV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	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	.650 Mode 2 F: .535 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	128	128	128
Average positioning time (msec)					190
Average access time (msec)	180	130	200		
Data transfer rate (MBytes/sec) Internal External	1.2-3.0	3.6	1.2-2.4	1.2-3.0	1.2
SIZE (mm: H x W x D)	12.7 x 128 x 130	12.8 x 127 x 130	13.7 x 131 x 140.5	13.7 x 131 x 140.5	13.7 x
FIRST CUSTOMER SHIPMENT	6/97	4Q97	3/97	3Q97	9/96
COMMENTS	For Notebook.	For Notebook.	For Notebook.	For Notebook.	

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
CD FORMAT DRIVE	CD-524E CD-524EA	CD-532E	CD-532S	DV-22E	CD-P520E
DISK/TREND GROUP	20	20	20	21	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Phase Change
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	DVD-ROM	PD
Relative speed: Read	12X-24X	13.8X-32X	13.8X-32X	2X/8X-20X*	--/20X*
Relative speed: Write	--	--	--	--	
Rotational speed (RPM)	6360-4800	7314	7314		
Interface	IDE/ATAPI	IDE/ATAPI	Ultra SCSI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray			Tray	Tray
Speed control	CAV/CLV			CAV/CLV	ZCAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.650 Mode 2 F: .540 Mode 1	.650 Mode 2 F: .540 Mode 1	.650 Mode 2 F: .540 Mode 1	F: 4.7/8.75	F: .650
Data surfaces per spindle	1	1	1	1	1
Track density (TPI)	15875	15875	15875	34324	21116/15875*
Maximum linear density (BPI)	27600	27600	27600	96000	29195/27600*
PERFORMANCE					
Buffer/cache size (KBytes)	128	128	512		
Average positioning time (msec)		85	85		
Average access time (msec)	90			180/150*	98
Data transfer rate (MBytes/sec) Internal External	1.8-3.6	2.07-4.8 16.7 PIO Mode 4	20.0 synch.	2.7/1.2-3.0*	1.2/3.0*
SIZE (mm: H x W x D)	41.3 x 146 x 192			12.7 x 129 x 129	
FIRST CUSTOMER SHIPMENT	6/97	4Q97	4Q97		2Q98
COMMENTS	For Desktop.			*CD-ROM mode. MultiRead.	*CD-ROM mode.

MANUFACTURER	TEAC	TEAC	TEAC	TOSHIBA	TOSHIBA
CD FORMAT DRIVE	CD-P520E Multi CD-R	CD-R55S	PD-518E	XM-1602B	XM-1702B
DISK/TREND GROUP	22	22	22	20	20
MARKET	OEM, DIST	OEM	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Phase Change	Dye Polymer	Phase Change	Replication	Replication
DRIVE: Drive type	PD/CD-R	CD-R	PD	CD-ROM	CD-ROM
Relative speed: Read	--/20X*	12X	8X*	8.5X-20X	10.3X-24X
Relative speed: Write	--/2X**	4X		--	--
Rotational speed (RPM)	2027/2027/4240*	6360-800	4240-1600*	4505-2400	5120
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CLV	ZCAV/CLV	CAV/CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .650	.650 Mode 2 F: .540 Mode 1	F: .650	.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)	21116/15875*	15875	21116/15875*	15875	15875
Maximum linear density (BPI)	29195/27600*	27600	29195/27600*	25400	27600
PERFORMANCE					
Buffer/cache size (KBytes)	512/1000/1000*	1000	128	128	128
Average positioning time (msec)	98		110/115*	125	100
Average access time (msec)		220		135	110
Data transfer rate (MBytes/sec) Internal External	1.3/.3/3.0	.6 WR/1.8 RD	1.2	1.28-3.0 11.1 PIO Mode 3	1.545-3.6 16.7 PIO Mode 4
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 192		12.7 x 128 x 129	12.7 x 128 x 129
FIRST CUSTOMER SHIPMENT		3Q97	5/97	2Q97	4Q97
COMMENTS	*CD-ROM mode. **CD-R mode.	Variable packet writing.	*CD-ROM mode.		

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
CD FORMAT DRIVE	XM-1802B	XM-6102	XM-6201B XM-6201F1	XM-6202B	XM-6202S
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	24X max.	24X	13.8X-32X	13.8X-32X	13.8X-32X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	5120	6360-3200	6900	6900	6900
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Slot
Speed control	CAV	CAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.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	27600	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	128	256	256	256	256
Average positioning time (msec)	100	85	85	78	78
Average access time (msec)	110	90	90	83	83
Data transfer rate (MBytes/sec) Internal External	3.6 max. 16.7 PIO Mode 4	3.6 13.3 PIO Mode 3	2.07-4.8 10.0 synch.	2.07-4.8 16.7 PIO Mode 4	2.07-4.8 16.7 PIO Mode 4
SIZE (mm: H x W x D)	12.7 x 128 x 129	41.1 x 144.5 x 188.2	41.5 x 146 x 193	41.5 x 148 x 193	41.5 x 146 x 190
FIRST CUSTOMER SHIPMENT		2Q97	4Q97	4Q97	4Q97
COMMENTS	MultiRead.	MultiRead.	F1 model is external mount. MultiRead.	MultiRead.	MultiRead.

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
CD FORMAT DRIVE	XM-6302B	SD-C2002	SD-C2102	SD-M1002	SD-M1102
DISK/TREND GROUP	20	21	21	21	21
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Phase Change	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	DVD-ROM	DVD-ROM	DVD-ROM	DVD-ROM
Relative speed: Read	13.8X-32X	2X/16X*	2.4X/20X*	2X/24X*	2X/24X*
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)	6900			1530-570	
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV	CLV	CLV/CAV	CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.635 Mode 2 F: .540 Mode 1	F: 4.700/8.750	F: 4.7/8.5/.65*	F: 4.700/8.750	8.500 F: 4.700
Data surfaces per spindle	1	1, 2	1, 2	1, 2	1, 2
Track density (TPI)	15875	34324	34324	34324	34324
Maximum linear density (BPI)	25400	96000	96000	96000	96000
PERFORMANCE					
Buffer/cache size (KBytes)	256		128	256	256
Average positioning time (msec)	80	110/110*	140/105*	140/110*	110/105*
Average access time (msec)	85	180/120	160/110*	220/120*	165/110*
Data transfer rate (MBytes/sec) Internal External	2.07-4.8 16.7 PIO Mode 4	2.7/2.4* 16.7 PIO Mode 4	3.268/3.0* 16.7 PIO Mode 4	2.7/3.6* 11.1/13.3	1.3-2.7/1.5-3.6 16.7 PIO Mode 4
SIZE (mm: H x W x D)	41.5 x 146 x 193	17 x 133.1 x 128	12.7 x 128 x 129	41.5 x 146 x 192.5	41.5 x 146 x 192.5
FIRST CUSTOMER SHIPMENT		4Q97	6/98	4Q97	
COMMENTS	MultiRead.	*CD-ROM mode.	*CD-ROM mode.	*CD-ROM mode.	*CD-ROM mode. MultiRead.

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	ULTIMA ELECTRONICS (ARTEC)	ULTIMA ELECTRONICS (ARTEC)
CD FORMAT DRIVE	SD-M1202	SD-W1002	SD-W1101	ACD-240	Super-32X
DISK/TREND GROUP	21	22	22	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Phase Change	Phase Change	Replication	Replication
DRIVE: Drive type	DVD-ROM	DVD-RAM	DVD-RAM	CD-ROM	CD-ROM
Relative speed: Read	4.8X/32X*	1X/16X*	2X/16X*	12X - 24X	14X-32X
Relative speed: Write	--	1X	1X		
Rotational speed (RPM)			1028-2400/3516*	0360-4800	6400
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Tray, Caddy	Tray	Tray
Speed control	CAV	CLV	ZCAV	PCAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: 4.7/8.5/.65*	F: 2.600	F: 2.600	.650	.650
Data surfaces per spindle	1, 2	1	1	1	1
Track density (TPI)	34324	34324	34324	15875	15875
Maximum linear density (BPI)	96000	62000	62000	27600	27600
PERFORMANCE					
Buffer/cache size (KBytes)	256	256	256	128	128
Average positioning time (msec)	105/90*	150/130*	150/140*	100	100
Average access time (msec)	135/95*			110	110
Data transfer rate (MBytes/sec)					
Internal	6.535/4.8*	1.35/2.4*	1.3-2.7/2.4	1.8-3.6	2.1-4.8
External	16.7 PIO Mode 4	16.7 PIO Mode 4	10.0 synch.	16.7/33.2	
SIZE (mm: H x W x D)	41.5 x 146 x 193	41.3 x 146 x 203	41.3 x 146 x 203	42 x 148 x 208	42 x 148 x 208
FIRST CUSTOMER SHIPMENT	6/98	1Q98	2Q98	3Q97	1Q98
COMMENTS	*CD-ROM mode.	*CD-ROM mode.	*CD-ROM mode. MultiRead.	MultiRead.	MultiRead.

MANUFACTURER	ULTIMA ELECTRONICS (ARTEC)	ULTIMA ELECTRONICS (ARTEC)	UNITRON	UNITRON	UNITRON
CD FORMAT DRIVE	Super-36X	Super-RW	UCD24J	UCD24N	UCD24S
DISK/TREND GROUP	20	22	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM	OEM, DIST
MEDIA: Recording technology	Replication	Phase Change	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-RW	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	16X-36X		24X	8X-24X	8X-24X
Relative speed: Write			--	--	--
Rotational speed (RPM)	7200		4800-4240	4240-4800	4240-4800
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	CAV/CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.650	.650	F: .660 Mode 1	.635 Mode 2 F: .553 Mode 1	F: .660 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	
Average positioning time (msec)	100				
Average access time (msec)	110		130	170	130
Data transfer rate (MBytes/sec) Internal External	2.4-5.4		3.6	3.6	3.6
SIZE (mm: H x W x D)	43 x 149 x 192			12.7 x 130 x 140	41.5 x 146 x 210
FIRST CUSTOMER SHIPMENT	2Q98	2Q98		6/96	1997
COMMENTS	MultiRead.			For Notebook computer.	Purchased mechanism.

MANUFACTURER	UNITRON	UNITRON	USDRIVES	USDRIVES	USDRIVES
CD FORMAT DRIVE	UCD36J	UCD38J	24DT	24ST	32DY
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	36X	38X	24X max.	24X max.	32X
Relative speed: Write	--	--	--	--	--
Rotational speed (RPM)			5000-4800	5000-4800	
Interface			IDE/ATAPI	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CAV/CLV	CAV/CLV	CAV/CLV	CAV/CLV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	F: .660 Mode 1	F: .660 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)	256	256	128	128	128
Average positioning time (msec)					
Average access time (msec)	90	90	130	130	95
Data transfer rate (MBytes/sec) Internal External	4.8	5.7	3.6	3.6 10.0 synch.	4.8
SIZE (mm: H x W x D)	41.5 x 146 x 210	41.5 x 146 x 210	42.5 x 148.5 x 202.5	42.5 x 148.5 x 202.5	42 x 148 x 195
FIRST CUSTOMER SHIPMENT	1998	1998	3Q97	3Q97	2Q98
COMMENTS			Purchased mechanism.	Purchased mechanism.	Purchased mechanism.

MANUFACTURER	USDRIVES	WEARNES PERIPHERALS	WEARNES PERIPHERALS	WEARNES PERIPHERALS	WEARNES PERIPHERALS
CD FORMAT DRIVE	CDRW620	CDS-24x Max	CDS-32x Max	CDR-622	CDRW-622
DISK/TREND GROUP	22	20	20	22	22
MARKET	DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Phase Change	Replication	Replication	Dye Polymer	Phase Change
DRIVE: Drive type	CD-RW	CD-ROM	CD-ROM	CD-R	CD-RW
Relative speed: Read	6X	12X-24X	14X-32X	6X	6X
Relative speed: Write	2X	--	--	2X	2X
Rotational speed (RPM)	2800-1000	6360-4800	7420-6400	3180-400	3180-400
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 (Gigabytes)	.650 Mode 2 F: .540 Mode 1	.742 Mode 2 F: .650 Mode 1	.742 Mode 2 F: .650 Mode 1	.740 Mode 2 F: .550 Mode 1	.742 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	128/256	128/256	512	
Average positioning time (msec)	290	130	100		
Average access time (msec)					
Data transfer rate (MBytes/sec) Internal External	.3 WR/.9 RD	1.8-3.6 16.7 PIO Mode 4	2.1-4.8 16.7 PIO Mode 4	.3 WR/.9 RD	.3WR/.9 RD
SIZE (mm: H x W x D)	41.5 x 146 x 209.5	42.9 x 149 x 208	42.9 x 149 x 208	42 x 149 x 210.5	42 x 149 x 210.5
FIRST CUSTOMER SHIPMENT	4Q97	1Q97	4Q97	1Q97	4Q97
COMMENTS	Purchased mechanism.		MultiRead.	Packet writing.	UDF packet writing.

MANUFACTURER	YAMAHA	YAMAHA	YAMAHA	YAMAHA	YAMAHA
CD FORMAT DRIVE	CDR400c CDR400c-NB	CDR400t CDR400t-NB CDR400t-VK	CDR400t2 CDR400t2-VK	CRW2216 CRW2216S CRW2216Sx	CRW2260t
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Phase Change	Phase Change
DRIVE: Drive type	CD-R	CD-R	CD-R	CD-RW	CD-RW
Relative speed: Read	6X	6X	6X	16X	6X
Relative speed: Write	4X	4X	4X	2X CDRW/2X CDR	2X/2X (RW)
Rotational speed (RPM)	3180-800	3180-800	3180-800	5300-400	3180-400
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Disk insertion	Caddy	Tray	Tray	Tray	Tray
Speed control	CLV	CLV	CLV	CLV/CAV*	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.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	27600	29870
PERFORMANCE					
Buffer/cache size (KBytes)	2000	2000	2000	1000	1000
Average positioning time (msec)					
Average access time (msec)	250	250	250	160*	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/.3/2.4	.3/.3/.9 4.2 asynch.
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	7/98	4Q97
COMMENTS	Packet writing.	Packet writing.	Packet writing. External mount.	Sx is external mount. *CD-ROM mode.	Packet writing.

MANUFACTURER	YAMAHA	YAMAHA	YAMAHA	YAMAHA	YAMAHA
CD FORMAT DRIVE	CRW4001t CDR4001t-NB	CRW4216E	CRW4216S	CRW4260t CRW4260tx	CRW4261
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Phase Change	Phase Change	Phase Change	Phase Change	Phase Change
DRIVE: Drive type	CD-RW	CD-RW	CD-RW	CD-RW	CD-RW
Relative speed: Read	6X	16X	16X	6X	6X
Relative speed: Write	4X/2X (RW)	2X CDRW/4X CDR	2X CDRW/4X CDR	4X/2X (RW)	4X/2X (RW)
Rotational speed (RPM)	3180-400	5300-400	5300-400	3180-400	3180-400
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI
Disk insertion	Tray	Tray	Tray	Tray	Tray
Speed control	CLV	CLV/CAV*	CLV/CAV*	CLV	CLV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.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	27600	27600	29870	29870
PERFORMANCE					
Buffer/cache size (KBytes)	2000	2000	2000	2000	2000
Average positioning time (msec)					
Average access time (msec)	230	160*	160*	230	230
Data transfer rate (MBytes/sec)					
Internal	.6/.3/.9	.6/.3**/2.4	.6/.3**/2.4	.6/.3/.9	.6/.3/.9
External	5.5	13.3 Synch.	8 Synch	4.2 synch.	5.5 synch.
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 193	41.3 x 146 x 193	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	3Q97	9/98	8/98	4Q97	5/98
COMMENTS	Packet writing.	*CD-ROM Mode. **CD-RW Mode. MultiRead.	*CD-ROM Mode. **CD-RW Mode. MultiRead.	Packet writing. tx is external mount.	Packet writing.

MANUFACTURER	YAMAHA	YAMAHA	YUNG FU (LXYCON)	YUNG FU (LXYCON)	YUNG FU (LXYCON)
CD FORMAT DRIVE	CRW4416E	CRW4416S CRW4416Sx	CDX-2000E	CDX-3200	CDX-3600
DISK/TREND GROUP	22	22	20	20	20
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Recording technology	Phase Change	Phase Change	Replication	Replication	Replication
DRIVE: Drive type	CD-RW	CD-RW	CD-ROM	CD-ROM	CD-ROM
Relative speed: Read	16X	16X	20X max.	32X max.	36X max.
Relative speed: Write	4X	4X	--	--	--
Rotational speed (RPM)	5300-400	5300-400	4240-1600		
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI,PC Cd	IDE/ATAPI	IDE/ATAPI
Disk insertion	Tray	Tray	Top	Tray	Tray
Speed control	CLV/CAV	CLV/CAV	CLV	CAV	CAV
CAPACITY/RECORDING DENSITY					
Nominal capacity (Gigabytes)	.666 Mode 2 F: .540 Mode 1	.666 Mode 2 F: .540 Mode 1	F: .635	F: .635	F: .635
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)	2000	2000	256	256 Max.	256 max.
Average positioning time (msec)			240		
Average access time (msec)	160	160	260	150	150
Data transfer rate (MBytes/sec) Internal External	2.4 max.	2.4 max. 5.5 synch.	3.0	4.8	5.4
SIZE (mm: H x W x D)	41 x 146 x 203	41 x 146 x 203	38 x 135 x 190	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	9/98	9/98	1997	1998	1998
COMMENTS	UDF packet writing.	Sx is external mount. UDF packet writing.	Portable.		

READ/WRITE OPTICAL DISK DRIVE SPECIFICATIONS

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.

1998 DISK/TREND optical disk product groups

For the 1998 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: DVD format read-only optical disk drives.
Group 22: CD/DVD format writable optical disk drives.

Read/write optical disk drives:

Group 23: Read/write optical disk drives, less than 4 gigabytes.
Group 24: Read/write optical disk drives, more than 4 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 or more cartridge capacity.

MANUFACTURER	ATG	ATG	ATG	ATG	ATG
OPTICAL DRIVE	GD 16000	GD 6000	GD 6001	GD 9001	GD 9001/S GD 9001S/E
DISK/TREND GROUP	24	24	24	24	24
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
Direct overwrite	No	No	No	No	No
Interface	SCSI-2	SCSI	SCSI	SCSI, SCSI-2	SCSI, SCSI-2
Speed control	ZCAV	CAV	CAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: 16.0 F: 16.0	F: 3.2	F: 3.2	F: 4.5	F: 5.1
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					
Buffer/cache size (Kbytes)					
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
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
OPTICAL DRIVE	ODW25	System 2000	2512A MOcity	DynaMO 640 PC	DynaMO 640Si
DISK/TREND GROUP	24	24	23	23	23
MARKET	CAPT,OEM,DIST	Captive, OEM	DIST	DIST	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
Direct overwrite	No	No		Yes	Yes
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	MCAV-S	MCAV-S	CAV/ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes)	F: 25.0	F: 7.412	F: .128/.230	F: .640/.540	F: .640/.540
Capacity per disk (Gigabytes)	F: 25.0	F: 14.824	F: .128/.230	F: . 640/.540	F: .640/.540
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					
Buffer/cache size (Kbytes)	8000, 16000	128	256	2000	2000
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.
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.	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
OPTICAL DRIVE	DynaMo 640AI	DynaMo 640SE	DynaMo 640SZI	M2512A DynaMO 230	M2513A Cat-4
DISK/TREND GROUP	23	23	23	23	23
MARKET	DIST	DIST	DIST	OEM, DIST	OEM, DIST
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
Direct overwrite	Yes	Yes	Yes		Yes
Interface	IDE/ATAPI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	ZCAV/CAV*	ZCAV/CAV*	ZCAV/CAV*	CAV/ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes)	F: .640/.540	F: .640/.540	F: .640/.540	F: .128/.230	F: .640/.540
Capacity per disk (Gigabytes)	F: .640/.540	F: .640/.540	F: .640/.540	F: .128/.230	F: .640/.540
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18480	18480	18480	10000/17940	18480/42042
Track density (TPI)	23090	23090	23090	15875/18275	23090
Maximum linear density (BPI)	52900	52900	52900	24400/29300	52900
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Buffer/cache size (Kbytes)	2000	2000	2000	256	2000/512
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	28	28	28	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	38.3	38.3	38.3
Spin-up/Spin-down times (sec)	7/5	7/5	7/5		7/4
Data transfer rate (MBytes/sec)					
Internal	3.9 max.	3.9 max.	3.9 max.	1.3-2.1	2.3-3.9
External	16.6 PIO mode4	10.0 synch.	10.0 synch.	5.0 synch.	5.0/10.0 synch.
SIZE (mm: H x W x D)	23.4 x 101.6 x 160	45 x 126 x 215	25.4 x 101.6 x 160	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	7/98	6/98	6/98	3/94	4/96
COMMENTS	*Read/Write 128 + 230 MB media.	*Read/Write 128 + 230 MB media. External mount.	*Read/Write 128 + 230 MB media.	DynaMO is external subsystem.	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
OPTICAL DRIVE	M2541B DynaMO 230 Portable	M2541BD MicroCat-3	M2541BF Pismo	M2541BS PCMCIA	M2541S MicroMO
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
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
Direct overwrite	Yes				
Interface	IDE	IDE	Power Book	PCMCIA	PCMCIA
Speed control	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV	CAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: .128/.230 F: .128/.230	F: .128/.230 F: .128/.230	F: .128/.230 F: .128/.230	F: .128/.230 F: .128/.230	F: .128/.230 F: .128/.230
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	10000/17940	10000/17940	10000/17940	10000/17940
Track density (TPI)	15875/18275	15875/18275	15875/18275	15875/18275	15875/18273
Maximum linear density (BPI)	24400/29300	24400/29300*	24400/29300*	24400/29300*	24400/29296*
Rotational speed (RPM)	2700	2700	2700	2700	2700
PERFORMANCE					
Buffer/cache size (Kbytes)	128	128	128	128	128(512 option)
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	70	70	65	70	65
Average rotational delay (msec)	11	11.1	11.1	11.1	11
Average access time (msec)	81	81.1	76.1	81.1	76
Spin-up/Spin-down times (sec)	7/6	7/6	7/6	7/6	7/6
Data transfer rate (MBytes/sec) Internal External	.975-1.575 6.0/8.0	1.0-1.6 6.0/8.0	1.0-1.6	1.0-1.6	1.0-1.6 8.0
SIZE (mm: H x W x D)	17 x 101.6 x 140	17.2 x 101.6 x 140	17.2 x 101.6 x 140	25.3 x 113.5 x 164.8	25.3 x 113.5 x 164.8
FIRST CUSTOMER SHIPMENT	10/95	1996	1996	1996	1Q96
COMMENTS	DynaMO is external subsystem.	*2,7 RLL Code.	*2,7 RLL code.	*2,7 RLL Code.	*2,7 RLL Code. Battery pack available.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	HEWLETT-PACKARD
OPTICAL DRIVE	MCB3064SS	MCC3064AP	MCC3064SS	ZEB0	2600fx
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM	OEM	OEM	DIST	OEM, DIST
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Multifunct-(MO)
Direct overwrite	Yes		Yes	Yes	
Interface	SCSI-2	IDE/ATAPI	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV/ZCAV	CAV	CAV/ZCAV	ZCAV	MCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes)	F: .640/.540	F: .540/.640	F: .640/.540	F: .640/.540	F: 1.3
Capacity per disk (Gigabytes)	F: .640/.540	F: .540/.640	F: .640/.540	F: .640/.540	F: 2.6
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18480/42042	18480/42042	18480/42042	18480/42042	75732*
Track density (TPI)	23090	23090	23090	23090	
Maximum linear density (BPI)	52900	52900	52900	52900	
Rotational speed (RPM)	4300	3600	3600	3600	3000/6000**
PERFORMANCE					
Buffer/cache size (Kbytes)	2000	512	2000	2000	1000
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	28	30	28	35	25
Average rotational delay (msec)	7	8.3	8.3	8.3	10
Average access time (msec)	35	38.3	35	43.3	35
Spin-up/Spin-down times (sec)	7/5	7/4	7/5	7/4	5.5/3.0
Data transfer rate (MBytes/sec)					
Internal	4.62 max.	3.9	3.87 max.	3.9	3.4
External	10.0 synch.	10.0 synch.	10.0 synch.	10.0 synch.	
SIZE (mm: H x W x D)	101.6 x 100.0 x 25.4	25.4 x 101.6 x 146	101.6 x 100.0 x 25.4	116 x 60 x 200	
FIRST CUSTOMER SHIPMENT	4Q97	4Q97	4Q97	1997	2/96
COMMENTS	Read/Write compatible with 128/230 MB media.	Read/Write compatible with 128/230 MB media.	Read/Write compatible with 128/230 MB media.	External mount. Sold in Japan.	External mount. *Logical tracks **With lower capacity media. 1,7 RLL Code.

MANUFACTURER	HEWLETT-PACKARD	HITACHI	HITACHI	KONICA	MAXOPTIX
OPTICAL DRIVE	C1113F C1114F	OD172 OU172	OL-F172S/D-21	OMD-9060	T4-1300
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM, DIST	CAPT,OEM,DIST	Captive	OEM, DIST	OEM, DIST
MEDIA: Disk diameter	130 mm	130 mm	130 mm	86 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Multifunct-(MO)
Direct overwrite		Yes	Yes		
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	MCAV	ZCAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: 1.3 F: 2.6	F: 1.304 F: 2.607	F: 1.304 F: 2.607	F: .640 F: .640	F: 65/.51/.32F :1.30/1.02/.65
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	75732*	74883 (logical)	74883 (logical)		37600/25000
Track density (TPI)		23000	23000		18273/16933
Maximum linear density (BPI)		50000*	50000*		29540*
Rotational speed (RPM)	3000/3600**	3000	3000	4500	3000
PERFORMANCE					
Buffer/cache size (Kbytes)	1000	1000	1000	2000	1024
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	25	39	39		39
Average rotational delay (msec)	10	10	10		10
Average access time (msec)	35	49	49		49
Spin-up/Spin-down times (sec)	5.5/3.0	7.5/4.5	5.0/2.5		7.6/4.5
Data transfer rate (MBytes/sec) Internal External	3.4	2.3-4.6 10.0 synch.	2.3-4.6 10.0 synch.		2.0 4.0 synch.
SIZE (mm: H x W x D)		41.3 x 146 x 203.7	82.5 x 146 x 203.2	25.4 x	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	2/96	4Q95	1Q96	2Q98	1/95
COMMENTS	*Logical tracks **With lower capacity media. 1,7 RLL Code.	*1,7 RLL Code. OU is external mount.	*1,7 RLL Code.		*2,7 RLL Code.

MANUFACTURER	MAXOPTIX	MAXOPTIX	MAXOPTIX	MOUNTAIN OPTECH	MOUNTAIN OPTECH
OPTICAL DRIVE	T4-2600	T5-2600	T6-5200	CS-250 R/W SE-250 R/W SI-250 R/W ST-250 R/W	CS-2600 SE-2600 SEL-2600 ST-2600
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	86 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Rewritable
Direct overwrite			Yes		
Interface	SCSI-2	SCSI-2	Ultra SCSI	SCSI	SCSI
Speed control	CAV	CAV	ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: 1.30/.65/.32 F:2.61/1.30/.64	F: 1.30/.65/.32 F:2.61/1.30/.64	.32/.65/1.3/2.6 .65/1.3/2.6/5.2	F: .230	F: .33/.65/1.30 F:.65/1.30/2.6
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	26010*	26010*	35294	11510/17853*	74883 (logical)
Track density (TPI)	22100	22100	29780	18273	23000
Maximum linear density (BPI)	51000	51000	63140	29540	50000
Rotational speed (RPM)	3000	3868	2942	3600	3375-4800
PERFORMANCE					
Buffer/cache size (Kbytes)	1024	1024	4000	64	1024
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	39	20	20	40	39
Average rotational delay (msec)	10	7.7	10.2	8.3	10
Average access time (msec)	49	27.7	30.2	48.3	49
Spin-up/Spin-down times (sec)	7.6/4.5	4.5/2.5	3.5/1.9		7.5/4.5
Data transfer rate (MBytes/sec) Internal External	3.37 10.0 synch.	4.6 10.0 synch.	2.85 - 5.9 20 synch.	1.475 max.	5.0 synch.
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146.1 x 203.2	44.5 x 117.5 x 206.4	41.9 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	4Q95	2Q97	5/98	1Q95	1996
COMMENTS	*75735 logical tracks.	*75735 logical tracks.		Ruggedized. *Logical tracks CS-250 is commercial version.	Rack mount and external mount options.

MANUFACTURER	MOUNTAIN OPTECH	NEC	NEC	NEC	NIKON
OPTICAL DRIVE	CS-2600X2 ST-2600X2	N1137-57 N7915-85 ODD-155 PC-OD502	ODD-160	N6513-23 N7913	DD53-B1 DD53-S1
DISK/TREND GROUP	23	23	23	24	23
MARKET	OEM	Captive	OEM	Captive	OEM, DIST
MEDIA: Disk diameter	130 mm	130 mm	130 mm	300 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Ablative	Magneto-Optic*
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Write Once	Rewritable
Direct overwrite		No	Yes	No	Yes
Interface	SCSI	SCSI	SCSI-2	Prop., SCSI	SCSI-2
Speed control	ZCAV	ZCAV	ZCAV	MCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: .33/.65/1.30 F:.65/1.30/2.6	F: .65/.325 F: 1.3/.65	F: 1.3 F: 2.6	F: 2.5 F: 2.5	F: .33/.65/1.30 F:.65/1.30/2.6
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	74883 (logical)	21600*	2600	49000	23050/75375**
Track density (TPI)	23000	18273	21200	16940	23000
Maximum linear density (BPI)	50000	29540	51000	25000	50000
Rotational speed (RPM)	3375-4800	4200/3000	3000	600	3600
PERFORMANCE					
Buffer/cache size (Kbytes)	1024	1000	4000		4000
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	39	32	35	150	24
Average rotational delay (msec)	10	10/7	10	50	8.3
Average access time (msec)	49	42/39	45	200	32.3
Spin-up/Spin-down times (sec)	7.5/4.5		2.5		3.5/2.9
Data transfer rate (MBytes/sec) Internal External	5.0 synch.	1.94	1.69-3.38	.900	2.0/4.0 10.0
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
FIRST CUSTOMER SHIPMENT	1996	3Q93	1Q96	6/90	1Q97
COMMENTS	2 drives in enclosure.	*37600 logical tracks. ODD-155 is external pkg. Purchased mechanism.	2 beam head. 1 cycle write.		*LIM-DOW. **Logical tracks.

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
OPTICAL DRIVE	230MO Plus* 230MO Turbo	640MO Turbo	MOS330E MOS330S MOS331E* MOS331S*	MOS341E	MOS350E
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM, DIST	DIST	OEM	OEM	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
Direct overwrite		Yes		Yes	Yes
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV	CAV/ZCAV	CAV/ZCAV	CAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: .230/.128	F: .540/.640	F: .230/.128	F: .540/.640	F: .540/.640 F: .540/.640
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11500	18480	11500**	18480	18480
Track density (TPI)	18273	23090	18273	23090	23090
Maximum linear density (BPI)	29300	52900	29300	52900	52900
Rotational speed (RPM)	4200	3600	4200	3600	4335
PERFORMANCE					
Buffer/cache size (Kbytes)	1000*	2000	256, 1000*	2000	2000
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	28	28	27	28	27
Average rotational delay (msec)	7.1	8.3	7.1	8.3	6.9
Average access time (msec)	35.1	36.3	34.1	36.3	34
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.	1.8-3.0 5.5 synch.	.920-3.5 6.7
SIZE (mm: H x W x D)		35 x 123 x 218	25.4 x 101.6 x 153.5	25.4 x 101.6 x 153.5	25.4 x 101.6 x 158
FIRST CUSTOMER SHIPMENT	10/94	1997	2Q96	2Q96	2Q98
COMMENTS	*Includes cache		*1 MB optional. **37600 logical tracks.		

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
OPTICAL DRIVE	MOS520E MOS520S	MOS525E	MOS540E	PowerMO 2600	PowerMO 640 640MO Turbo Black/White
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM	OEM	OEM, DIST	DIST	DIST
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
Direct overwrite					Yes
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control	CAV/ZCAV	ZCAV	CAV/ZCAV	CAV/ZCAV**	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes) Capacity per disk (Gigabytes)	F: .650/.325	F: .595/.650*	F: .33/.65/1.3 F:.65/1.31/2.6	F: .33/.68/1.3 F:.65/1.3/2.6	F: .540/.640 F: .540/.640
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18750*	21600**	26040*	26040*	18480
Track density (TPI)	18273/15875	18273	22030	22030	23090
Maximum linear density (BPI)	31005/27597	29540	31500	31500	52900
Rotational speed (RPM)	3000/4500	3500	3600	3600	4335
PERFORMANCE					
Buffer/cache size (Kbytes)	1000**	1000***	4000	4000	2000
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	6.9
Average access time (msec)	66/60.67	37.57	34.3	34.3	34
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.	.920-3.5 6.7
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	43 x 136 x 217
FIRST CUSTOMER SHIPMENT	11/93	5/94	1Q96		2Q98
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.	Not sold in US. External mount.

MANUFACTURER	OLYMPUS	PHILIPS LMS	PINNACLE MICRO	PIONEER	PIONEER
OPTICAL DRIVE	SYS.230	LD 6100	Apex	DE-SH2200 DE-UH2200	DE-SH7101 DE-UH7101
DISK/TREND GROUP	23	24	24	23	23
MARKET	DIST	OEM, DIST	OEM	OEM, DIST	OEM
MEDIA: Disk diameter	86 mm	300 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Ablative	Magneto-Optic	Magneto-Optic	MO/Dye Polymer
DRIVE: Operating mode	Rewritable	Write Once	Multifunct-(MO)	Rewritable	Multifunction
Direct overwrite		No	Yes		
Interface	SCSI-2,Prt.Port	SCSI-2	SCSI-2/HPAC	SCSI	SCSI
Speed control	CAV/ZCAV**	CAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes)	F: .128/.230	F: 12.000	F: 1.3/2.286**	F: 1.1	F: .327
Capacity per disk (Gigabytes)	F: .128/.230		F: 1.61/4.57**	F: 2.2	F: . 654
Data surfaces per spindle	1	2	1	1	1
Tracks per surface	11500*	63000	36300 (user)		19958
Track density (TPI)	18273	NS	25400		15875
Maximum linear density (BPI)	29300	NS	63342*		15875
Rotational speed (RPM)	4200	858	3755/2400**	3000	2400
PERFORMANCE					
Buffer/cache size (Kbytes)	256	2000	1000		64
Servo type	Continuous	Sampled	Continuous	Sampled	Sampled
Average positioning time (msec)	27	65	19/21**	42	53
Average rotational delay (msec)	7.1	35	8/12.5**	10	12.5
Average access time (msec)	34.1	100	27/33.5**	52	65.5
Spin-up/Spin-down times (sec)		3/1.5	3/2		
Data transfer rate (MBytes/sec)					
Internal	2.4	2.7 RD/1.3 WR	4.3/3.5**	5.3	.635
External		10.0 synch.	10.0 synch.	1.4-2.6	2.4
SIZE (mm: H x W x D)	50.4 x 152.4 x 203.2	178 x 475 x 683	41 x 146 x 210.3	41.3 x 147 x 203	41.3 x 146 x 203.2
FIRST CUSTOMER SHIPMENT		2Q95	4Q96	1Q95	2Q93
COMMENTS	*37600 logical tracks. **At highest capacity. External mount.	Dual head drive	*1,7 RLL Code. **At highest capacity.	DE-SH2200 is external mount.	DE-SH7101 is external mount.

MANUFACTURER	PIONEER	SONY	SONY	SONY	SONY
OPTICAL DRIVE	DE-SH9101 DE-UH9101	CMO-N540-10 CMO-R540-10	CMO-N540-40 CMO-R540-40	RMO-S591 RMO-S594	RMO-S594/DWP
DISK/TREND GROUP	23	23	23	23	23
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	MO/Dye Polymer	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunction	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Rewritable
Direct overwrite					Yes
Interface	SCSI	SCSI-2	SCSI-2	SCSI-2	
Speed control	CAV	ZCAV	ZCAV	ZCAV	CAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes)	F: .850/.327	F: .650/1.3	F: .650/1.30	F: 1.3	F:.325*/.65/1.3
Capacity per disk (Gigabytes)	F: 1.7/.654	F: 1.3/2.6	F: 1.3/2.6	F: 2.6	F:.650/1.3/2.6
Data surfaces per spindle	1	1	1	1	1
Tracks per surface		26010	26010	26010*	
Track density (TPI)		22100	22100	22100	
Maximum linear density (BPI)		51000	51000	51000	
Rotational speed (RPM)	2700	3600	3600	3600	
PERFORMANCE					
Buffer/cache size (Kbytes)	1000	1000	4000	1000, 4000	
Servo type	Sampled	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	43	25	25	25	25
Average rotational delay (msec)	11.1	8.3	8.3	8.3	
Average access time (msec)	54.1	33.3	33.3	33.3	
Spin-up/Spin-down times (sec)		2.5/2.2	2.5/2.2	2.5/2.2	
Data transfer rate (MBytes/sec)					
Internal	1.2-2.2	2.0-4.0	2.0-4.0	2.0-4.2	4
External	5.3	5.0 synch.	5.0 synch.	5.0 synch.	
SIZE (mm: H x W x D)	42 x 147 x 210	70 x 211 x 293	70 x 211 x 293	70 x 211 x 293	
FIRST CUSTOMER SHIPMENT	2Q96	4Q96	4Q96	1Q96	
COMMENTS	DE-SH9101 is external mount.	R series is Sony brand.	R series is Sony brand.	*75735 logical tracks.	*Read only.

MANUFACTURER	SONY	SONY	SONY	SONY	
OPTICAL DRIVE	SMO-F541 SMO-F544	SMO-F541DW SMO-F544DW	SMO-F551	SMO-S551 RMO-S551	
DISK/TREND GROUP	23	23	23	23	
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	
DRIVE: Operating mode	Rewritable	Rewritable	Multifunct-(MO)	Multifunct-(MO)	
Direct overwrite		Yes	Yes	Yes	
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	
Speed control	ZCAV	CAV	ZCAV	ZCAV	
CAPACITY/RECORDING DENSITY					
On-line capacity (Gigabytes)	F: 1.3	F: .650/1.30	F: 1.3/2.6	F: 1.3/2.6	
Capacity per disk (Gigabytes)	F: 2.6	F: 1.3/2.6	F: 2.6/5.2	F: 2.6/5.2	
Data surfaces per spindle	1	1	1	1	
Tracks per surface	26010*	26010*	35294	35294	
Track density (TPI)	22100	22100	29780	29780	
Maximum linear density (BPI)	51000	51000	63140	63140	
Rotational speed (RPM)	3600	3600	3300/3600	3300/3600	
PERFORMANCE					
Buffer/cache size (Kbytes)	1000, 4000	1000, 4000	4000	4000	
Servo type	Continuous	Continuous	Continuous	Continuous	
Average positioning time (msec)	25	25			
Average rotational delay (msec)	8.3	8.3	8.3/9.1	8.3/9.1	
Average access time (msec)	33.3	33.3	33.3/34.1	33.3/34.1	
Spin-up/Spin-down times (sec)	2.5/2.2	2.5/2.2	5.5/3.5	5.5/3.5	
Data transfer rate (MBytes/sec)					
Internal	2.0-4.2	2.0-4.0	1.97-5.07	1.97-5.07	
External	5.0 synch.	10.0 synch.	10.0 synch.	10.0 synch.	
SIZE (mm: H x W x D)	41.4 x 146 x 203	41.4 x 146 x 203	41.3 x 146 x 203	70 x 211 x 293	
FIRST CUSTOMER SHIPMENT	1Q96	2Q97	2Q98	2Q98	
COMMENTS	*75735 logical tracks. F544 has 4 MB buffer.	*75735 logical tracks. F544 has 4 MB buffer.		External mount.	

CD FORMAT DISK TOWER SPECIFICATIONS

1998 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. Miniserver modules from leading suppliers have also been included for convenience, and are identified as "Miniservers".

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: Pentium 200: 64

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.

1998 DISK/TREND optical disk product groups

For the 1998 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: DVD format read-only optical disk drives.
Group 22: CD/DVD format writable optical disk drives.

Read/write optical disk drives:

Group 23: Read/write optical disk drives, less than 4 gigabytes.
Group 24: Read/write optical disk drives, more than 4 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 or more cartridge capacity.

MANUFACTURER	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES
CD FORMAT TOWER	CD PRO Server Net	CD Server	Compact Storage	MAX Tower	Multi-Protocol CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Network
Drive type	Minichanger	CD-ROM	Minichanger	CD-ROM	CD-ROM
Relative speed	16X	24X, 32X	16X	24X, 32X	16X, 24X, 32X
Tower host/net	Ethernet, TR	Ethernet, TR	SCSI host	SCSI host	Ethernet
software environment	Various	Various	Various	Various	Various
Tower capacity (Gbytes) MIN	3.25	4.6	3	4.6	4.6/3.25
MAX	45.5	31.9	91	22	9.1/45.5
Minimum drives per tower	1	7	1	7	7
Maximum drives per tower	14	35	28	35	14
Tower interface to host/net	Ethernet Token ring	Ethernet Token Ring	SCSI-2	SCSI-2	Ethernet Token ring
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	32
Features:					
Processor type & memory (MB)	Pentium: 512	Pentium: 512	--		32 bit RISC
Tower HDD buffer, if used (GB)	2	2	--		--
Hot swap drives	Option	Option	No	No	No
Redundant power supply	Option	Option	Option	Option	Option
Minichangers	Yes	No	Yes	No	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0/12.0	1.2/2.0/12.0	5.0	10.0	1.2/2.0/12.0
drive (MB/sec)	2.4	3.6, 4.8	2.4	3.6, 4.8	2.4, 3.6, 4.8
DRIVES: Nominal capacity/drive (GB)	3.25	.65	3.25	.65	.65/3.25
Average positioning time (msec)		Drive dependent		Drive dependent	Drive dependent
Average access time (msec)	120	Drive dependent	120	Drive dependent	Drive dependent
Drive models	Nakamichi	Toshiba	Nakamichi	Toshiba	Various
TOWER SIZE: Inches: H x W x D			30 x 14.75 x 17.75	30 x 14.75 x 17.75	28.75 x 14.75 x 16.75
POWER: (Watts or KVA)		300-600	300-900 watts	300-900 watts	300-600
FIRST CUSTOMER SHIPMENT	2Q96	2Q95	2Q96	2Q95	4Q96
COMMENTS	RAID option. Complete server.	Rack mount option. Complete server.	Network option.	1 SCSI ID per 7 drives.	Axis server.

MANUFACTURER	ADVANCED MEDIA SERVICES	ADVANCED MEDIA SERVICES	ALLION COMPUTER	ALLION COMPUTER	ALLION COMPUTER
CD FORMAT TOWER	Network Ready CD Tower	Standard Series	CD-Serv/Mate CD-ROM Server	CD-Serv/Tower	FISC CD
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Host	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X, 24X, 32X	24X, 32X	Drive dependent	Drive dependent	Drive dependent
Tower host/net software environment	Ethernet NetWare, NT	SCSI host Various	Ethernet Various	Ethernet Various	Ethernet Various
Tower capacity (Gbytes) MIN	4.6/3.25	4.6	.65	.65	.65/3.25*
MAX	9.1/45.5	18.2	9.1	9.1	5.2/26.0*
Minimum drives per tower	7	7	1	1	1
Maximum drives per tower	14	28	14	14	8
Tower interface to host/net	Ethernet Token ring	SCSI-2	Ethernet 10BT Ethernet 10B2	Ethernet 10BT Ethernet 10B2	Ethernet 10BT, 100BT
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI
Cache size (min, max: MB)	.256	.256			
Features:					
Processor type & memory (MB)	Intel	--	--	--	Cyrix 180:8
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	Option	Option	No	No	No
Minichangers	Option	No	No	No	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0/12.0	5.0	1.2	1.2	1.2/12
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
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	Toshiba	Various	Various	Various
TOWER SIZE: Inches: H x W x D	30 x 14.75 x 17.75	30 x 14.75 x 17.75	2.55 x 8.27 x 6.5	17 x 6.9 x 15.7	1.625 x 5.25 x 8
POWER: (Watts or KVA)	300-900 watts	300-900 watts			
FIRST CUSTOMER SHIPMENT	2Q95	1Q95	1997	1997	6/98
COMMENTS	Microtest server.		Shipped less drives.	Shipped less drives.	Shipped less drives. *With Nakamichi minichangers.

MANUFACTURER	ATRONICS	AXIS COMMUNICATIONS	AXIS COMMUNICATIONS	AXIS COMMUNICATIONS	AXIS COMMUNICATIONS
CD FORMAT TOWER	IDEal CDServer	CD/E StorPoint Miniserver	CD/T FE StorPoint Miniserver	CD/TR, CD/T StorPoint Miniserver	CD/TE StorPoint Miniserver
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
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 software environment	Ethernet NetWare, other	Ethernet Windows, OS/2, UNIX,NetW.,Web	Token Ring Windows, OS/2, UNIX,NetW.,Web	Token Ring Windows, OS/2, UNIX,NetW.,Web	Ethernet Windows, OS/2, UNIX,NetW.,Web
Tower capacity (Gbytes) MIN	4.2	.65	.65	.65	4.6
MAX	4.2	4.6	9.1	4.6	9.1
Minimum drives per tower	7	1	1	1	1
Maximum drives per tower	7	7	14	7	14
Tower interface to host/net	Ethernet, TR	E'net 10BT,10B2	Ethernet 100BT	TR STP, UTP	E'net 10BT, AUI
Drive interface	SCSI-2, EIDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 128	2, 32	2, 32	2, 32	2, 32
Features:					
Processor type & memory (MB)	486: 4	32 bit RISC	32 bit RISC	32 bit RISC	32 bit RISC
Tower HDD buffer, if used (GB)	--	No	No	No	No
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Option	Yes	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	1.2	12	2.0	1.2/2.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
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	17 x 8 x 25	1.7 x 5.9 x 8.8	1.7 x 5.9 x 8.8	1.7 x 5.9 x 8.8	1.7 x 5.9 x 8.2
POWER:(Watts or KVA)	230	15 watts	18 watts	18 watts	19 watts
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	1997	4Q96	4Q96
COMMENTS		Supports 56 disks in library with LUN addressing.	Supports 56 disks in library with LUN addressing.	Supports 56 disks in library with LUN addressing.	Supports up to 112 disks in library with LUN addressing. 1 or 2 SCSI channels.

MANUFACTURER	AXONIX	AXONIX	BOFFIN	BOFFIN	BOFFIN
CD FORMAT TOWER	CD-Sharer ProLinQ	Super CD-Sharer ProLinQ	91-CDRT1414	91-CDRT2828	91-CDRT77
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	Drive dependent	32X	16X, 32X	16X, 32X	16X, 32X
Tower host/net software environment	Windows,OS/2,NT NetW., DOS, Web	Windows,OS/2,NT NetW., DOS, Web	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT
Tower capacity (Gbytes) MIN	.65	.65	4.55	9.1	
MAX	9.1	9.1	9.1	18.2	4.55
Minimum drives per tower	1	1	7	14	7
Maximum drives per tower	14	14	14	28	7
Tower interface to host/net	Ethernet, TR	Ethernet, TR	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			
Features:					
Processor type & memory (MB)	X86:8-128	X86:8-128	--	--	--
Tower HDD buffer, if used (GB)	Option	4-40	--	--	--
Hot swap drives	No		Option	Option	Option
Redundant power supply	No		No	No	No
Minichangers	Option	Option	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	1.2/12/2.0	5.0	5.0	5.0
drive (MB/sec)	Drive dependent	4.8	2.4, 4.8	2.4, 4.8	2.4, 4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	Drive dependent	Drive dependent			
Average access time (msec)	Drive dependent	Drive dependent	160, 85	160, 85	160, 85
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D			17 x 18 x 23	32.5 x 19 x 26.5	15.75 x 7.5 x 16
POWER: (Watts or KVA)	.12 KVA		600 watts	600 watts	600 watts
FIRST CUSTOMER SHIPMENT	1996	1996			
COMMENTS	Custom configurations available.	CD-ROM server module.			

MANUFACTURER	BOFFIN	BOFFIN	BOFFIN	BOFFIN	BOFFIN
CD FORMAT TOWER	91-CDX1414MJ5	91-CDX2828MJ5	91-CDX77MJ5	91-IS144	91-IS2828
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Network	Network
Drive type	Minichanger	Minichanger	Minichanger	CD-ROM	CD-ROM
Relative speed	16X	16X	16X	16X, 32X	16X, 32X
Tower host/net software environment	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT	PC compatible DOS, Windows, NT	Ethernet NetWare	Ethernet VINES, DOS, NT, OS/2, Windows
Tower capacity (Gbytes) MIN	45.5	91	22.75	9.1	18.2
MAX					
Minimum drives per tower	7	7	7	14	28
Maximum drives per tower	14	28	7	14	28
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		
Features:					
Processor type & memory (MB)	--	--	--	Pentium 233: 64	Pentium 233: 64
Tower HDD buffer, if used (GB)	--	--	--	4	4
Hot swap drives	Option	Option	Option	Option	Option
Redundant power supply	Option	Option	Option	Option	Option
Minichangers	Yes	Yes	Yes	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	5.0	1.2/12/2.0	1.2/12/2.0
drive (MB/sec)	2.4	2.4	2.4	2.4, 4.8	2.4, 4.8
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	3.25	.65	.65
Average positioning time (msec)					
Average access time (msec)	120	120	120	160, 85	160, 85
Drive models	Nakamichi	Nakamichi	Nakamichi	Various	Various
TOWER SIZE: Inches: H x W x D	17 x 18 x 23	32.5 x 19 x 26.5	15.75 x 7.5 x 16	17 x 18 x 23	32.5 x 19 x 26.5
POWER: (Watts or KVA)	600 watts	1200 watts	600 watts	600 watts	
FIRST CUSTOMER SHIPMENT					
COMMENTS	Drives are 5 disk changers.	Drives are 5 disk changers.	Drives are 5 disk changers.	Rack mount option.	Rack mount option.

MANUFACTURER	BOFFIN	BOFFIN	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL
CD FORMAT TOWER	91-IS77	95-CDS523328 17-CDS523328	ADMIRAL	BARRISTER II	CAPTAIN
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	Minichanger	CD-ROM, Minich.	CD-ROM, Minich.	CD-ROM, Minich.
Relative speed	16X, 32X				
Tower host/net	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet
software environment	VINES, DOS, NT, OS/2, Windows	VINES, DOS, NT, OS/2, Windows	NT, Novell	NT, Novell	NT, Novell
Tower capacity (Gbytes) MIN			3.25	3.25	3.25
MAX	9.2	91	91	19.5	45.5
Minimum drives per tower	14	7	1	1	1
Maximum drives per tower	14	28	28	6	14
Tower interface to host/net	Ethernet, TR	Ethernet, TR	Ethernet	Ethernet	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)	Pentium 233: 64	Pentium 233: 64	Pentium 200: 32	Pentium 200: 32	Pentium 200: 32
Tower HDD buffer, if used (GB)	4	4	2-27	2-27	9-18
Hot swap drives	Option	Option	--	--	--
Redundant power supply	Option	Option	--	--	--
Minichangers	No	Yes	Yes		Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	1.2/12/2.0	1.2/12	1.2/12	1.2/12
drive (MB/sec)	2.4, 4.8	2.4	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (GB)	.65	3.25	3.25	3.25	3.25
Average positioning time (msec)					
Average access time (msec)	160, 85	120	120	120	120
Drive models	Various	Nakamichi	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	15.75 x 7.5 x 10	32.5 x 19 x 26.5	31.25 x 15.25 x 24	26 x 7.5 x 17	17.25 x 15.25 x 24
POWER: (Watts or KVA)	300 watts	500 watts			
FIRST CUSTOMER SHIPMENT					
COMMENTS	Rack mount option.	95-CDS523328 has hot swap options.	Optional configurations.	CD-R option.	

MANUFACTURER	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL
CD FORMAT TOWER	CDT1000	CDT14000	CDT3500	CDT500	CDT7000
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Drive type	Minichanger	Minichanger	Minichanger	Minichanger	Minichanger
Relative speed	16X	16X	16X	16X	16X
Tower host/net software environment	SCSI host Various	SCSI host Windows, Novell NT, UNIX, Mac	SCSI host Windows, Novell NT, UNIX, Mac	SCSI host Various	SCSI host Windows, Novell NT, UNIX, Mac
Tower capacity (Gbytes) MIN	16.25	3.25	3.25	6.5	3.25
MAX	16.25	91.2	22.75	6.5	45.5
Minimum drives per tower	5	1	1	2	1
Maximum drives per tower	5	28	7	2	14
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	
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	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)		10	10		10
drive (MB/sec)	2.4	2.4	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	3.25	3.25	3.25
Average positioning time (msec)					
Average access time (msec)	120	120	120	120	120
Drive models	Nakamichi	Nakamichi	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D		31 x 14.75 x 21.5			16 x 14.75 x 21.5
POWER:(Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS	Optional configurations.	Optional configurations.	Optional configurations.	Optional configurations.	Optional configurations.

MANUFACTURER	CHIA SHIN TECHNOLOGY	CHIA SHIN TECHNOLOGY	CMS ENHANCEMENTS	CMS ENHANCEMENTS	COMPAQ
CD FORMAT TOWER	CD-Serve	CD-Serve Tower	CD14-32XE	CD7-32XE	CD Storage
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	Captive, Dist
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	Drive dependent	Drive dependent	16X, 32X	16X, 32X	12X
Tower host/net software environment	Ethernet MAC, NT, WIN95 DOS, UNIX, OS/2	Ethernet MAC, NT, WIN95 DOS, UNIX, OS/2	NetWare, NT UNIX, other	NetWare, NT UNIX, other	SCSI host NT, Netware Unix
Tower capacity (Gbytes) MIN	.65	.65	1.95	1.95	
MAX	9.1	4.55	9.1	4.55	4.55
Minimum drives per tower	1	1	3	3	7
Maximum drives per tower	14	7	14	7	7
Tower interface to host/net	E'net 10BT,10B2	E'net 10BT,10B2	Ethernet, TR	Ethernet, TR	SCSI-2
Drive interface	SCSI	SCSI	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)			.256, .512	.256, .512	
Features:					
Processor type & memory (MB)	--	--	32 bit RISC	32 bit RISC	--
Tower HDD buffer, if used (GB)	--	--	Option	Option	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	No	Option	Option	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2	1.2/12/2.0	1.2/12/2.0	4.5
drive (MB/sec)	Drive dependent	Drive dependent	2.4, 4.8	2.4, 4.8	1.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	Drive dependent	Drive dependent			110
Average access time (msec)	Drive dependent	Drive dependent	115, 85	115, 85	120
Drive models	Various	Various	Various	Various	Toshiba
TOWER SIZE: Inches: H x W x D	2.6 x 8.4 x 10.6		27.5 x 8.4 x 17	15.5 x 8.4 x 17	16 x 7 x 16
POWER: (Watts or KVA)					230 watts
FIRST CUSTOMER SHIPMENT	3Q97	3Q97	1997	1997	4Q97
COMMENTS	Network server module.				Rack mount option.

MANUFACTURER	CUTTING EDGE	CUTTING EDGE	CUTTING EDGE	CUTTING EDGE	CYCMA
CD FORMAT TOWER	AccessStor-CD/DVD	CD-RAIDStor-CD	ServStor-CD/DVD	ShareStor-CD/DVD	CD-100x-18
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Host	Network
Drive type	CD/DVD-ROM	CD/DVD-ROM	CD/DVD-ROM	CD/DVD-ROM	CD-ROM
Relative speed	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Tower host/net software environment	Ethernet, other NetWare, NT, UNIX, other	Ethernet, other	Ethernet, TR ATM, FDDI	SCSI host	Ethernet
Tower capacity (Gbytes) MIN	4.55/32.9	6.5/47	4.55/32.9	4.55/32.9	
MAX	16.2/13/.6	130/940	41/296.1	18.2/131.6	18.2
Minimum drives per tower	7	10	7	7	
Maximum drives per tower	28	200	63	28	1/28*
Tower interface to host/net	E'net,TR,other	Ethernet, TR	E'net,TR, other	SCSI-2	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.256/1.024	.256	.256	
Features:					
Processor type & memory (MB)	32 bit RISC	Pentium II	Pentium,PowerPC		
Tower HDD buffer, if used (GB)	--	4.3	1.6-3.2		18
Hot swap drives	Option	Option	Option	Option	
Redundant power supply	Option	Option	Option	Option	
Minichangers	Option	Option	Option	Option	
TOWER PERFORMANCE: Transfer rate: host/net (MB/sec)	1.2/2.0/12.0	1.2/12/2/20	1.2/2.0/12.0/20	10.0/20.0/40.0	1.2/12
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65/4.7	.65/4.7	.65 /4.7	.65 /4.7	.65
Average positioning time (msec) 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	Configuration dependent	Configuration dependent	Configuration dependent	Configuration dependent	
POWER: (Watts or KVA)	300-600 watts	300-600 watts	300-600 watts	300-600 watts	
FIRST CUSTOMER SHIPMENT	3Q95	1998	3Q95	1Q93	
COMMENTS	Axis controller	Axis controller Raid option.	24 MB RAM. Custom configuration.		*Number of cached disk images.

MANUFACTURER	CYCMA	CYCMA	CYCMA	CYCMA	DTS COMPUTER
CD FORMAT TOWER	CD-100x-4	CD-100x-9	Torre 14	Torre 7	DP300
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Various
Tower host/net software environment	Ethernet	Ethernet	SCSI host	SCSI host	UNIX, NetWare, Windows, NT
Tower capacity (Gbytes) MIN					4.6
MAX	4.55	9.1	9.1	4.55	4.6
Minimum drives per tower					7
Maximum drives per tower	1/7*	1/14*	14	7	7
Tower interface to host/net	Ethernet	Ethernet	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)	4	9	--	--	--
Hot swap drives					No
Redundant power supply					No
Minichangers					--
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	1.2/12	10	10	1.2/2.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)					Drive dependent
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Various	Various	Various	Various	TEAC
TOWER SIZE: Inches: H x W x D					21.3 x 8.7 x 13
POWER: (Watts or KVA)					200 watts
FIRST CUSTOMER SHIPMENT					
COMMENTS	*Number of cached disk images.	*Number of cached disk images.			Sold in Europe

MANUFACTURER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER
CD FORMAT TOWER	CD-4	CD-7	CD-14	CDD-14	CDD-7
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
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 software environment	DOS, Windows, OS/2, UNIX DOS, Windows	OS/2, UNIX DOS, Windows	OS/2, UNIX, DOS, Windows	OS/2, UNIX, DOS, Windows	OS/2, UNIX DOS, Windows
Tower capacity (Gbytes) MIN	.65	.65	.65	.65	.65
MAX	2.6	4.55	9.1	9.1	4.55
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	4	7	14	14	7
Tower interface to host/net	SCSI, other	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)	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	No
Redundant power supply	No	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	5.0
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
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	9 x 6.5 x 15	13 x 7 x 15.25	26 x 9 x 16	28.75 x 9 x 16.75	18.75 x 8.75 x 13
POWER: (Watts or KVA)	230 watts	230 watts	460 watts	600 watts	300 watts
FIRST CUSTOMER SHIPMENT	1993	1993	1993	1993	1993
COMMENTS					

MANUFACTURER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER
CD FORMAT TOWER	EX-14	EX-28	EX-7	JB-14	JB-28
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST		
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	Minichanger	Minichanger
Relative speed	4X-20X	4X-20X	4X-20X	16X	16X
Tower host/net software environment	Ethernet, TR, NetWare, NT, NFS, Web	Ethernet, TR, NetWare, NT, NFS, Web	Ethernet, TR, NetWare, NT, NFS, Web	NetWare, NT, NFS, Web	NFS, Web, NT, NetWare
Tower capacity (Gbytes) MIN	.65	.65	.65	3.25	3.25
MAX	9.1	18.2	4.55	45.5	91
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	28	7	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	Drive dependent	.256	.256
Features:					
Processor type & memory (MB)				32 bit RISC	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	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)	Drive dependent	Drive dependent	Drive dependent	2.4	2.4
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	3.25 (5 disks)	3.25 (5 disks)
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent		
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	120	120
Drive models	Various	Various	Various	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	26 x 9 x 16	32.6 x 22 x 25	22 x 7 x 15.25	26 x 9 x 16	32.6 x 22 x 25
POWER: (Watts or KVA)	600 watts	600 watts	300 watts	600 watts	600 watts
FIRST CUSTOMER SHIPMENT	3Q96	3Q96	3Q96	3Q96	3Q96
COMMENTS				Host attach option. Axis controller 5 disk changer.	Host attach option. Axis controller 5 disk changer.

MANUFACTURER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER	EXCEL COMPUTER
CD FORMAT TOWER	JB-7	RM-5	RM-7	Twister 105	Twister 35
DISK/TREND GROUP	51	51	51	51	51
MARKET		DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Host	Network	Network
Drive type	Minichanger	CD-ROM	CD-ROM	Minichanger	Minichanger
Relative speed	16X	4X-20X	4X-20X	16X	16X
Tower host/net software environment	NFS, Web, NT, NetWare	OS/2, UNIX, DOS, Windows	DOS, Windows, OS/2, UNIX	Various	Various
Tower capacity (Gbytes) MIN	3.25	.65	.65	6.5	6.5
MAX	22.75	36.4	4.55	68.25	22.75
Minimum drives per tower	1	1	1	2	2
Maximum drives per tower	7	56	7	21	7
Tower interface to host/net	Ethernet, TR	SCSI, other	SCSI, other	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	.256	.256
Features:					
Processor type & memory (MB)	32 bit RISC	--	--	Pentium: 64	Pentium: 64
Tower HDD buffer, if used (GB)	--	--	--	54	18
Hot swap drives	No		No	No	No
Redundant power supply	No		No	Option	Option
Minichangers	Yes	Option	Option	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0	5.0	5.0	1.2/12/2.0	1.2/12/2.0
drive (MB/sec)	1.8-2.4	Drive dependent	Drive dependent	1.8-2.4	1.8-2.4
DRIVES: Nominal capacity/drive (GB)	3.25 (5 disks)	.65	.65	3.25	3.25
Average positioning time (msec)		Drive dependent	Drive dependent		
Average access time (msec)	120	Drive dependent	Drive dependent	120	120
Drive models	Nakamichi	Various	Various	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	13 x 7 x 15.25	Configuration dependent	7 x 19 x 27	33 x 25 x 26	26 x 9 x 18
POWER: (Watts or KVA)	300 watts	300-600 watts	230 watts	1000 watts	300 watts
FIRST CUSTOMER SHIPMENT	3Q96	1994	1993	3Q98	3Q98
COMMENTS	Host attach option. Axis controller 5 disk changer.	Rack mount series.			

MANUFACTURER	EXCEL COMPUTER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
CD FORMAT TOWER	Twister 70	C2987A	C2988A	J3276A	J3277A
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	Captive	Captive	Captive	Captive
TOWER CONFIGURATION: Attachment	Network	Network	Host	Network	Network
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	32X	32X	32X	32X
Tower host/net software environment	Various	Ethernet NT, UNIX, Win. Novell, other	SCSI Host Various	Ethernet NT, UNIX, Win. Novell, other	Ethernet NT, UNIX, Win. Novell, other
Tower capacity (Gbytes) MIN	6.5	.65	.65	.65	.65
MAX	45.5	4.55	4.55	4.55	4.55
Minimum drives per tower	2	1	1	1	1
Maximum drives per tower	14	7	7	7	7
Tower interface to host/net	Ethernet, TR	Ethernet	SCSI-2	Ethernet	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	.512	.512	.512	.512
Features:					
Processor type & memory (MB)	Pentium: 64	2		2	2
Tower HDD buffer, if used (GB)	36	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	Option	No	No	No	No
Minichangers	Yes	Option	Option	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	1.2	10	1.2/12	1.2/12
drive (MB/sec)	1.8-2.4	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	3.25	.65	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	120	85	85	85	85
Drive models	Nakamichi	HPC2807A	HPC2807A	HPC2807A	HPC2807A
TOWER SIZE: Inches: H x W x D	33 x 25 x 26	17.3 x 8.46 x 12.6	17.3 x 8.46 x 12.6	17.5 x 8.5 x 14.5	17.5 x 8.5 x 14.5
POWER: (Watts or KVA)	1000 watts	40 watts + drives		40 watts	40 watts + drives
FIRST CUSTOMER SHIPMENT	3Q98	1997	1997	2Q98	2Q98
COMMENTS		Requires J3169A or J3168A Server module.		Drives not included.	DVD option.

MANUFACTURER	HEWLETT-PACKARD	JES	JES	JES	JVC
CD FORMAT TOWER	J3278A	14bay	2bay	7bay	BC-CR16000
DISK/TREND GROUP	51	51	51	51	51
MARKET	Captive	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Host	Host	Host
Drive type	CD-ROM	CD-ROM	Minichanger	CD-ROM	CD-R
Relative speed	32X	Drive dependent	16X	Drive dependent	
Tower host/net software environment	Ethernet NT, UNIX, Win. Novell, other	SCSI host Various	SCSI host Various	SCSI host Various	SCSI host Windows, NT
Tower capacity (Gbytes) MIN	.65		6.5		
MAX	9.1	9.1	6.5	4.55	6.5
Minimum drives per tower	1	14	2	7	10
Maximum drives per tower	14	14	2	7	10
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)	.512	.256	.256	.256	1000
Features:					
Processor type & memory (MB)	.18	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Option	No	Yes	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12		10	10	10
drive (MB/sec)	4.8	Drive dependent	1.8-2.4	Drive dependent	.6 WR
DRIVES: Nominal capacity/drive (GB)	.65	.65	3.25	.65	.65
Average positioning time (msec)					
Average access time (msec)	85	Drive dependent	120	Drive dependent	
Drive models	HPC2807A	Various	Nakamichi	Various	JVC
TOWER SIZE: Inches: H x W x D	17.5 x 8.5 x 14.5	28.75 x 14.75 x 16.75	4.75 x 10 x 11	18.75 x 8.75 x 13	16.5 x 17 x 21.6
POWER: (Watts or KVA)	40 watts + drives	600 watts	65 watts	300 watts	
FIRST CUSTOMER SHIPMENT	2Q98				1998
COMMENTS	DVD option.	Network attach option.	Network attach option.	Network attach option. Rack mount option.	Adaptec PCI-SCSI card included.

MANUFACTURER	JVC	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS
CD FORMAT TOWER	BC-CR8000	CD-J147016X-NS	CD-J2814016X-NS	CD-J3516X-NS	CD-J5628016X-NS
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Network	Network	Network
Drive type	CD-R	Minichanger	Minichanger	Minichanger	Minichanger
Relative speed		16X	16X	16X	16X
Tower host/net software environment	SCSI host Windows, NT	Ethernet	Ethernet	Ethernet	Ethernet
Tower capacity (Gbytes) MIN					
MAX	3.25	45.5	91.0	22.75	182.0
Minimum drives per tower	5	14	28	7	56
Maximum drives per tower	5	14	28	7	56
Tower interface to host/net	SCSI-2	Ethernet	Ethernet	Ethernet	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	1000	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	32 bit RISC	32 bit RISC	32 bit RISC	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	No	Yes	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10	1.2/12	1.2/12	1.2/12	1.2/12
drive (MB/sec)	.6 WR	2.4	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (GB)	.65	3.25	3.25	3.25	3.25
Average positioning time (msec)					
Average access time (msec)		120	120	120	120
Drive models	JVC	Nakamichi	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	17.5 x 8.5 x 13.25	18 x 14 x 15	32.6 x 22 x 25	13 x 8.75 x 18.75	70 x 23 x 25
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	1998				
COMMENTS	Adaptec PCI-SCSI card included.				

MANUFACTURER	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS
CD FORMAT TOWER	CDR-J147016X-PC	CDR-J2814016X-PC	CDR-J3516X-PC	CDR-J5628016X-PC	CDR-P1424-NS
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Network
Drive type	Minichanger	Minichanger	Minichanger	Minichanger	CD-ROM
Relative speed	16X	16X	16X	16X	24X
Tower host/net software environment	SCSI host	SCSI host	SCSI host	SCSI host	Ethernet
Tower capacity (Gbytes) MIN					
MAX	45.5	91.0	22.75	182.0	9.1
Minimum drives per tower	14	28	7	56	14
Maximum drives per tower	14	28	7	56	14
Tower interface to host/net	SCSI-2	SCSI-2	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)	--	--	--	--	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	Yes	Yes	Yes	Yes	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10	10	10	10	1.2/12
drive (MB/sec)	2.4	2.4	2.4	2.4	3.6
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	3.25	3.25	.65
Average positioning time (msec)					
Average access time (msec)	120	120	120	120	99
Drive models	Nakamichi	Nakamichi	Nakamichi	Nakamichi	Panasonic
TOWER SIZE: Inches: H x W x D	18 x 14 x 15	32.6 x 22 x 25	13 x 8.75 x 18.75	70 x 23 x 25	18 x 14 x 15
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS					DVD-ROM option.

MANUFACTURER	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS
CD FORMAT TOWER	CDR-P1424-PC	CDR-P282824-NS	CDR-P282824-PC	CDR-P5624-NS	CDR-P5624-PC
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Host	Network	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	24X	24X	24X	24X	24X
Tower host/net software environment	SCSI host	Ethernet	SCSI host	Ethernet	SCSI host
Tower capacity (Gbytes) MIN					
MAX	9.1	18.2	18.2	36.4	36.4
Minimum drives per tower	14	28	28	56	56
Maximum drives per tower	14	28	28	56	56
Tower interface to host/net	SCSI-2	Ethernet	SCSI-2	Ethernet	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)	--	32 bit RISC	--	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	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10	1.2/12	10	1.2/12	10
drive (MB/sec)	3.6	3.6	3.6	3.6	3.6
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	99	99	99	99	99
Drive models	Panasonic	Panasonic	Panasonic	Panasonic	Panasonic
TOWER SIZE: Inches: H x W x D	18 x 14 x 15	32.6 x 22 x 25	32.6 x 22 x 25	70 x 23 x 25	70 x 23 x 25
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS	DVD-ROM option.	DVD-ROM option.	DVD-ROM option.	DVD-ROM option.	DVD-ROM option.

MANUFACTURER	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS
CD FORMAT TOWER	CDR-P7724-NS	CDR-P7724-PC	CDR-T1432X-NS	CDR-T1432X-PC	CDR-T282832X-NS
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Network	Host	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	24X	24X	32X	32X	32X
Tower host/net software environment	Ethernet	SCSI host	Ethernet	SCSI host	Ethernet
Tower capacity (Gbytes) MIN					
MAX	4.55	4.55	9.1	9.1	18.2
Minimum drives per tower	7	7	14	14	28
Maximum drives per tower	7	7	14	14	28
Tower interface to host/net	Ethernet	SCSI-2	Ethernet	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)	32 bit RISC	--	32 bit RISC	--	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	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	10	1.2/12	10	1.2/12
drive (MB/sec)	3.6	3.6	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	99	99	85	85	85
Drive models	Panasonic	Panasonic	Toshiba	Toshiba	Toshiba
TOWER SIZE: Inches: H x W x D	13 x 8.75 x 18.75	13 x 8.75 x 18.75	18 x 14 x 15	18 x 14 x 15	32.6 x 22 x 25
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS	DVD-ROM option.	DVD-ROM option.			

MANUFACTURER	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS	KINTRONICS
CD FORMAT TOWER	CDR-T282832X-PC	CDR-T5632X-NS	CDR-T5632X-PC	CDR-T7732X-NS	CDR-T7732X-PC
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Host	Network	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	32X	32X	32X	32X	32X
Tower host/net software environment	SCSI host	Ethernet	SCSI host	Ethernet	SCSI host
Tower capacity (Gbytes) MIN	18.2	36.4	36.4	4.55	4.55
MAX					
Minimum drives per tower	28	56	56	7	7
Maximum drives per tower	28	56	56	7	7
Tower interface to host/net	SCSI-2	Ethernet	SCSI-2	Ethernet	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)	--	32 bit RISC	--	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	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10	1.2/12	10	1.2/12	10
drive (MB/sec)	4.8	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	85	85	85	85	85
Drive models	Toshiba	Toshiba	Toshiba	Toshiba	Toshiba
TOWER SIZE: Inches: H x W x D	32.6 x 22 x 25	70 x 23 x 25	70 x 23 x 25	13 x 8.75 x 18.75	13 x 8.75 x 18.75
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
CD FORMAT TOWER	LKCU04M02F UDSS	LKCU04M02T UDSS	LKCU05M04F UDSS	LKCU07M02F UDSS	LKCU07M02T
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	Minichanger	Minichanger	Minichanger	Minichanger	Minichanger
Relative speed	16X	16X	16X, 66X	16X	16X
Tower host/net software environment	NT, OS/2, UNIX NetWare	NT, OS/2, UNIX NetWare	NT, OS/2, UNIX NetWare	Ethernet NetWare, NT UNIX, OS/2	Ethernet NetWare, NT UNIX, OS/2
Tower capacity (Gbytes) MIN	3.25	3.25	3.25	3.25	3.25
MAX	13	13	13	22.75	22.75
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	4	4	4	7	7
Tower interface to host/net	Ethernet	Token Ring	Ethernet	Ethernet	Token Ring
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)	--	--	4	--	--
Hot swap drives	No	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)	1.2	2.0	1.2/12	1.2/12	2.0
drive (MB/sec)	1.8-2.4	1.8-2.4	1.8-2.4, 9.9	1.8-2.4	1.8-2.4
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	3.25	3.25	3.25
Average positioning time (msec)		Drive dependent			
Average access time (msec)	120	Drive dependent	120	120	120
Drive models	Nakamichi	Various	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	28 x 14 x 27	28 x 14 x 27	28 x 14 x 27	27 x 14 x 28	27 x 14 x 28
POWER: (Watts or KVA)	250 watts	250 watts	250 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT	1998	1998	3Q97	1998	1998
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	LKCU08M04F	LKCU08M04T	LKCU09M04F UDSS	LKCU09M05F UDSS	LKCU14M02F
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	OEM, DIST	OEM, DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	Minichanger	Minichanger	Minichanger	Minichanger	Minichanger
Relative speed	16X	16X	16X, 66X	16X	16X
Tower host/net software environment	Ethernet NetWare, UNIX OS/2, NT	Ethernet NetWare, UNIX OS/2, NT	NT, OS/2, UNIX NetWare	NT, OS/2, UNIX NetWare, NT	Ethernet NetWare, UNIX OS/2, NT
Tower capacity (Gbytes) MIN	3.25	3.25	3.25	3.25	3.25
MAX	22.75	22.75	13	19.5	45.5
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	7	7	4	6	14
Tower interface to host/net	Ethernet	Token Ring	Ethernet	Ethernet	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)	9	9	9	18	--
Hot swap drives	No	No	No	No	No
Redundant power supply	Yes	Yes	Yes	Yes	Yes
Minichangers	Yes	Yes	Yes	No	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	2.0	1.2/12	1.2/12	1.2/12
drive (MB/sec)	1.8-2.4	1.8-2.4	1.8-2.4, 9.9	1.8-2.4	1.8-2.4
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	3.25	3.25	3.25
Average positioning time (msec)			Drive dependent		
Average access time (msec)	120	120	Drive dependent	120	120
Drive models	Nakamichi	Nakamichi	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	27 x 14 x 28	27 x 14 x 28	28 x 14 x 27	27 x 14 x 28	27 x 14 x 28
POWER: (Watts or KVA)			250 watts	250 watts	
FIRST CUSTOMER SHIPMENT	1998	1998	3Q97	3Q97	1998
COMMENTS					

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
CD FORMAT TOWER	LKCU15M04F	LKVU07N04F UDSS	LKVU07N04T UDSS	LKVU07N05F UDSS	LKVU07N05T UDSS
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	32X	32X	32X, 66X	32X, 66X
Tower host/net software environment	Ethernet NetWare, UNIX OS/2, NT	Ethernet NetWare NT, OS/2, UNIX	Token Ring NetWare NT, OS/2, UNIX	NT, OS/2, UNIX NetWare	NT, OS/2, UNIX NetWare
Tower capacity (Gbytes) MIN	3.25	.65	.65	.65	.65
MAX	45.5	4.55	4.55	4.55	4.55
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	7	7	7	7
Tower interface to host/net	Ethernet	E'net 10BT,10B5	Token Ring	Ethernet	Token Ring
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	2, 32	2, 32	2, 32	2, 32
Features:					
Processor type & memory (MB)		--	--	--	--
Tower HDD buffer, if used (GB)	9	Option	Option	4	4
Hot swap drives	No	No	No	No	No
Redundant power supply	Yes	Yes	Yes	Yes	Yes
Minichangers	Yes	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	1.2/100	2.0	1.2/12	2.0
drive (MB/sec)	1.8-2.4	4.8	4.8	4.8	4.8, 9.9
DRIVES: Nominal capacity/drive (GB)	3.25	.65	.65	.65	.65
Average positioning time (msec)		Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	120	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Drive models	Nakamichi	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	27 x 14 x 28	27 x 14 x 28	27 x 14 x 28	28 x 14 x 27	28 x 14 x 27
POWER: (Watts or KVA)		250 watts	250 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT	1998	1998	1997	1998	1998
COMMENTS					

MANUFACTURER	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS	LEGACY STORAGE SYSTEMS
CD FORMAT TOWER	LKVU14N04F UDSS	LKVU14N04T UDSS	LVU07N04X UDSS	Vantage	Vantage 850 Vantage 950*
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	32X	32X	32X	Various	Various
Tower host/net software environment	NT, OS/2, UNIX NetWare	NT, OS/2, UNIX NetWare	SCSI host NetWare NT, OS/2, UNIX	Ethernet NetWare, UNIX, Windows, other	Ethernet NetWare, UNIX, Windows, other
Tower capacity (Gbytes) MIN	4.55	4.55	.65	4.6	4.6
MAX	9.1	9.1	4.55	36.4	36.4
Minimum drives per tower	1	1	1	7	7
Maximum drives per tower	14	14	7	56	56
Tower interface to host/net	Ethernet	Token Ring	SCSI-2	E'net,TR,ATM*	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 32	2, 32	.512	.256	.256
Features:					
Processor type & memory (MB)	--	--	--	Pentium 90:64MB	
Tower HDD buffer, if used (GB)	--	--	--	--	
Hot swap drives	No	No	No	No	--
Redundant power supply	Yes	Yes	No	No	--
Minichangers	No	No	No	No	--
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	2.0	5.0	1.2/2.0	1.2/2.0
drive (MB/sec)	4.8	4.8	4.8	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
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	Sony, Toshiba Plextor	Sony, Toshiba Various
TOWER SIZE: Inches: H x W x D	28 x 14 x 27	28 x 14 x 27	27 x 14 x 28	77.3 x 23 x 31.5	1.3 x 7.7 x 5.2
POWER: (Watts or KVA)	250 watts	250 watts	250 watts	250 watts	12 watts
FIRST CUSTOMER SHIPMENT	1998	1998	1998		
COMMENTS	Rack mount option.	Rack mount option.		*Also FDDI, CDDI.	Direct network attached server *Token Ring interface.

MANUFACTURER	MERIDIAN DATA	MERIDIAN DATA	MERIDIAN DATA	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL
CD FORMAT TOWER	CD Net Universal Server	CD NetROM	TNT Server 2000	CD Express Connect	ECS-1320
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Network	Network	Network
Drive type	CD-ROM	CD-ROM, DVD-ROM	CD-ROM, DVD-ROM	CD/DVD-ROM	CD-ROM
Relative speed	32X	Drive dependent	Drive dependent	Drive dependent	32X
Tower host/net software environment	Ethernet NetWare, UNIX, NT, NFS, TCP/IP	SCSI host Netware, NT,DOS OS/2,UNIX,other	Ethernet NT, NetWare	Ethernet NetWare, NT,NFS UNIX, Web, OS/2	Ethernet NetWare, NT NFS, UNIX, Web
Tower capacity (Gbytes) MIN	.65	.65	Drive dependent	.65	.65
MAX	9.1	18.2, 131.6	Drive dependent	9.1/65.8/45.5	5.2
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	28	63	14	8
Tower interface to host/net	Ethernet Token Ring	SCSI-2	Ethernet	Ethernet, TR	Ethernet
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	2, 32		128, 384	.256	.512*
Features:					
Processor type & memory (MB)	Embedded RISC:2	--	Pentium: 128	32 bit RISC: 32	--
Tower HDD buffer, if used (GB)	--	Option	9.1-163.8	--	--
Hot swap drives	Option	Option	In rack mount	No	No
Redundant power supply	Option	Option	In rack mount	No	No
Minichangers	Option	No	No	Option	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	10.0	1.2/12	1.2/12/2.0	20 synch.
drive (MB/sec)	4.8	4.8, 2.8	Drive dependent		4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65, 4.7	.65/4.7	.65/4.7/3.25	.65
Average positioning time (msec)			Drive dependent	65	
Average access time (msec)	70	120, 150	Drive dependent	75	85
Drive models	Toshiba, TEAC	Toshiba, TEAC Pioneer	Pioneer, TEAC Toshiba	Various	Various
TOWER SIZE: Inches: H x W x D	16 x 9 x 16	28.2 x 21.7 x 16.5	Configuration dependent	16.1 x 6.5 x 16.5	16.1 x 14.38 x 16
POWER: (Watts or KVA)	180/300 watts	180-600 watts	400/600 watts	86 watts	53
FIRST CUSTOMER SHIPMENT	2Q97	3Q96	3Q98	4Q97	6/98
COMMENTS	7 drive rack mount option. Purchased controller.	Expandable to 70 drives. Rack mount option.	Many config. options. Complete server RAID 0,1,5.	Nakamichi minichanger option.	*per drive.

MANUFACTURER	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL
CD FORMAT TOWER	ECS-1340	ECS-2420	SECD32XDE16	SECD32XET8	SECD32XST
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Host
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	32X	32X	32X	32X
Tower host/net software environment	Ethernet NetWare, NT NFS, UNIX, Web	Ethernet NetWare, NT NFS, UNIX, Web	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT, OS/2, Mac	SCSI host NetWare, NT,
Tower capacity (Gbytes) MIN	.65	.65	.65	.65	.65
MAX	22.75	5.2	10.4	5.2	4.6
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	7	16	16	8	7
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)	.512*	.512*	.512*	.512*	.512*
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	No	No	Option	Option	Option
Redundant power supply	No	No	Option	Option	Option
Minichangers	Yes	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	20 synch.	20 synch.	20 synch.	20 synch.	20 synch.
drive (MB/sec)	2.4	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	3.25	.65	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	120	85	85	85	85
Drive models	Nakamichi	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	16.1 x 14.38 x 16	16.1 x 14.38 x 16	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)	86	105	350 watts	141 watts	70-109 watts
FIRST CUSTOMER SHIPMENT	6/98	6/98	4Q97	4Q97	4Q97
COMMENTS	*per drive.	*per drive. Double tower.	*Per drive.	*Per drive.	*Per drive.

MANUFACTURER	MICRO DESIGN INTERNATIONAL	MICRO DESIGN INTERNATIONAL	MICROTEST	MICROTEST	MICROTEST
CD FORMAT TOWER	USS-CD17 Ultraserve	USS-CD34 Ultraserve	Classic DiscPort	DiscPort Enterprise Server	DiscPort 2
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	OEM, DIST	OEM	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	Minichanger	Minichanger	CD-ROM	CD-ROM	CD/DVD-ROM
Relative speed	16X	16X	Drive dependent	12X	Drive dependent
Tower host/net software environment			Ethernet NetWare, NT	Ethernet, TR NetWare, NT	Ethernet NetWare, NT
Tower capacity (Gbytes) MIN	3.25	3.25	.65	4.6	.65
MAX	12	24	4.6	41/82	4.55
Minimum drives per tower			1	7	1
Maximum drives per tower			7	63/112	7
Tower interface to host/net	Ethernet	Ethernet	Ethernet, TR	Ethernet, TR	10BT, 100BT
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)	Pentium 166: 32	Pentium 166: 32		PentPro166:69MB	Pentium: 16
Tower HDD buffer, if used (GB)	9.1	18	N/A	2.3-9.1	Option
Hot swap drives	No	No	N/A	Yes	No
Redundant power supply	No	No	N/A	No	No
Minichangers	Yes	Yes	Option	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	1.2/12	1.2/2.0	1.2/12.0/2.0	1.2/12
drive (MB/sec)	2.4/16.7*	2.4/16.7*	Drive dependent	1.8	
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	.65	.65	
Average positioning time (msec)			Drive dependent	115	
Average access time (msec)			Drive dependent	125	
Drive models	Nakamichi	Nakamichi	Various	Toshiba	Various
TOWER SIZE: Inches: H x W x D	15.75 x 8.75 x 17.5	15.75 x 8.75 x 17.5	12 x 12 x 5.5	Configuration dependent	
POWER: (Watts or KVA)			35 watts	300 watts	
FIRST CUSTOMER SHIPMENT	1998	1998	1997	4Q96	1998
COMMENTS	*Hard drive output rate.	*Hard drive output rate.	Server controller.	Hard disk can emulate CD-ROMS	Server controller. Supports external hard drives.

MANUFACTURER	MICROTEST	MICROTEST	MICROTEST	MICROTEST	MICROTEST
CD FORMAT TOWER	DiscPort PRO	DiscPort Tower	DiscPort VT	DiscPort XL	DiscZerver
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD/DVD-ROM	CD-ROM	CD/DVD-ROM
Relative speed	Drive dependent	4X, 8X, 12X	Drive dependent	Drive dependent	Drive dependent
Tower host/net software environment	Ethernet NetWare, NT	Ethernet, TR NetWare, NT	Ethernet NetWare, NT	Ethernet NetWare, NT	Ethernet NetWare, NT
Tower capacity (Gbytes) MIN	.65	4.6	.65	.65	.65/4.7
MAX	9.2	9.2	4.55	4.6	4.55/32.9
Minimum drives per tower	1	7	1	1	4
Maximum drives per tower	14	14	7	7	7
Tower interface to host/net	Ethernet	Ethernet, TR	10BT, 100BT	Ethernet	10BT, 100BT
Drive interface	SCSI-2	SCSI-2	SCSI	SCSI-2	SCSI/IDE
Cache size (min, max: MB)					
Features:					
Processor type & memory (MB)		N/A	Pentium: 16		Pentium: 16
Tower HDD buffer, if used (GB)	N/A	N/A	4.3/8.4	N/A	4.3/8.4
Hot swap drives	N/A	N/A	No	N/A	No
Redundant power supply	N/A	N/A	No	N/A	No
Minichangers	Option	Option	Option	Option	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2/2.0	1.2/12	1.2/2.0	1.2/12
drive (MB/sec)	Drive dependent	Drive dependent		Drive dependent	
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65/4.7	.65	.65/4.7
Average positioning time (msec)	Drive dependent	Drive dependent		Drive dependent	
Average access time (msec)	Drive dependent	Drive dependent		Drive dependent	
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	12 x 12 x 5.5	12 x 20 x 25		12 x 12 x 5.5	
POWER: (Watts or KVA)	35 watts	400 watts		35 watts	
FIRST CUSTOMER SHIPMENT	2Q95	4Q95	1998	3Q96	1998
COMMENTS	Server controller.	Available without drives.	Server controller. Includes caching software.	Server controller.	Server controller. Available without drives.

MANUFACTURER	NEWTECH	OPEN STORAGE SOLUTIONS	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL
CD FORMAT TOWER	NCDserver-35/TX	OpenNet	Maxtet 33X	Maxtet/CD	Maxtet/CD Mini
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST, OEM	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Net	Network	Host	Host	Host
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	Minichanger
Relative speed	16X	Drive dependent	33X**	24X, 32X	16X
Tower host/net software environment	Network Netware,NT,UNIX Windows, Other	Ethernet Various	SCSI host Windows, DOS, OS/2,Apple,oth.	SCSI host Windows, Apple NT, Novell, oth	SCSI host Windows, Apple NT, Novell, oth
Tower capacity (Gbytes) MIN		.65	5.5	5.5	26
MAX	22.75	4.55	44	44	26
Minimum drives per tower	--	1	8	8	8
Maximum drives per tower	7	7	64*	64*	8
Tower interface to host/net	Ethernet 10 BT/100BT	Ethernet	SCSI-2	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)		2, 32	5.5, 44		
Features:					
Processor type & memory (MB)	32 bit RISC:2MB	32 bit RISC	--	--	--
Tower HDD buffer, if used (GB)		--	Yes	--	--
Hot swap drives		No	Yes	Yes	Yes
Redundant power supply		No	--	--	--
Minichangers		No	No	No	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	1.2	9**	5.0	1.2
drive (MB/sec)	1.5-2.4	Drive dependent	9**	3.6, 4.8	1.8-2.4
DRIVES: Nominal capacity/drive (GB)	3.25	.65	.65	.65	3.25
Average positioning time (msec)	130				
Average access time (msec)		Drive dependent	8**	85	120
Drive models	Nakamichi	Various	Various	Various	Nakamichi MJ5.16SI
TOWER SIZE: Inches: H x W x D	15.4 x 7.1 x 13.8		Configuration dependent	Configuration dependent	18 x 14 x 13
POWER: (Watts or KVA)	49 watts		300 watts	300-1800 watts	300 watts
FIRST CUSTOMER SHIPMENT	1998	1997	1997	1994	1997
COMMENTS	Axis controller	Axis controller	*Rack mount. **With HDD caching.	*Rack mount.	

MANUFACTURER	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	OPTICAL ACCESS INTERNATIONAL	OPTICS STORAGE
CD FORMAT TOWER	Netserve/33X	Netserve/CD	Netserve/CD Mini 40	Nightshade	OPTICS-SERVE
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	OEM	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	33X**	24X, 32X	16X	Drive dependent	12X
Tower host/net software environment	Ethernet Windows, DOS, OS/2,Apple,oth.	Ethernet Windows, DOS, OS/2,Apple,oth.	Ethernet Windows, Apple DOS, OS/2, oth.	Ethernet	Windows, UNIX, DOS, Apple, OS/2
Tower capacity (Gbytes) MIN	5.5	5.5	26	--	4.55
MAX	44	44	26	--	9.1
Minimum drives per tower	8	8	8	1	7
Maximum drives per tower	64*	64*	8	14	14
Tower interface to host/net	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet 10BT, 10B2
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	80386EX:16-64	Inteli960:16-64	i960	
Tower HDD buffer, if used (GB)	Yes	Option	--	Option	
Hot swap drives	Yes	Yes	Yes	Option	No
Redundant power supply	--	--	--	--	No
Minichangers	No	No	Yes	--	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2	1.2	1.2	1.2
drive (MB/sec)	9**	3.6, 4.8	2.4	Drive dependent	1.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	3.25	.65	.65
Average positioning time (msec)					150
Average access time (msec)	8**	85	120	Drive dependent	
Drive models	Various	Various	Nakamichi MJ5.16SI	Various	Optics Storage
TOWER SIZE: Inches: H x W x D	Configuration dependent	Configuration dependent	18 x 14 x 13		17 x 7 x 15.75
POWER: (Watts or KVA)	300-1800 watts	300 watts	300 watts		
FIRST CUSTOMER SHIPMENT	1997	1997	1997		
COMMENTS	*Rack mount. **With HDD caching.	*Rack mount.			

MANUFACTURER	ORNETIX	ORNETIX	ORNETIX	PLEXTEC	PLEXTEC
CD FORMAT TOWER	HyperLinQ Miniserver	Platinum HyperTower	Titanium HyperTower	CD-LAN-14XX CD-LAN-E-14XX	CD-LAN-21XX
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM, other	Minichanger	Minichanger	CD-ROM	CD-ROM
Relative speed	55X*	16X	16X	24X, 32X	24X, 32X
Tower host/net software environment	Ethernet, other Novell, Windows DOS, OS/2, Web	Ethernet NetWare, Windows	Ethernet NetWare, Windows	Ethernet, TR Various	Ethernet, TR Various
Tower capacity (Gbytes) MIN	Drive dependent			.65	.65
MAX	Drive dependent	3.25*	22.75*	9.1	21.7
Minimum drives per tower	7	1	7	1	1
Maximum drives per tower	14	1	7	14	21
Tower interface to host/net	Ethernet, TR	Ethernet Token Ring	Ethernet Token Ring	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)		8-128	8-128	--	--
Tower HDD buffer, if used (GB)		4	9	--	--
Hot swap drives	--	No	No	No	No
Redundant power supply	--	No	No	No	No
Minichangers	--	Yes	Yes	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0/2.0	1.2/12/2	1.2/12/2	1.2/12.0/2.0	1.2/12.0/2.0
drive (MB/sec)	8.25*			3.6/4.8	3.6/4.8
DRIVES: Nominal capacity/drive (GB)	Drive dependent	3.25	3.25	.65	.65
Average positioning time (msec)	Drive dependent				
Average access time (msec)	Drive dependent	120	120	Drive dependent	Drive dependent
Drive models	Various	Nakamichi	Nakamichi	Various	Various
TOWER SIZE: Inches: H x W x D	1.61 x 5.75 x 8.53	19.5 x 8.5 x 19.5	25 x 16.75 x 20		
POWER: (Watts or KVA)	25 watts	200 watts	300 watts		
FIRST CUSTOMER SHIPMENT	2Q97	3Q98	3Q98	1996	1996
COMMENTS	Miniserver. *HDD buffered.	1 to 5 hard drives. *Plus hard drive capacity.	1 to 5 hard drives. *Plus hard drive capacity.		

MANUFACTURER	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC
CD FORMAT TOWER	CD-LAN-E-28XX	CD-LAN-JA-14XX	CD-LAN-JA-21XX	CD-LAN-JA-28XX	CD-LAN-R
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	Minichanger	Minichanger	Minichanger	CD-ROM
Relative speed	24X, 32X	16X	16X	16X	24X, 32X
Tower host/net	Ethernet, TR	Ethernet	Ethernet	Ethernet	
software environment	Various	Various	Various	Various	
Tower capacity (Gbytes) MIN	.65	3.25	3.25	3.25	
MAX	18.2	45.5	68.25	91	
Minimum drives per tower	1	1	1	1	7
Maximum drives per tower	28	14	21	28	56
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	No	Yes	Yes	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)	3.6/4.8	2.4	2.4	2.4	3.6/4.8
DRIVES: Nominal capacity/drive (GB)	.65	3.25	3.25	2.6/3.0	.65
Average positioning time (msec)					
Average access time (msec)	Drive dependent	120	120	Drive dependent	Drive dependent
Drive models	Various	Nakamichi	Nakamichi	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.

MANUFACTURER	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC
CD FORMAT TOWER	CDJA-14XX	CDJA-7XX	CDT-14XX CDT-E-14XX	CDT-28XX	CDT-7XX
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Host
Drive type	Minichanger	Minichanger	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	16X	24X, 32X	24X, 32X	24X, 32X
Tower host/net	Ethernet, TR	Ethernet, TR	SCSI host	SCSI host	SCSI host
software environment	Various	Various	Various	Various	Various
Tower capacity (Gbytes) MIN	3.25	3.25	.65	.65	.65
MAX	42	21	9.1	18.2	4.55
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	14	7	14	28	7
Tower interface to host/net	Ethernet, TR	Ethernet, TR	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)	--	--	Option	Option	Option
Hot swap drives	No	No	No	Option	No
Redundant power supply	No	No	No	Option	No
Minichangers	Yes	Yes	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12.0/2.0	1.2/12.0/2.0	10.0	10.0	10.0
drive (MB/sec)	2.4	2.4	3.6/4.8	3.6/4.8	3.6/4.8
DRIVES: Nominal capacity/drive (GB)	2.6/3.0	2.6/3.0	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	120	120	Drive dependent		
Drive models	Nakamichi	Nakamichi	Various	Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	1996	1996	1996	1997	1996
COMMENTS	Rack mount option.	Rack mount option.		Rack mount option.	

MANUFACTURER	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTEC	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	DMAX-28XX	IDMAX-14XX IDMAX-E-14XX	IDMAX-7XX	PlexConnect	CD-20X4
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Network	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	24X, 32X	24X, 32X	24X, 32X	24X, 32X	20
Tower host/net software environment	SCSI host Various	SCSI host Various	SCSI host Various	Ethernet Various	SCSI host
Tower capacity (Gbytes) MIN	.65	.65	.65	4.55	2.6
MAX	18.2	9.1	4.55	18.2	4.55
Minimum drives per tower	1	1	1	7	4
Maximum drives per tower	28	14	7	28	7
Tower interface to host/net	SCSI-2	SCSI-2	SCSI-2	Ethernet, TR	SCSI
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)				Drive dependent	.512
Features:					
Processor type & memory (MB)		--	--	32 bit RISC: 2	--
Tower HDD buffer, if used (GB)		--	--	6.5-32.5	--
Hot swap drives	Option	Option	Option	Option	Yes
Redundant power supply	Option	Option	Option	Yes	
Minichangers	No	No	No	Option	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	10.0	10.0	1.2/12/2	10
drive (MB/sec)	3.6/4.8	3.6/4.8	3.6/4.8	3.6/4.8	3
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)					90
Average access time (msec)				Drive dependent	95
Drive models	Various	Various	Various	Various	PX-20TS
TOWER SIZE: Inches: H x W x D	32.6 x 22 x 25	32.6 x 14.2 x 25	25.4 x 19 x 25	25.4 x 19 x 25	12 x 8.5 x 17
POWER: (Watts or KVA)	300 watts	300 watts	300 watts	300 watts	
FIRST CUSTOMER SHIPMENT	1997	1996	1996	1997	
COMMENTS	Rack mount option.		Rack mount option.	Many configurations.	

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	CD-20X7	NPA-32-CS-7	NPA-32-TS-7	NPA-32CS-14-100	NPA-32CS-7-100
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	20	32X	32X	32X	32X
Tower host/net software environment	SCSI host	Ethernet NT, Windows, UNIX, Web	Ethernet NT, Windows, UNIX, Web	Ethernet NT, Windows, UNIX, Web	Ethernet NT, Windows, UNIX, Web,other
Tower capacity (Gbytes) MIN	4.55	4.55	4.55	4.55	4.55
MAX	4.55	4.55	4.55	9.1	4.55
Minimum drives per tower	7	7	7	7	7
Maximum drives per tower	7	7	7	14	7
Tower interface to host/net	SCSI	10BT	10BT	10BT, 100BT	10BT, 100BT
Drive interface	SCSI-2	Ultra SCSI	Ultra SCSI	Ultra SCSI	Ultra SCSI
Cache size (min, max: MB)	.512	2, 32	2, 32	2, 32	2, 32
Features:					
Processor type & memory (MB)	--	RISC: 32	RISC: 32	RISC: 32	RISC: 32
Tower HDD buffer, if used (GB)	--	--	--	--	3 or >
Hot swap drives	Yes	Yes	Yes	Yes	Yes
Redundant power supply		No	No	No	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10	1.2	1.2	1.2/12	1.2/12
drive (MB/sec)	3	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	90	80	80	80	80
Average access time (msec)	95	85	85	85	85
Drive models	PX-20TS	PX-32-CS	PX-32-TS	PX-32-CS	PX-32-CS
TOWER SIZE: Inches: H x W x D	12 x 8.5 x 17	17.6 x 8.5 x 15	17.6 x 8.5 x 15	17.6 x 8.5 x 15	17.6 x 8.5 x 15
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS		Axis network server.	Axis network server.		Axis network server.

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	NPA-32TS-7-100	NPA2-32-CS-7	NPA2-32-TS-7	NPA2-32TS-14-100	NPA2-32TS-7-100
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	32X	32X	32X	32X	32X
Tower host/net software environment	Ethernet NT, Windows, UNIX, Web	Ethernet NT, Windows	Ethernet NT, Windows	Ethernet NT, Windows, UNIX, Web,other	Ethernet NT, Windows, UNIX, Web,other
Tower capacity (Gbytes) MIN	4.55	4.55	4.55	4.55	4.55
MAX	4.55	9.1	9.1	9.1	9.1
Minimum drives per tower	7	7	7	7	7
Maximum drives per tower	7	14	14	14	14
Tower interface to host/net	10BT, 100BT	10BT	10BT	10BT, 100BT	10BT, 100BT
Drive interface	Ultra SCSI	Ultra SCSI	Ultra SCSI	Ultra SCSI	Ultra SCSI
Cache size (min, max: MB)	2, 32	2, 32	2, 32	2, 32	2, 32
Features:					
Processor type & memory (MB)	RISC: 32	RISC:	RISC:	RISC: 32	RISC:
Tower HDD buffer, if used (GB)	3 or >	--	--	--	--
Hot swap drives	Yes	Yes	Yes	Yes	Yes
Redundant power supply	No	No	No	No	No
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	1.2	1.2	1.2/12	1.2/12
drive (MB/sec)	4.8	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	80	80	80	80	80
Average access time (msec)	85	85	85	85	85
Drive models	PX-32-TS	PX-32-CS	PX-32-TS	PX-32-TS	PX-32-TS
TOWER SIZE: Inches: H x W x D	17.6 x 8.5 x 15	17.6 x 8.5 x 15	17.6 x 8.5 x 15	17.6 x 8.5 x 15	17.6 x 8.5 x 15
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS	Axis network server.	2 SCSI ports: 7 optional drives.	2 SCSI ports: 7 optional drives.		2 SCSI ports: 7 optional drives.

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	PS-20TS-2	PS-20TS-2-2NNW	PS-20TS-2IXS	PT-32CS-X4	PT-32CS-X7
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	20X	20X	20X	32	32
Tower host/net software environment	Ethernet	Ethernet Netware	Ethernet Netware, NT	SCSI host Netware, NT	SCSI host
Tower capacity (Gbytes) MIN	4.55	4.55	4.55	2.6	4.55
MAX	36.4	36.4	36.4	4.55	4.55
Minimum drives per tower	7	7	7	4	7
Maximum drives per tower	56	56	56	7	7
Tower interface to host/net	Ethernet	Ethernet	Ethernet	SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	Ultra SCSI	Ultra SCSI
Cache size (min, max: MB)	.512	.512	.512	.512	.512
Features:					
Processor type & memory (MB)	Pentium	Pentium	Pentium	--	--
Tower HDD buffer, if used (GB)	3 or >	3 or >	.032	--	--
Hot swap drives	Yes	Yes	Yes	Yes	Yes
Redundant power supply	Yes	Yes	Yes	No	
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12	1.2/12	1.2/12	20	20
drive (MB/sec)	3	3	3	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	90	90	90	80	80
Average access time (msec)	95	95	95	85	85
Drive models	PX-20TS	PX-20TS	PX-20TS	PX-32CS	PX-32CS
TOWER SIZE: Inches: H x W x D	13 x 17 x 15.25	13 x 17 x 15.25	13 x 17 x 15.25	12 x 8.5 x 17	12 x 8.5 x 17
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
CD FORMAT TOWER	PT-32TS-X4	PT-32TS-X7	PT-IXS-32CS-X4	PT-IXS-32CS-X4	PT-IXS-32CS-X7
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	32	32	32	32	32
Tower host/net software environment	SCSI host Netware, NT	SCSI host Netware, NT	SCSI host	SCSI host	SCSI host
Tower capacity (Gbytes) MIN	2.6	4.55	2.6	2.6	4.55
MAX	4.55	4.55	4.55	4.55	4.55
Minimum drives per tower	4	7	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
Drive interface	Ultra SCSI	Ultra SCSI	Ultra SCSI	Ultra SCSI	Ultra SCSI
Cache size (min, max: MB)	.512	.512	.512	.512	.512
Features:					
Processor type & memory (MB)	--	--	PC	PC	PC
Tower HDD buffer, if used (GB)	--	--	PC	PC	--
Hot swap drives	Yes	Yes	Yes	Yes	Yes
Redundant power supply	No	No			
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	20	20	20	20	20
drive (MB/sec)	4.8	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	80	80	80	80	80
Average access time (msec)	85	85	85	85	85
Drive models	PX-32TS	PX-32TS	PT-32CS	PT-32CS	PT-32CS
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	12 x 8.5 x 17
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	PT-IXS-32TS-X7	Replex	14 Ethernet-2 CD Tower	14 Plus CD Tower	14 Token Ring-2 CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST		DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Network	Host	Network
Drive type	CD-ROM	CD-R, CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	32	8X-12X WR,4X RD	16X, 32X	16X, 32X	16X, 32X
Tower host/net software environment	SCSI host	SCSI host	PC NetWare,DOS,NT OS/2,UNIX,Wind.	PC NetWare, DOS, NT, OS/2, Wind.	PC NetWare,DOS,NT OS/2,UNIX,Wind.
Tower capacity (Gbytes) MIN	4.55	2.6	4.5	4.5	4.5
MAX	4.55	2.6	9.1	9.1	9.1
Minimum drives per tower	7	4	7	7	7
Maximum drives per tower	7	4	14	14	14
Tower interface to host/net	SCSI-2	SCSI	Ethernet	SCSI-2	Token Ring
Drive interface	Ultra SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.512	2000	.256	.256	.256
Features:					
Processor type & memory (MB)	PC	--	Proprietary	--	Proprietary
Tower HDD buffer, if used (GB)	PC	--		--	
Hot swap drives	Yes	Yes	No	No	No
Redundant power supply			Yes	No	Yes
Minichangers	No	No	Option	No	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	20	10	1.2	10.0	2.0
drive (MB/sec)	4.8	.6 WR/1.8 RD	2.4/4.8	2.4/4.8	2.4/4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	80				
Average access time (msec)	85	190	150/90	150/90	150/90
Drive models	PT-32TS	PX-R412			
TOWER SIZE: Inches: H x W x D	12 x 8.5 x 17		18.75 x 8.75 x 13	22.4 x 15.5 x 17.8	22.4 x 15.5 x 17.8
POWER: (Watts or KVA)			369 watts	369 watts	369 watts
FIRST CUSTOMER SHIPMENT		1998	2/96	4/96	4/96
COMMENTS		3 CD-R drives and 1 CD-ROM drive.			

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	28 Plus CD Tower	28 Server CD Tower	7 Ethernet CD Tower	7 Mac CD Tower	7 Plus CD Tower
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Network	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X, 32X	16X, 32X	16X, 32X	16X, 32X	16X, 32X
Tower host/net software environment	PC NetWare, DOS, OS/2, NT, UNIX	PC NetWare, DOS, OS/2, NT, UNIX	Win., NT, OS/2, NetWare, UNIX	Apple System 7 or >	SCSI host Win., NT, OS/2, NetWare, UNIX
Tower capacity (Gbytes) MIN	4.5	4.5	.65	1.3	1.3
MAX	18.2	18.2	4.5	4.5	4.5
Minimum drives per tower	7	7	1	2	2
Maximum drives per tower	28	28	7	7	7
Tower interface to host/net	SCSI-2	Enet,TR,other	Ethernet	SCSI	SCSI
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)	--	PII 400:64-384	Proprietary	--	--
Tower HDD buffer, if used (GB)	--	16	No	No	No
Hot swap drives	No	No	No	No	No
Redundant power supply	Yes	Yes	No	No	No
Minichangers	No	Option	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	1.2/2.0/12.0	1.2	4.2/5.0	10
drive (MB/sec)	2.4/4.8	2.4/4.8	2.4/4.8	2.4/4.8	2.4/4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)					
Average access time (msec)	150/90	150/90	150/90	150/90	150/90
Drive models					
TOWER SIZE: Inches: H x W x D	33.5 x 17.5 x 26	33.5 x 17.5 x 26	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)	400 watts	400 watts	106 watts	106 watts	106 watts
FIRST CUSTOMER SHIPMENT	7/97	7/97	8/94	6/94	6/94
COMMENTS					

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	7 Subsystem CD Tower	7 Token Ring CD Tower	CCA35-E2	CCA70-E2	CD FORCE 14
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	Minichanger	Minichanger	CD-ROM
Relative speed	16X, 32X	16X, 32X	16X	16X	32X
Tower host/net software environment	SCSI host Win., NT, OS/2, NetWare, UNIX	Win., NT, OS/2, NetWare, UNIX	Ethernet NT, Novell	Ethernet NT, Novell	PC NetWare,DOS,NT OS/2, UNIX
Tower capacity (Gbytes) MIN	1.3	.65	22.75	45.5	4.5
MAX	4.5	4.5	22.75	45.5	9
Minimum drives per tower	2	1	7	14	7
Maximum drives per tower	7	7	7	14	14
Tower interface to host/net	SCSI	Token Ring	Ethernet	Ethernet	E'net,TR,C/FDDI
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	--	Proprietary	--	--	PII 400:64-384
Tower HDD buffer, if used (GB)	No	No	--	--	8-16
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	Yes
Minichangers	No	No	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10	2.0	1.2	1.2	
drive (MB/sec)	2.4/4.8	2.4/4.8	2.4	2.4	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	3.25	3.25	.65
Average positioning time (msec)			220	220	115/99
Average access time (msec)	150/90	150/90			
Drive models			Nakamichi	Nakamichi	Various
TOWER SIZE: Inches: H x W x D	18.75 x 8.75 x 13	18.75 x 8.75 x 13	18.75 x 8.75 x 13	22.4 x 15.5 x 17.8	22.4 x 15.5 x 17.8
POWER: (Watts or KVA)	106 watts	106 watts	106 watts	369 watts	369 watts
FIRST CUSTOMER SHIPMENT	10/93	1/95	7/98	7/98	7/96
COMMENTS					

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	CD FORCE 28	CD FORCE Rax-63	CD Server 14	CD Server 28	CD Tower Rax
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	32X	32X	32X	32X	32X
Tower host/net 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,NT OS/2, UNIX	PC NetWare, DOS, OS/2, NT, UNIX
Tower capacity (Gbytes) MIN	4.5	4.5			4.6
MAX	18.2	40.9			38.4
Minimum drives per tower	7	7	7	7	7
Maximum drives per tower	28	210	14	28	210
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	Enet,TR,other
Drive interface	SCSI	SCSI-2	SCSI	SCSI	SCSI-2
Cache size (min, max: MB)	.256	.256	.256	.256	.256
Features:					
Processor type & memory (MB)	PII 400:64-384	PII 400:64-384	Pent.200:16-128	PII 400:64-384	PII 400:64-384
Tower HDD buffer, if used (GB)	8-16	--	--	--	Yes
Hot swap drives	No	--	No	No	No
Redundant power supply	Yes	--	No	Yes	Yes
Minichangers	Yes	Option	Option	Option	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)		1.2/12/2/20			1.2/2.0/12.0
drive (MB/sec)	4.8	4.8	4.8	4.8	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	10/9	115/99	10/9	115/99	115
Average access time (msec)					
Drive models	Various	Various	Various	Various	Various
TOWER SIZE: Inches: H x W x D	33.5 x 17.5 x 26	84 x 22 x 34	22.4 x 15.5 x 17.8	33.5 x 17.5 x 26	
POWER: (Watts or KVA)	400 watts	1400 watts	369 watts	400 watts	1400 watts
FIRST CUSTOMER SHIPMENT	7/97	4/96	6/96	7/97	5/95
COMMENTS		Rack mount.	Third party software.	Third party software.	Rack mount.

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	CD Tower-E2 CD Tower-T2	CD-R/5D	CD/DVD FORCE 14	CD/DVD FORCE 28	DataFORCE 110
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	OEM, DIST.	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Network	Network	Network
Drive type	CD-ROM	CD-R	DVD-ROM, CD-ROM	CD-ROM, DVD-ROM	Minichanger
Relative speed	16X, 32X	4X	1X/16X*	32X,24X,1X	16X
Tower host/net software environment	Ethernet DOS, NT OS/2, UNIX	SCSI host Windows, NT	PC NetWare, OS/2, Win., NT, UNIX	NetWare, NT	Ethernet, TR, NT, NetWare, OS/2, other
Tower capacity (Gbytes) MIN	.65		32.9	4.55	
MAX	9.1	3.25	65.8	131.6	6.5
Minimum drives per tower	1	5	7	7	1
Maximum drives per tower	14	5	14	28	2
Tower interface to host/net	Ethernet	SCSI-2	E'net,TR,C/FDDI	E'net,TR,other	Ethernet, TR
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256	1000	128/256*	.128/.256*	.256
Features:					
Processor type & memory (MB)	--	--	No	Pentium	Pentium: 32
Tower HDD buffer, if used (GB)	--	--	No	Option	*
Hot swap drives	No	No	No	No	
Redundant power supply	No	No	No	Yes	
Minichangers	No	No	Option	Option	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	10	1.2/2.0/12.0	1.2/2/12	1.2/12/2.0
drive (MB/sec)	2.4, 4.8	.6	1.38	4.8, 3.6/1.38	2.4
DRIVES: Nominal capacity/drive (GB)	.65	.65	4.7/.65*	4.7/.65*	3.25
Average positioning time (msec)	Drive dependent		200	Drive dependent	10*
Average access time (msec)	150/90	165	230/99*	91-130	
Drive models	Various			Various	Nakamichi
TOWER SIZE: Inches: H x W x D	20.2 x 15.5 x 17.82		22.4 x 15.5 x 17.8	30 x 20 x 20	19 x 7.5 x 17
POWER: (Watts or KVA)			369 watts		
FIRST CUSTOMER SHIPMENT	9/97	2Q98	6/97	9/97	1997
COMMENTS			Can mix CD-ROM and DVD-ROM. *CD-ROM.	5 disc minichanger option. *CD-ROM.	*5400 RPM HDD.

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY
CD FORMAT TOWER	DataFORCE 120	DataFORCE 140	Hyper CD FORCE Rax	Hyper CD FORCE 12	Hyper CD FORCE 24
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	Minichanger	Minichanger	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	16X	60X, 266X*	60X, 266X*	60X, 266X*
Tower host/net software environment	Ethernet, TR, NT, NetWare, OS/2, other	Ethernet, TR, NT, NetWare, OS/2, other	PC NetWare, OS/2, Win., NT, UNIX	PC NetWare, OS/2, Win., NT, UNIX	PC NetWare,DOS,NT OS/2, UNIX
Tower capacity (Gbytes) MIN		3.25	4.6	3.9	4.5
MAX	13	6.5	40.9	7.8	15.6
Minimum drives per tower	1	1	7	6	7
Maximum drives per tower	2	2	63	12	24
Tower interface to host/net	Ethernet, TR	Ethernet, TR	E'net,TR,C/FDDI	E'net,TR,C/FDDI	E'net,TR,C/FDDI
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)	Pentium: 32	Pentium 200: 32	Pent.200:16-128	No	Pent.200:16-128
Tower HDD buffer, if used (GB)	*	*	5	4	4
Hot swap drives		No	Yes	No	No
Redundant power supply		No	Yes	No	Yes
Minichangers	Yes	Yes	Option	Option	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	1.2/12/2.0	1.2/12.0	1.2/2.0/12.0	1.2/2.0/12.0
drive (MB/sec)	2.4	2.4	.6/1.2/1.8	5.4/7.95*	5.4/7.95*
DRIVES: Nominal capacity/drive (GB)	3.25	3.25	.65	.65	.65
Average positioning time (msec)	10*	10*	10/9	10/9	10/9
Average access time (msec)					
Drive models	Nakamichi	Nakamichi	Various	Various	Various
TOWER SIZE: Inches: H x W x D	23.5 x 7.5 x 16	19 x 7.5 x 17	84 x 22 x 34	22.4 x 15.5 x 17.8	33.5 x 17.5 x 26
POWER: (Watts or KVA)			1400 watts	369 watts	400 watts
FIRST CUSTOMER SHIPMENT	5/98	3Q98	9/96	10/96	7/97
COMMENTS	*5400 RPM HDD.	*5400 RPM HDD.	*Rigid disk drive buffering Rack mount.	*Rigid disk drive buffering	*Rigid disk drive buffering

MANUFACTURER	PROCOM TECHNOLOGY	PROCOM TECHNOLOGY	REXAS	REXAS	REXAS
CD FORMAT TOWER	Hyper CD FORCE 18	Hyper CD-100X	CDMR451	CDRS100	CDRS200
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Host
Drive type	CD-ROM	CD-ROM	CD-ROM, CD-R	CD-ROM	CD-ROM
Relative speed	60X, 266X*	100X*		16X and up	16X and up
Tower host/net software environment	PC NetWare, OS/2, Win., NT, UNIX		SCSI host Windows	SCSI host Windows, UNIX	SCSI host Windows, UNIX
Tower capacity (Gbytes) MIN	7.8	4.5	.65	.65	.65
MAX	11.7	41	4.25	4.55	4.55
Minimum drives per tower	12	7	5	1	1
Maximum drives per tower	18	63	245*	7	7
Tower interface to host/net	E'net,TR,C/FDDI	E'net,TR,C/FDDI		SCSI-2	SCSI-2
Drive interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	.256				
Features:					
Processor type & memory (MB)	No	Pent.200:16-128	--	--	--
Tower HDD buffer, if used (GB)	4	5	--	--	--
Hot swap drives	No	Yes	No	No	Yes
Redundant power supply	No	Yes	No	Option	Yes
Minichangers	Option	Option	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/2.0/12.0	1.2/2/12	5	10.0	10.0
drive (MB/sec)	5.4/7.95*	15.5	.6 WR/2.4 RD	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65		.65	.65
Average positioning time (msec)	10/9			Drive dependent	Drive dependent
Average access time (msec)		7.5		Drive dependent	Drive dependent
Drive models	Various		Yamaha CDR400	Various	Various
TOWER SIZE: Inches: H x W x D	30.2 x 20 x 20	Configuration dependent	23.2 x 8.3 x 17.1	13.3 x 7.1 x 16.7	23.2 x 8.3 x 17.1
POWER: (Watts or KVA)	487 watts		.48 KVA	.3 KVA	.3 KVA
FIRST CUSTOMER SHIPMENT	12/96	4Q97	1998		
COMMENTS	*Rigid disk drive buffering	*Rigid disk drive buffering	*With expander.		

MANUFACTURER	REXAS	REXAS	REXAS	REXAS	SCINET
CD FORMAT TOWER	CDRS201	CDRS202	CDRS212	CDRS402	Disc Jockey
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Network	Host	Network
Drive type	CD-ROM,Minichr.	Minichanger	Minichanger	Minichanger	Minichanger
Relative speed	16X	16X	16X	16X	16X
Tower host/net software environment	NT, Windows	NT, Windows	Ethernet, NT,Win,Netware LAN Manager	UNIX	Ethernet, other NetWare, NT
Tower capacity (Gbytes) MIN					10.4
MAX	9.75	22.75	22.75	22.75	182
Minimum drives per tower					4
Maximum drives per tower	7	7	7	7	56
Tower interface to host/net	SCSI-2	SCSI-2	Ethernet	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)					Pentium: 4-128
Tower HDD buffer, if used (GB)					Yes
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	Yes	Yes	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5	5	1.2	5	1.2/12.0/2.0
drive (MB/sec)	2.4	2.4	2.4	2.4	2.4
DRIVES: Nominal capacity/drive (GB)	3.25/.65	3.25	3.25	3.25	3.25
Average positioning time (msec)					
Average access time (msec)		130	130	130	130
Drive models	Nakamichi, Other	Nakamichi	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D	23.2 x 8.3 x 17.1	23.2 x 8.3 x 17.1	23.2 x 8.3 x 17.1	23.2 x 8.3 x 17.1	
POWER: (Watts or KVA)	.3 KVA	.3 KVA	.3 KVA	.3 KVA	
FIRST CUSTOMER SHIPMENT					3Q98
COMMENTS	2 Minichanger. 5 CD-ROM.				

MANUFACTURER	SCINET	SCINET	SCINET	SCINET	SMART AND FRIENDLY
CD FORMAT TOWER	LS Series CD-Server	Series 2000 CD-Server	Series 5000 CD-Server	Series 700 CD-Server	CDD 14032
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	Drive dependent	Drive dependent	Drive dependent	Drive dependent	32X
Tower host/net software environment	Ethernet, other NetWare, NT	Ethernet, other NetWare, NT	Ethernet, other NetWare, NT	Ethernet, other NetWare, NT	Ethernet Novell, NT
Tower capacity (Gbytes) MIN	2.6	4.55	4.55	4.55	4.55
MAX	4.55	Drive dependent	Drive dependent	Drive dependent	9.1
Minimum drives per tower	4	7	7	7	7
Maximum drives per tower	7	56	56	42	14
Tower interface to host/net	Ethernet, TR	Ethernet, TR	Ethernet, TR	Ethernet, TR	Ethernet
Drive interface	SCSI-2/EIDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Cache size (min, max: MB)	63	128	128	128	
Features:					
Processor type & memory (MB)	486-66: 4-6	Pentium: 32-128	Pentium: 64-128	Pentium: 4-128	--
Tower HDD buffer, if used (GB)	Option	Yes	Yes	Yes	--
Hot swap drives	No	Yes	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	Option	Option	Option	Option	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
drive (MB/sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	4.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
Average access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	120
Drive models	Matsushita	Matsushita	Matsushita	Matsushita	
TOWER SIZE: Inches: H x W x D	26.4 x 8.3 x 17.3	37 x 21.1 x 29			
POWER: (Watts or KVA)	250 watts	600 watts	600 watts	300 watts	
FIRST CUSTOMER SHIPMENT	3/97	4/97	1998	3/96	
COMMENTS	Expandable to 28 drives.		Up to 280 disks with mini-changers installed.	Up to 254 disks with mini-changers installed.	

MANUFACTURER	SMART AND FRIENDLY	SMART AND FRIENDLY	SMART AND FRIENDLY	SMART AND FRIENDLY	SMART AND FRIENDLY
CD FORMAT TOWER	CDD 70032	CD Tower	CD-SmartNet	CDJ 20016	CDJ 35016
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Network	Host	Host
Drive type	CD-ROM	CD-ROM	Minichanger	Minichanger	Minichanger
Relative speed	32X	16X	16X	16X	16X
Tower host/net software environment	Ethernet Novell, NT	SCSI host Various	Ethernet Novell, NT	SCSI host Various	SCSI host Various
Tower capacity (Gbytes) MIN	.65	3.25	3.25		
MAX	4.55	9.1	3.25	16.25	22.75
Minimum drives per tower	1	5	1	4	7
Maximum drives per tower	7	14	1	4	7
Tower interface to host/net	Ethernet	SCSI-2	10BT, 100BT	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)	--	--	586: 16 MB	--	--
Tower HDD buffer, if used (GB)	--	--	40	--	--
Hot swap drives	No	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	Yes	No	Yes	Yes
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	5.0	1.2/12	5.0	5.0
drive (MB/sec)	4.8	1.2/2.4	4.8	2.4	2.4
DRIVES: Nominal capacity/drive (GB)	.65	.65	3.25	3.25	3.25
Average positioning time (msec)		Drive dependent			
Average access time (msec)	120	Drive dependent	120	120	120
Drive models		Various	Nakamichi	Nakamichi	Nakamichi
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT		1996		4Q97	4Q97
COMMENTS			Hard drive buffered Server		

MANUFACTURER	SMART AND FRIENDLY	SMART AND FRIENDLY	SMART AND FRIENDLY	SMS DATA PRODUCTS	SMS DATA PRODUCTS
CD FORMAT TOWER	CDJ 70016	CDT 40032	CDT 70032	1070 Tower	1070DP Tower-7
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Network	Network	Host	Network
Drive type	Minichanger	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X	32X	32X	12X	12X
Tower host/net software environment	SCSI host Various	Ethernet Novell, NT	Ethernet Novell, NT	SCSI host	Ethernet, Novell, NT
Tower capacity (Gbytes) MIN		.65	.65	1.3	2.6
MAX	45.5	2.6	4.55	4.6	4.6
Minimum drives per tower	14	1	1	2	4
Maximum drives per tower	14	4	7	7	7
Tower interface to host/net	SCSI-2	Ethernet	Ethernet	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	No	No	Option	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	1.2	1.2	5.0	1.2/2.0
drive (MB/sec)	2.4	4.8	4.8	1.8	1.8
DRIVES: Nominal capacity/drive (GB)	3.25	.65	.65	.65	.65
Average positioning time (msec)				Drive dependent	Drive dependent
Average access time (msec)	120	120	120	Drive dependent	Drive dependent
Drive models	Nakamichi			Various	Various
TOWER SIZE: Inches: H x W x D					
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT	4Q97				
COMMENTS					

MANUFACTURER	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS
CD FORMAT TOWER	10700P Tower-7/4	S70014	S70021	S70028	S7007NOV/NOVTR
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Host	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	8X, 12X	8X, 12X	8X, 12X	8X, 12X
Tower host/net software environment	SCSI host Novell, NT	SCSI host	SCSI host	SCSI host	Ethernet, TR Novell
Tower capacity (Gbytes) MIN	2.6	9.2	13.8		4.6
MAX	4.6				
Minimum drives per tower	4	14	21	28	7
Maximum drives per tower	7	14	21	21	7
Tower interface to host/net	Ethernet, TR	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	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	5.0	5.0	5.0	5.0	1.2/2.0
drive (MB/sec)	1.8	1.2, 1.8	1.2, 1.8	1.2, 1.8	1.2, 1.8
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
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)					
FIRST CUSTOMER SHIPMENT					
COMMENTS		CD-R option.	CD-R option.	CD-R option.	CD-R option.

MANUFACTURER	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SMS DATA PRODUCTS	SVEC COMPUTER
CD FORMAT TOWER	S7007NT	S70070PT	Series 3000 Millenia	Series 5000 Millenia	FD7300-CD
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Host	Host	Host	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X, 12X	8X, 12X	12X	12X	Drive dependent
Tower host/net software environment	Ethernet Windows NT	SCSI host	SCSI host Novell, UNIX, VINES, DOS	SCSI host Novell, UNIX, VINES, DOS	Ethernet, HTTP
Tower capacity (Gbytes) MIN	4.55	4.55	13.65	13.65	.65
MAX	4.55	4.55	40.95	127.4	7.8
Minimum drives per tower	7	7	21	63	1
Maximum drives per tower	7	7	63	196	12
Tower interface to host/net	Ethernet	SCSI-2	Ethernet, TR	Ethernet, TR	Ethernet
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)	--	--	Option: 4	Option: 4	--
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)	1.2	5.0	10.0	10.0	1.2
drive (MB/sec)	1.2, 1.8	1.2, 1.8	Drive dependent	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
Average positioning time (msec)	Drive dependent	Drive dependent			Drive dependent
Average access time (msec)	Drive dependent	Drive dependent			Drive dependent
Drive models	Various	Various	Toshiba	Toshiba	Various
TOWER SIZE: Inches: H x W x D					7 x 16.8 x 17.7
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					4Q97
COMMENTS	CD-R option.	CD-R option.			Rack mount.

MANUFACTURER	TAC SYSTEMS	TAC SYSTEMS	TAC SYSTEMS	TAC SYSTEMS	TAC SYSTEMS
CD FORMAT TOWER	CD MiniTower	CD Tower	LANRedi DataMart	MiniTower LANRedi	TowerDrive LANRedi
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Host	Host	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	16X, other	16X, other	16X, other	16X, other	16X, other
Tower host/net software environment	SCSI host	SCSI host	Ethernet Novell, NT, NFS, UNIX	Ethernet Novell, NT NFS, UNIX, Web	Ethernet Novell, NT, NFS, UNIX
Tower capacity (Gbytes) MIN	4.55	4.55	13.7	4.55	9.1
MAX	4.55	41	42	4.55	9.1
Minimum drives per tower	7	7	21	7	14
Maximum drives per tower	7	63	63	7	14
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)	.256	.256	.256	.256	.26
Features:					
Processor type & memory (MB)	--	--	--	--	--
Tower HDD buffer, if used (GB)	--	--	--	--	--
Hot swap drives	Option	No	Yes	No	No
Redundant power supply	Option	No	Yes	Yes	Yes
Minichangers	No	No	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	10.0	10.0	1.2/12/2.0	1.2/12/2.0	1.2/12/2.0
drive (MB/sec)	2.4, other	2.4, other	2.4, other	2.4, other	2.4, other
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	.65
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	15 x 6 x 15.5	30 x 6 x 15.5
POWER: (Watts or KVA)	250 watts	500 watts	500 watts	250 watts	250 watts
FIRST CUSTOMER SHIPMENT	1996	1996	1997	1997	1997
COMMENTS	Rack mount option. Custom configurations.	Custom configurations.	Host attach option. Axis controller.	Rack mount option. Axis controller.	Rack mount option. Axis controller.

MANUFACTURER	TAC SYSTEMS	TEAC	TEKRAM TECHNOLOGY	TEKRAM TECHNOLOGY	TEN X TECHNOLOGY
CD FORMAT TOWER	TwinTower LANRedi	CD-SERVER	CD-share	CS700	TenXpert
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	DIST	OEM	DIST	DIST
TOWER CONFIGURATION: Attachment	Network	Network	Network	Network	Network
Drive type	CD-ROM	CD-ROM	CD-ROM	CD-ROM	Various
Relative speed	16X, other	32X	12X, 16X		Drive dependent
Tower host/net software environment	Ethernet Novell, NT NFS, UNIX, Web	Ethernet OS/2, UNIX, NT Win 95	Ethernet NT, Netware Windows	Ethernet Windows, NT, Novell	Ethernet DOS, Windows, NT, UNIX
Tower capacity (Gbytes) MIN	4.55	4.55	.65	.65	Drive dependent
MAX	18.2	9.1	4.2	5.2	Drive dependent
Minimum drives per tower	7	7	1	1	--
Maximum drives per tower	28	14	8	8	--
Tower interface to host/net	Ethernet, TR	Ethernet	Ethernet 10BT/100BT	Ethernet 10BT/100BT	Ethernet 10BT
Drive interface	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI	SCSI-2
Cache size (min, max: MB)	.256			.128	--
Features:					
Processor type & memory (MB)	--	--	386/486:1/4 MB	386/486:1/4 MB	Intel 386EX: 4
Tower HDD buffer, if used (GB)	--	--	--	--	2, 4, 8
Hot swap drives	Yes	No	No	No	No
Redundant power supply	No	No	No	No	No
Minichangers	No	No	No	No	Option
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2/12/2.0	1.2	1.2, 12	1.2/12	1.2
drive (MB/sec)	2.4, other	4.8	1.8, 2.4	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65	.65	.65	.65	Drive dependent
Average positioning time (msec)	Drive dependent	85		Drive dependent	Drive dependent
Average access time (msec)	Drive dependent		1.8, 2.4	Drive dependent	Drive dependent
Drive models	Various	TEAC CD-532S	Various	Various	Drive dependent
TOWER SIZE: Inches: H x W x D	36 x 13 x 16		17.3 x 7.1 x 16.5	17.3 x 7.1 x 16.5	--
POWER: (Watts or KVA)	250 watts		300 watts	250 watts	--
FIRST CUSTOMER SHIPMENT	1997	1997	1998	2Q97	1Q96
COMMENTS	Rack mount option. Axis controller.	Distributed only in Germany.		Network server module.	Controller only.

MANUFACTURER	TEN X TECHNOLOGY	TEN X TECHNOLOGY	TODD ENTERPRISES	TODD ENTERPRISES	TODD ENTERPRISES
CD FORMAT TOWER	TenXpert-2/26r TenXpert-4	TenXpert-2/30p	Proline 7	Proline 4	VL14
DISK/TREND GROUP	51	51	51	51	51
MARKET	DIST	OEM	OEM, DIST	OEM, DIST	OEM, DIST
TOWER CONFIGURATION: Attachment	Network	Network	Host	Host	Host
Drive type	CD-R,Minichang.	Minichanger	CD/DVD-ROM	CD/DVD-ROM	CD/DVD-ROM
Relative speed	6X/4X, 16X	16X			
Tower host/net	Ethernet	Ethernet	SCSI host	SCSI host	SCSI host
software environment	DOS, Windows, NT, UNIX	DOS, Windows, NT, UNIX	Various	Various	Various
Tower capacity (Gbytes) MIN	3.9	3.25	.65/4.7	.65/4.7	.65/4.7
MAX	16.9	19.5	4.55/32.9	2.6/18.8	9.2/65.8
Minimum drives per tower	1	1	1	1	1
Maximum drives per tower	6	6	7	4	14
Tower interface to host/net	Ethernet 10BT	Ethernet 10BT	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/.512	.256/.512	.256/5.2
Features:					
Processor type & memory (MB)	Intel 386EX: 4	Intel 386EX: 4			--
Tower HDD buffer, if used (GB)	2	2			--
Hot swap drives	No	No	Yes	Yes	No
Redundant power supply	No	No	No	No	No
Minichangers	Yes	Yes	No	No	No
TOWER PERFORMANCE:					
Transfer rate: host/net (MB/sec)	1.2	1.2	5	5	5.0/10.0/10.0
drive (MB/sec)	1.2/2.4	2.4	Drive dependent	Drive dependent	.6/.9/1.2
DRIVES: Nominal capacity/drive (GB)		3.25	.65/4.7	.65/4.7	.65
Average positioning time (msec)			Drive dependent	Drive dependent	Drive dependent
Average access time (msec)	Drive dependent	120			
Drive models	Various	Nakamichi			
TOWER SIZE: Inches: H x W x D	18.75 x 8.75 x 13	18.75 x 8.75 x 13	15.2 x 6.75 x 15.2	9.25 x 6.75 x 5.2	28.5 x 8.75 x 17
POWER:(Watts or KVA)	85 watts	85 watts			
FIRST CUSTOMER SHIPMENT	1998	1998	1998	1998	
COMMENTS	Expandable to 16 drives. Also custom configurations.	Expandable to 15 drives. Also custom configurations.	Network attach option.	Network attach option.	Network attach option.

MANUFACTURER	TODD ENTERPRISES	TODD ENTERPRISES	TODD ENTERPRISES	VISION COMPUTERS	VISION COMPUTERS
CD FORMAT TOWER	VL28	VL4	VL7	NOVUS	STRADUS
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	DIST	DIST
TOWER CONFIGURATION: Attachment	Host	Host	Host	Network	Host
Drive type	CD/DVD-ROM	CD/DVD-ROM	CD/DVD-ROM	CD-ROM	CD-ROM
Relative speed				Various	Various
Tower host/net software environment	SCSI host Various	SCSI host Various	SCSI host Various	Ethernet	SCSI host
Tower capacity (Gbytes) MIN	.65/4.7	.65/4.7	.65/4.7	4.6	4.6
MAX	18.2/131.6	2.6/18.8	4.55/32.9	19.5	19.5
Minimum drives per tower	1	1	1	7	7
Maximum drives per tower	28	4	7	30	30
Tower interface to host/net	SCSI-2	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/.512	.256/.512	.256/.512		
Features:					
Processor type & memory (MB)	--	--	--	Pentium100:16MB	--
Tower HDD buffer, if used (GB)	--	--	--	1	--
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)	5.0/10.0/10.0	5.0/10.0/10.0	5.0/10.0/10.0	1.2	5.0
drive (MB/sec)	.6/.9/1.2	.6/.9/1.2	.6/.9/1.2	Drive dependent	Drive dependent
DRIVES: Nominal capacity/drive (GB)	.65/4.7	.65	.65/4.7	.65	.65
Average positioning time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average access time (msec)				Drive dependent	Drive dependent
Drive models				Various	Various
TOWER SIZE: Inches: H x W x D		9.25 x 6.75 x 15.2	15.2 x 6.75 x 15.2		
POWER: (Watts or KVA)					
FIRST CUSTOMER SHIPMENT					
COMMENTS	Network attach option.	Network attach option.	Network attach option.		

1998 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.

1998 DISK/TREND optical disk product groups

For the 1998 report, products are classified in nine groups.

CD format optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: DVD format read-only optical disk drives.
Group 22: CD/DVD format writable optical disk drives.

Read/write optical disk drives:

Group 23: Read/write optical disk drives, less than 4 gigabytes.
Group 24: Read/write optical disk drives, more than 4 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 or more cartridge capacity.

MANUFACTURER	ASACA	ASACA	ASACA	ASACA	ASACA
OPTICAL LIBRARY	AC-600	AC-800	AM-1450 DVD	AM-250 DVD	AM-750 DVD
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.65	.65	9.4	9.4	9.4
Cartridge type	Caddy	Caddy	None	None	None
DRIVE: Type	CD-ROM/CD-R	CD-ROM/CD-R	DVD/DVD-R	DVD/DVD-R	DVD/DVD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)			1100	200	600
Maximum disk capacity (units)	600	800	1500	300	800
Number of drives: Maximum	16	4	24	6	12
Interface: Library Drive	SCSI-2 RS232C	SCSI-2 RS232C	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	390	520	14100	2350	7520
Import/export module (disks)	19	19	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis/pivot	Y axis/pivot	Y axis/pivot
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	3.5	3.5	3.5	3.5	3.5
Spin-up + drive ready time (sec)	10	10	15	15	15
Spin-down time (sec)	1.5	1.5			
Average drive access time (msec)	85	85	120	120	120
Drive data transfer rate (MB/s)	2082-4828 KB	2082-4828 KB	2.76	2.76	2.76
FIRST CUSTOMER SHIPMENT			1998	1998	1998
COMMENTS			Disk Flip mechanism.	Disk Flip mechanism.	Disk Flip mechanism.

MANUFACTURER	ASACA	ASACA	ASACA	ASM	ASM
OPTICAL LIBRARY	AO-420	AO-560	AOL-626	CDR 100	CDR 200
DISK/TREND GROUP	53	53	53	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (GB)	1.3	1.3	1.3	.540	.540
Cartridge type	ISO	ISO	ISO	Caddy	Caddy
DRIVE: Type	Magneto Optic	Magneto Optic	Magneto Optic	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)				92	184
Maximum disk capacity (units)	420	560	626	100	200
Number of drives: Maximum	8	2	24	4	8
Interface: Library	SCSI-2	SCSI-2	RS232C	SCSI-2	SCSI-2
Drive	RS232C	RS232C		SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1092	1456	1627	54	108
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	2	2	2	1	1
Average media exchange time (sec)	3.5	3.5	3.5	4-6	4-6
Spin-up + drive ready time (sec)	5.5	5.5	5.5	Drive dependent	Drive dependent
Spin-down time (sec)	3.0	3.0	3.0	Drive dependent	Drive dependent
Average drive access time (msec)	35	35	35	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	4.6	4.6	4.6	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT				4/94	4/94
COMMENTS				Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY	CDR 300	CDR 500	CDR 1200	CDR 1300	CDR 1400
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.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)	276	460	675	1079	1431
Maximum disk capacity (units)	300	500	723	1143	1563
Number of drives: Maximum	12	20	18	24	44
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)	166	270	390	617	844
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	2	2	2
Average media exchange time (sec)	4-6		6-8	6-8	6-8
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	7/94	6/94	8/93	8/93	4/93
COMMENTS	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY	MO 20	ASM 12 WORM	MO 100	MO 1000	MO 150
DISK/TREND GROUP	52	53	53	53	53
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	300 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	1.3/2.6/5.2	15/12	1.3/2.6/5.2	1.3/2.6/5.2	1.3/2.6/5.2
Cartridge type	ANSI/ISO	Sony, Philips	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Write Once	Rewritable	Rewritable	Rewritable
Drive models	Sony, Nikon, HP Maxoptix		Sony, Nikon, HP Maxoptix	Sony, Nikon, HP Maxoptix	Sony, Nikon, HP Maxoptix
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	20 (4 drives)	34	94 (10 drives)	200 (24 drives)	126 (8 drives)
Maximum disk capacity (units)	26 (2 drives)	72	112 (2 drives)	1000 (2 drives)	162 (2 drives)
Number of drives: Maximum	4 (2 standard)	4*	10 (4 standard)	24	8 (4 standard)
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)	33.8/67.6/135.2	1080/864	146/291/582	1300/2600/5200	210/421/842
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	6	6	7	6-8	6-8
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	2/93	9/96	7/93	1993	1993
COMMENTS	Options: Barcode reader. Rigid disk drive.	*2 with Philips drives. Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
OPTICAL LIBRARY	MO 50	PD 100	PD 50	TrueWORM 100	TrueWORM 1000
DISK/TREND GROUP	53	53	53	53	53
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	1.3/2.6/5.2	Drive dependent	Drive dependent	.65	.65
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Write Once	Write Once
Drive models	Sony, Nikon, HP Maxopix	Matsushita	Matsushita	Pioneer U5101 Panasonic 7394Z	Pioneer U5101 Panasonic 7394Z
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	38 (8 drives)			94 (10 drives)	200 (3 drives)
Maximum disk capacity (units)	50 (2 drives)	100	50	112 (2 drives)	1000(22 drives)
Number of drives: Maximum	8 (2 standard)	4	2	10 (4 standard)	33
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)	72.5/145/290	66.8	33.4	65	650
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis			X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	6-8	6	6	7	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	1993			4/93	3/93
COMMENTS	Options: Barcode reader. Rigid disk drive.	Based on Matsushita model.	Based on Matsushita model.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.

MANUFACTURER	ASM	ASM	ASM	ATG	ATG
OPTICAL LIBRARY	TrueWORM 150	TrueWORM 20	TrueWORM 50	AC 16000	GF 6910
DISK/TREND GROUP	53	53	53	52	52
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	12"	12"
Nominal disk capacity (GB)	.65	.65	.65	10.2	10.2
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ATG	Proprietary
DRIVE: Type	Write Once	Write Once	Write Once	Write Once	Write Once
Drive models	Pioneer U5101 Panasonic 7394Z	Pioneer U5101 Panasonic 7394Z	Pioneer U5101 Panasonic 7394Z	GD 16000	GD 6001 GD 9001 GD 9001S
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	144 (10 drives)	20 (4 drives)	50 (4 drives)	1	6
Maximum disk capacity (units)	162 (2 drives)	26 (2 drives)	56 (2 drives)	6	6
Number of drives: Maximum	10 (4 standard)	4	4 (2 standard)	1	1
Interface: Library Drive	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-2, RS232C SCSI-2	SCSI-1 SCSI-2	SCSI SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	97.5	13	32.5	96	30.6
Import/export module (disks)	1	1	1	1 or 6	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	1	1
Average media exchange time (sec)	8	8	6	2.5	2.5
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	2.4	3
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	1.8	2
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	119	Drive dependent
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	3.3	1.0
FIRST CUSTOMER SHIPMENT	4/93	7/93	7/93	3Q96	1992
COMMENTS	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.	Options: Barcode reader. Rigid disk drive.		

MANUFACTURER		CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY		id100	INF250/2 Infinidisc	INF250/4 Infinidisc	INF250/6 Infinidisc	INF250/8 Infinidisc
DISK/TREND GROUP		50	50	50	50	50
MARKET		OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA:	Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
	Nominal disk capacity (GB)	.650/4.7	.650	.650	.650	.650
	Cartridge type	None	None	None	None	None
DRIVE:	Type	CD/DVD-ROM,CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R
	Drive models	32X,12X/4X	32X,12X/4X	32X,12X/4X	32X,12X/4X	32X,12X/4X
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	20	250	250	250	250
	Maximum disk capacity (units)	100	250	250	250	250
	Number of drives: Maximum	4	2	4	6	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)	65/470	162.5	162.5	162.5	162.5
	Import/export module (disks)	1/20	1	1	1	1
PERFORMANCE						
	Positioner type	Y axis	Rotary/ Y axis	Rotary/ Y axis	Rotary/ Y axis	Rotary/ Y axis
	Pickers per positioner	1	1	1	1	1
	Average media exchange time (sec)	8	10-15	10-15	10-15	10-15
	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)	4.8,1.8/.6	Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT		4Q97	4Q96	4Q96	4Q96	4Q96
COMMENTS						

MANUFACTURER	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY	INF500/2 Infinidisc	INF500/4 Infinidisc	InfiniDVD	Infiniwriter	id100/DVD
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650	.650	2.6	.650	2.6
Cartridge type	None	None	None	None	Magazine
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	DVD-RAM	CD-R	DVD-RAM
Drive models	32X,12X/4X	32X,12X/4X	Hitachi GF-1050	12X/4X CD-ROM 32X	Hitachi GF-1050
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	500	500	250	250	20
Maximum disk capacity (units)	500	500	500	250	100
Number of drives: Maximum	2	4	8	6	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)	325	325	1300	162.5	65/260
Import/export module (disks)	1	1	1	1	20
PERFORMANCE					
Positioner type	Rotary/ Y axis	Rotary/ Y axis	Rotary/ Y axis	Rotary/ Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	10-15	10-15	10-15	10-15	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	120	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	1.5	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT				5/97	3Q98
COMMENTS				Includes color inkjet label printer.	Bar coded magazine.

MANUFACTURER	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS
OPTICAL LIBRARY	1602	ASM-123W	ASM-149M	ASM-176M	ASM-224W
DISK/TREND GROUP	52	52	52	52	52
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (GB)	Drive dependent	5.6/12.0	6.8	8.0	10.2
Cartridge type	Drive dependent	Philips LMS	Nikon	Nikon	ATG
DRIVE: Type	Wr.Once,Rewrit.	Write Once	Rewritable	Rewritable	Write Once
Drive models	ATG, LMS	LD 4100	DD121-1AJ	DD121-1AJ	GD 9001/S
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	29	22	22	22	22
Maximum disk capacity (units)	29	22	22	22	22
Number of drives: Maximum	2	2	2	2	2
Interface: Library Drive	SCSI-2, RS232C SCSI	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	295*/232**	123.2	149	176	224.4
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	6.5	7.2	8	8	7.2
Spin-up + drive ready time (sec)	Drive dependent	3.5	4	4	2.6
Spin-down time (sec)	Drive dependent	1.5	2.2	2.2	2
Average drive access time (msec)	Drive dependent	115	76	76	116
Drive data transfer rate (MB/s)	Drive dependent	1.0	1.1	1.1	1.5
FIRST CUSTOMER SHIPMENT	10/91	2Q94	1994	2Q94	2Q94
COMMENTS	*With ATG drive **With Nikon drive.				

MANUFACTURER	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	CYGNET STORAGE SOLUTIONS	DISC
OPTICAL LIBRARY	1800/A2	1800/L2	1800/N1	CASS	D1260
DISK/TREND GROUP	53	53	53	53	50
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	120 mm
Nominal disk capacity (GB)	10.2	5.6/12.0	8.0	10.2	.650
Cartridge type	ATG	LMSI	Nikon	ATG	Caddy
DRIVE: Type	Write Once	Write Once	Rewritable	Write Once	CD-ROM, CD-R
Drive models	ATG GD 9001S	Philips LMS4100 Philips LMS6100	Nikon DD121-1AJ	ATG GD 9001S	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	61	61	61	111	1282
Maximum disk capacity (units)	141	141	141	131	1478
Number of drives: Maximum	5	5	5	4	32
Interface: Library Drive	SCSI-2, RS232C SCSI	SCSI, RS232C SCSI	RS-232C SCSI-2	IBM channel --	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1438	789.6/1692	1128	1132	961
Import/export module (disks)	1	1	1		2
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7.2	7.2	9	7.2	7
Spin-up + drive ready time (sec)	2.6	3.5	5.8	2.6	1-3
Spin-down time (sec)	2.0	1.5	3.2	2	2-3
Average drive access time (msec)	116	115	137	116	150
Drive data transfer rate (MB/s)	1.5	1.0	1.5	1.5	Drive dependent
FIRST CUSTOMER SHIPMENT	10/91	7/91	1Q94	1995	7/94
COMMENTS	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	ESCON option.	

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
OPTICAL LIBRARY	D210U	D300	D600	D630 D630-1U	DJ200
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM	OEM	OEM	OEM	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650	.650	.650	.650	.650
Cartridge type	Caddy	Caddy	Caddy	Caddy	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	Sony
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	
Minimum disk capacity (units)	140	263	526	641	
Maximum disk capacity (units)	238	361	722	739	200
Number of drives: Maximum	16	16	32	16	6
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)	152	235	469	480	130
Import/export module (disks)	1	1	2	1	1/50
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	
Pickers per positioner	2	2	2	2	1
Average media exchange time (sec)	7	7	7	7	8
Spin-up + drive ready time (sec)	1-3	1-3	1-3	1-3	
Spin-down time (sec)	2-3	2-3	2-3	2-3	
Average drive access time (msec)	150	150	150	150	
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
FIRST CUSTOMER SHIPMENT	9/95	7/94	7/94	7/94	
COMMENTS					

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
OPTICAL LIBRARY	DJ600	D1050-2	D150U	D245	D280U
DISK/TREND GROUP	50	53	53	53	53
MARKET	OEM, DIST	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	.650	1.3/2.6/5.2	1.3/2.6/5.2	1.3/2.6/5.2	1.3/2.6/5.2
Cartridge type	None	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVE: Type	CD-ROM, CD-R	Wr.Once,Rewrit.	Rewritable	Rewritable	Rewritable
Drive models	Sony	Sony, HP	Sony, HP	Sony, HP	Sony, HP
LIBRARY CONFIGURATION: Attachment		Host	Host	Host	Host
Minimum disk capacity (units)		914	140	207	260
Maximum disk capacity (units)	600	1054	170	257	290
Number of drives: Maximum	6	32	8	12	12
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)	390	4753-5481	884	1336	1508
Import/export module (disks)	1/50	2	1	1	1
PERFORMANCE					
Positioner type		X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	2	2	2	2
Average media exchange time (sec)	8	3	3	3	3
Spin-up + drive ready time (sec)		2-3	1-3	1-3	1-3
Spin-down time (sec)		2-3	2-3	2-3	2-3
Average drive access time (msec)		19-35	19-35	19-35	19-35
Drive data transfer rate (MB/s)		Drive dependent	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT		5/92	4Q95	4Q95	4Q95
COMMENTS		Custom configurations available.	Custom configurations available.	Custom configurations available.	Custom configurations available.

MANUFACTURER	DISC	DISC	DISC	DSM GMBH & CO.	DSM GMBH & CO.
OPTICAL LIBRARY	D50	D525-1 D525U	D60	CDR 40 CDR 51 TERASTORE	CDR 53 CDR 55 TERASTORE
DISK/TREND GROUP	53	53	53	50	50
MARKET	OEM	OEM	OEM	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (GB)	2.6/5.2	1.3/2.6/5.2	2.6/5.2	.600 (Mode 1)	.600 (Mode 1)
Cartridge type	ANSI/ISO	Drive dependent	ANSI/ISO	Caddy	Caddy
DRIVE: Type	Rewritable-(MO)	Wr.Once,Rewrit.	Rewritable-(MO)	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Sony	Sony, HP	Sony	Plextor Yamaha	Plextor Yamaha
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)		457		28 (CDR 40)	112 (CDR 53)
Maximum disk capacity (units)	50	527	60	63 (CDR 51)	179 (CDR 55)
Number of drives: Maximum	4	16	2	6	14
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)	260	2740	312	17-38	67-107
Import/export module (disks)	1/10	1	1/10	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	2	1	2	2
Average media exchange time (sec)	4	7	4	3, 5	6.5
Spin-up + drive ready time (sec)	Drive dependent	2-3	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	2-3	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	19-35	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	Drive dependent	1.8	Drive dependent	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	2097	5/92	2097	1/94	7/94
COMMENTS	Purchased mechanism.	Custom configurations available.	Purchased mechanism.		

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
OPTICAL LIBRARY	CDR 71 CDR 72 CDR 73 CDR 74/75/76 TERASTORE	CDR 72-T TERASTORE	CDR1272-U TERASTORE	100-600 TERASTORE	4000 5100 TERASTORE
DISK/TREND GROUP	50	50	50	53	53
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	12"	130 mm
Nominal disk capacity (GB)	.600 (Mode 1)	.650 (Mode 1)	.650 (Mode 1)	Drive dependent	Drive dependent
Cartridge type	Caddy	Caddy	Caddy	Proprietary	ANSI/ISO
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	Write Once	Wr.Once,Rewrit.
Drive models	Plextor Yamaha	Various	Various	ATG Philips-LMS	Maxoptix Nikon Sony
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	273 (CDR 71)	273 (CDR 71)	308	30*	24 (4000)
Maximum disk capacity (units)	2492 (CDR 76)	7435 (CDR 74)	343	748*	63 (5100)
Number of drives: Maximum	16*	32	14	12	5
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)	164-1500	518.8	233.2	480-12000	125-328
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	4-12	4-6	4	8-12	3, 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	2/95	2/95	7/94	9/87	4/92
COMMENTS	*Field upgradable.	Drives Disks 4 763 8 749 12 735 32 665	Drives Disks 4 343 8 329 12 315 14 308	*Field upgradable.	

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	EASTMAN KODAK	EASTMAN KODAK
OPTICAL LIBRARY	48 TERASTORE	5300 5500 TERASTORE	7100 7200 7300 7600 TERASTORE	CD ADL-150 CD ADL-150R	CD Library 144
DISK/TREND GROUP	53	53	53	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM	CAPT,OEM,DIST
MEDIA: Nominal disk diameter	12"	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (GB)	Drive dependent	Drive dependent	Drive dependent	.600	.650
Cartridge type	Proprietary	ANSI/ISO	ANSI/ISO	None	None
DRIVE: Type	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	ATG Philips-LMS	Maxoptix Nikon Sony	Maxoptix Nikon Sony	Toshiba	TEAC CD-516S TEAC CD-R50S
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	30*	96 (5300)*	234 (7100)*	50	108
Maximum disk capacity (units)	60	179 (5500)	2492 (7600)	150	162
Number of drives: Maximum	3	6	42	4	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	RS232 SCSI	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	480-960	499-931	1217-12958	90	105.3
Import/export module (disks)	1	1	1	1/50	1/18
PERFORMANCE					
Positioner type	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	6.5	4-12	2	8
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	2	
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	1	
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent		150
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	.6 (4X)	2.4 (16X)
FIRST CUSTOMER SHIPMENT	11/89	11/89	3/93	4Q95	3Q97
COMMENTS	*Field upgradable.	*Field upgradable.	*Field upgradable.	NSM mechanism. -150R model has CDR drive.	4X CD-R.

MANUFACTURER	EASTMAN KODAK	EMASS	FILENET	FILENET	FUJITSU
OPTICAL LIBRARY	2000E	AML/J	Model 0150 OSAR 107/144 GT	OSAR 50 GTL	F6448/JX M2522/JX M2522/LX
DISK/TREND GROUP	53	53	53	53	52
MARKET	Captive, OEM	OEM, DIST	Captive, OEM	Captive	Captive, OEM
MEDIA: Nominal disk diameter	14"	130 mm	12"	12"	130 mm
Nominal disk capacity (GB)	25.0	2.6	12.0	12.0	2.6
Cartridge type	ANSI/ISO	ANSI/ISO	LMSI	LMSI	ANSI/ISO
DRIVE: Type	Write Once	Rewritable	Write Once	Write Once	Rewritable
Drive models	ODW25	Various	LMSI LD 6100	LMSI 6100	M2508B
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	50	396	107	40	28
Maximum disk capacity (units)	134, 100	396	144	50	28
Number of drives: Maximum	2, 4	4	6	3	2
Interface: Library Drive	SCSI-2, RS232 SCSI-2	SCSI-2 SCSI-2	RS232, RS422 SCSI-2	SCSI, RS232 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	3350	1030	1728	600	72
Import/export module (disks)	1	1/10	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	2	1	2	2	1
Average media exchange time (sec)	6.5		4.0	4	8
Spin-up + drive ready time (sec)	2.3	Drive dependent	3.0	3	3.7
Spin-down time (sec)	1.2	Drive dependent	1.5	1.5	3.3
Average drive access time (msec)	170	Drive dependent	130	120	32.3
Drive data transfer rate (MB/s)	1.8	Drive dependent	4.0	10.0	2.0-4.0
FIRST CUSTOMER SHIPMENT	2Q97		3/91	10/95	2Q97
COMMENTS		Library can store multiple media types.	Maximum capacity with 2 drives.		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
OPTICAL LIBRARY	M2522/AX	M2532B1	M2532B2	F6445/A1 M255X/A1	F6445/A2 M255X/A2
DISK/TREND GROUP	52	52	52	53	53
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	86 mm	86 mm	130 mm	130 mm
Nominal disk capacity (GB)	1.3	.640	.640	.644	.644
Cartridge type	ANSI/ISO	ISO	ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	M2504B	Fujitsu M2513A	Fujitsu M2513A	M2507L	M2507L
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	28	35	35	390	780
Maximum disk capacity (units)	28	35	35	390	780
Number of drives: Maximum	2	1	2	6	11
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*
Library capacity (Gbytes) (with maximum disk capacity)	36	22	22	251.2	502.3
Import/export module (disks)	1	35	35	10/10	10/10
PERFORMANCE					
Positioner type	Y axis	X axis	X axis	Rotary Drum Y axis picker	Rotary Drum (2) 2 Y axis picker
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	6.5	6.5	10	10
Spin-up + drive ready time (sec)	5.5	7	7	5.5	5.5
Spin-down time (sec)	3.5	4	4	4.5	4.5
Average drive access time (msec)	40	43.3	43.3	40.6	40.6
Drive data transfer rate (MB/s)	1.0-2.0	2.3-3.9	2.3-3.9	2.08	2.08
FIRST CUSTOMER SHIPMENT	2Q95	2Q96	2Q96	4Q91	4Q91
COMMENTS				Single pass write. *With DIR (M109X/F1785).	Single pass write. *With DIR (M109X/F1785).

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	GRUNDIG	GRUNDIG
OPTICAL LIBRARY	F6445/A2X2 M255X/A2X2	F6448/KX M2522/KX M2522/MX	M2522/BX	GMS 1035CD	GMS 2105CD
DISK/TREND GROUP	53	53	53	50	50
MARKET	Captive, OEM	Captive, OEM	OEM	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (GB)	.644	2.6	1.3	.650	.650
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	Tray	Tray
DRIVE: Type	Rewritable	Rewritable	Rewritable	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	M2507L	M2508B	M2504B	Various	Various
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	1560	78	78	35	35
Maximum disk capacity (units)	1560	78	78	35	105
Number of drives: Maximum	10	4	4	2	5
Interface: Library Drive	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1004.6	202	101	22.75	68.25
Import/export module (disks)	10/10	1*	1*	1/35	1/35
PERFORMANCE					
Positioner type	Rotary Drum (4) 4 Y axis picker	Rotary Drum Y axis picker	Rotary Drum Y axis picker	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	10	9	9	6*	6*
Spin-up + drive ready time (sec)	5.5	3.7	5.5	Drive dependent	Drive dependent
Spin-down time (sec)	4.5	3.3	3.5	Drive dependent	Drive dependent
Average drive access time (msec)	40.6	32.3	40	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	2.08	2.0-4.0	1.0-2.0	Drive dependent	Drive dependent
FIRST CUSTOMER SHIPMENT	4Q91	2Q97	4Q94	9/94	9/94
COMMENTS	Single pass write. *With DIR (M109X/F1785).	*20 cartridges. Available with DEE option.	*20 cartridges. Available with DEE option.	*Includes spin-up and spin-down time.	*Includes spin-up and spin-down time.

MANUFACTURER	GRUNDIG	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
OPTICAL LIBRARY	GMS 3280CD	160ex	C1100F C1101F C1115F C1116F 40fx	80ex	C1150F 80fx
DISK/TREND GROUP	50	52	52	52	52
MARKET	OEM, DIST	CAPT, OEM, DIST	OEM, DIST	CAPT, OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	.65	5.2	2.6	5.2	2.6
Cartridge type	Tray	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM, CD-R	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	Various	H-P 5200ex	H-P C1113F	H-P 5200ex	H-P C1113F
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	35	32	16	16	32
Maximum disk capacity (units)	280	32	16	16	32
Number of drives: Maximum	6 (4 CD-R)	2	2	2	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	182	166.4	41.6	83.2	83.2
Import/export module (disks)	1/35	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	12*	10*	12	10*	10
Spin-up + drive ready time (sec)	Drive dependent	5.5	5.5	5.5	5.5
Spin-down time (sec)	Drive dependent	3.0	3.0	3.0	3.0
Average drive access time (msec)	Drive dependent	35	35	35	35
Drive data transfer rate (MB/s)	Drive dependent	4.6	3.4	4.6	3.4
FIRST CUSTOMER SHIPMENT	1998		2/96		2/96
COMMENTS	* includes spin up + spin down time.	*Includes spin-up/spin-down.	C1100 and 1101 have single drive. C1101 and C1116 are differential.	*Includes spin-up/spin-down.	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
OPTICAL LIBRARY	1200ex	C1160F 160fx	C1170F 200fx	320ex	C1104F* C1105F 330fx
DISK/TREND GROUP	53	53	53	53	53
MARKET	CAPT, OEM, DIST	OEM, DIST	OEM, DIST	CAPT, OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	5.2	2.6	2.6	5.2	2.6
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 5200ex	H-P C1113F	H-P C1113F	H-P 5200ex	H-P C1113F
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	238	64	76	64	128
Maximum disk capacity (units)	238	64	76	64	128
Number of drives: Maximum	10	4	2	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)	1237.6	166.4	197.6	332.8	332.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	
Average media exchange time (sec)	12*	10	10	10*	10
Spin-up + drive ready time (sec)		5.5	5.5	5.5	5.5
Spin-down time (sec)		3.0	3.0	3.0	3
Average drive access time (msec)	35	35	35	35	35
Drive data transfer rate (MB/s)	4.6	3.4	3.4	4.6	3.4
FIRST CUSTOMER SHIPMENT		2/96	2/96		3/96
COMMENTS	*Includes spin-up/spin-down.			*Includes spin-up/spin-down.	Expandable to 600fx. *4 drives.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
OPTICAL LIBRARY	400ex	C1107F* C1108F C1110F C1112F 600fx	660ex	DL-111-10	DL-F111-2
DISK/TREND GROUP	53	53	53	50	50
MARKET	CAPT, OEM, DIST	OEM, DIST	CAPT, OEM, DIST	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (GB)	5.2	2.6	5.2	2.6	2.6
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	None	None
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	DVD-RAM	DVD-RAM
Drive models	H-P 5200ex	H-P C1113F	H-P 5200ex	Hitachi CD/DVD ROM compatible	Hitachi CD/DVD ROM compatible
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	78	238	128	100	100
Maximum disk capacity (units)	78	238	128	100	100
Number of drives: Maximum	2	12	6	2	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)	395.2	618.8	665.6	260	260
Import/export module (disks)	1	1	1	1/10	1/10
PERFORMANCE					
Positioner type	Y axis	X-Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1		1	1	1
Average media exchange time (sec)	10*	10	10*	3	3
Spin-up + drive ready time (sec)	5.5	5.5	5.5		
Spin-down time (sec)	3.0	3	3.0		
Average drive access time (msec)	35	35	35	210	210
Drive data transfer rate (MB/s)	4.6	3.4	4.6	10	10
FIRST CUSTOMER SHIPMENT		3/96		1998	1998
COMMENTS	*Includes spin-up/spin-down.	*6, 8, 10, 12 drives respectively.	*Includes spin-up/spin-down.	1 MB buffer. Sold in Japan.	1 MB buffer. Sold in Japan.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
OPTICAL LIBRARY	DL-F111-50	OL172S-20A	OL172-180	OL172-48	OL500-270
DISK/TREND GROUP	50	52	53	53	53
MARKET	OEM	CAPT,OEM,DIST	CAPT,OEM,DIST	CAPT,OEM,DIST	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	2.6	2.6	2.607	1.3	2.6
Cartridge type	None	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	DVD-RAM	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	Hitachi CD/DVD ROM compatible	Hitachi OL-172S-11	Hitachi OL-F172S/D21	Hitachi OL-F172 OL-F172D-21	Hitachi OL-F172D-21
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	100	20	180	48*	270
Maximum disk capacity (units)	150	20	192*	60	306*
Number of drives: Maximum	2	2	4	4	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)	390	52	500	156	797
Import/export module (disks)	1/10	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1		1	1	1
Average media exchange time (sec)	3	5	6	6	8
Spin-up + drive ready time (sec)		7.5	5	5	5
Spin-down time (sec)		4.5	2.5	2.5	2.5
Average drive access time (msec)	210	49	49	49	49
Drive data transfer rate (MB/s)	10	1.7-3.4	1.7-3.4	1.7-3.4	1.7-3.4
FIRST CUSTOMER SHIPMENT	1998	1Q97	1Q96	1Q96	4Q96
COMMENTS	1 MB buffer. Sold in Japan.	Available only with single-ended SCSI.	*With 2 drives. Available with single-ended or differential SCSI.	*With 4 drives. Available with single-ended or differential SCSI.	*With 2 drives. Available only with differential SCSI.

MANUFACTURER	HITACHI	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	OL502-228	3995-C20	3995-C40	3995-C60	3995-C12 3995-C32
DISK/TREND GROUP	53	52	52	52	53
MARKET	Captive, OEM	Captive, DIST	Captive, DIST	Captive, DIST	Captive, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	2.6	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	Hitachi OL-F172D-21	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8
LIBRARY CONFIGURATION: Attachment	Host	Net	Host	Host	Host
Minimum disk capacity (units)	228	20	20	20	52
Maximum disk capacity (units)	264*	20	20	20	52
Number of drives: Maximum	8	2	2	1	3 (2 for C12)
Interface: Library Drive	SCSI-2 SCSI-2	Ethernet, TR SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	S/390 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	688	52	52	52	135
Import/export module (disks)	2	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)	8	5.6	5.6	5.2	5.2
Spin-up + drive ready time (sec)	5	5.5	5.5	5.5	5.5
Spin-down time (sec)	2.5	3.5	3.5	3.5	3.5
Average drive access time (msec)	49	33.3	33.3	33.3	33.3
Drive data transfer rate (MB/s)	1.7-3.4	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96		4Q96
COMMENTS	*With 2 drives. Available only with differential SCSI.	Plasmon mechanism. Rewritable and WORM media.	Plasmon mechanism. Attaches to AS/400.	Plasmon mechanism.	Plasmon mechanism. C12 is expansion unit. For DFSMS/MVS systems.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	3995-C16 3995-C36	3995-C18 3995-C38	3995-C22	3995-C24	3995-C26
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive, DIST	Captive, DIST	Captive, DIST	Captive, DIST	Captive, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8
LIBRARY CONFIGURATION: Attachment	Host	Host	Net	Net	Net
Minimum disk capacity (units)	156	258	52	104	156
Maximum disk capacity (units)	156	258	52	104	156
Number of drives: Maximum	7 (6 for C16)	7 (6 for C18)	2	4	6
Interface: Library Drive	S/390 SCSI-2	S/390 SCSI-2	Ethernet, TR SCSI-2	Ethernet, TR SCSI-2	Ethernet, TR SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	405	671	135	270	405
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	5.2	5.6	5.6
Spin-up + drive ready time (sec)	5.5	5.5	5.5	5.5	5.5
Spin-down time (sec)	3.5	3.5	3.5	3.5	3.5
Average drive access time (msec)	33.3	33.3	33.3	33.3	33.3
Drive data transfer rate (MB/s)	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96	4Q96	4Q96
COMMENTS	Plasmon mechanism. C16 is expansion unit. For DFSMS/MVS systems.	Plasmon mechanism. C18 is expansion unit. For DFSMS/MVS systems.	Plasmon mechanism. Rewritable and WORM media.	Plasmon mechanism. Rewritable and WORM media.	Plasmon mechanism. Rewritable and WORM media.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	3995-C28	3995-C34	3995-C42	3995-C44	3995-C46
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive, DIST	Captive, DIST	Captive, DIST	Captive	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8
LIBRARY CONFIGURATION: Attachment	Net	Host	Host	Host	Host
Minimum disk capacity (units)	258	104	52	104	104
Maximum disk capacity (units)	258	104	52	104	104
Number of drives: Maximum	6	5	2	2	4
Interface: Library Drive	Ethernet, TR SCSI-2	S/390 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	671	270	135	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)	6.2	5.6	5.2	5.4	5.4
Spin-up + drive ready time (sec)	5.5	5.5	5.5	5.5	5.5
Spin-down time (sec)	3.5	3.5	3.5	3.5	3.5
Average drive access time (msec)	33.3	33.3	33.3	33.3	33.3
Drive data transfer rate (MB/s)	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96	2/97	5/97
COMMENTS	Plasmon mechanism. Rewritable and WORM media.	Plasmon mechanism. For DFSMS/MVS systems.		Plasmon mechanism. For AS/400.	Plasmon mechanism. For AS/400. Upgrade from C44.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
OPTICAL LIBRARY	3995-C48	3995-C62	3995-C64	3995-C66	3995-C68
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive	Captive, DIST	Captive, DIST	Captive, DIST	Captive, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2	2.6, 5.2
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8	IBM 0632-C4,C8
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	258	52	104	156	258
Maximum disk capacity (units)	258	52	104	156	258
Number of drives: Maximum	4	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)	671	135	270	405	671
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis with pivot	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	5.2	5.4	5.8	6
Spin-up + drive ready time (sec)	5.5	5.5	5.5	5.5	5.5
Spin-down time (sec)	3.5	3.5	3.5	3.5	3.5
Average drive access time (msec)	33.3	33.3	33.3	33.3	33.3
Drive data transfer rate (MB/s)	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0	2.0-4.0
FIRST CUSTOMER SHIPMENT	2/97				
COMMENTS	Plasmon mechanism. For AS/400.	Plasmon mechanism.	Plasmon mechanism.	Plasmon mechanism.	Plasmon mechanism.

MANUFACTURER	JVC	JVC	JVC	JVC	JVC
OPTICAL LIBRARY	MC-1200	MC-1600	MC-2200P	MC-1100 MC-1110	MC-2600P
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650	.650	.650	.650	.650
Cartridge type	None	None	None	None	None
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-R, CD-RW	CD-ROM, CD-R	CD-R, CD-RW
Drive models	Plextor	Plextor	Plextor	Plextor	Plextor
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	50	50	50		50
Maximum disk capacity (units)	200	600	200	100	600
Number of drives: Maximum	6	6		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)	130	390	130	65	690
Import/export module (disks)	1/50	1/50	1/50	1/50	1/50
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	8	8	6	6	6
Spin-up + drive ready time (sec)					
Spin-down time (sec)					
Average drive access time (msec)	85-115/165-390	85-115/165-390	85-115/165-390	85-115/165-390	85-115/165-390
Drive data transfer rate (MB/s)	4.8, 1.8/.6*	4.8, 1.8/.6*	4.8, 1.8/.6*	4.8, 1.8/.6*	4.8, 1.8/.6*
FIRST CUSTOMER SHIPMENT	2Q97	2Q97	1998		1998
COMMENTS	*CD-R drives are 12X Read, 4X Write. CD-ROM drives are 32X.	*CD-R drives are 12X Read, 4X Write. CD ROM drives are 32X.	*CD-R drives are 12X Read, 4X Write. CD-ROM drives are 32X. Includes label printer.	*CD-R drives are 12X Read, 4X Write. CD-ROM drives are 32X.	*CD-R drives are 12X Read, 4X Write. CD-ROM drives are 32X. Includes label printer.

MANUFACTURER	KUBIK ENTERPRISES	KUBIK ENTERPRISES	KUBOTA	KUBOTA	MATSUSHITA ELECTRIC INDUSTRIAL
OPTICAL LIBRARY	CD Tower	CDR240M CDR240MA	K2020	K4020	LF-J100A2
DISK/TREND GROUP	50	50	52	53	50
MARKET	OEM	OEM	OEM	OEM	DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	130 mm	120 mm
Nominal disk capacity (GB)	.650	.650	2.6	2.6	.650*/.668
Cartridge type	N/A	N/A	ANSI/ISO	ANSI/ISO	Magazine
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	Multifunct-(MO)	Multifunct-(MO)	PD
Drive models	Toshiba, Plextor	Toshiba, Plextor	Kubota	Kubota	MEI LF1004 (4X)
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	480	240	20	40	100
Maximum disk capacity (units)	1680	240	20	40	100
Number of drives: Maximum	28	4	2	2	2
Interface: Library Drive	SCSI, RS232C SCSI	SCSI, RS232C SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1092	156	52	104	66.8
Import/export module (disks)	1	1	1	1	1/10
PERFORMANCE					
Positioner type	Rotary	Rotary	Y axis	Y axis	Y axis
Pickers per positioner	1-4	1-4	1	1	2
Average media exchange time (sec)	7	7	4	4	6
Spin-up + drive ready time (sec)	1	1	4.5	4.5	6
Spin-down time (sec)	1	1	2.5	2.5	3
Average drive access time (msec)	Drive dependent	Drive dependent	19	19	179.8
Drive data transfer rate (MB/s)	.614/1.8	.614/1.8	4.65	4.65	0.518-1.141
FIRST CUSTOMER SHIPMENT	1995	1992	1996	1997	7/96
COMMENTS	Contains 2 to 7 CDR240.	CDR240MA is rack mount version.	Sold in Japan	Sold in Japan	10 disk magazine. *CD-ROM mode.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MAXOPTIX	MAXOPTIX	NAKAMICHI	NAKAMICHI
OPTICAL LIBRARY	LF-J50A2	MX620	MX640	MJ5.16	MJ5.165i
DISK/TREND GROUP	50	52	53	50	50
MARKET	DIST	OEM, DIST	DIST	OEM	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650*/.668	2.6	2.6	.650	.650
Cartridge type	Magazine	ANSI/ISO	ANSI/ISO	None	None
DRIVE: Type	PD	Rewritable-(MO)	Rewritable-(MO)	CD-ROM (16X)	CD-ROM (16X)
Drive models	MEI LF1004 (4X)	Maxoptix T6-5200	Maxoptix T6-5200		
LIBRARY CONFIGURATION: Attachment	Host	Host*	Host	Host	Host
Minimum disk capacity (units)	50	20	40	5	5
Maximum disk capacity (units)	50	20	40	5	5
Number of drives: Maximum	2	2	2	1	1
Interface: Library	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2
Drive	SCSI-2	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	33.4			3.25	3.25
Import/export module (disks)	1/10	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)	6	4	4	4	4
Spin-up + drive ready time (sec)	6	4.5	4.5		
Spin-down time (sec)	3	2.5	2.5		
Average drive access time (msec)	179.8	19	19	120	120
Drive data transfer rate (MB/s)	0.518-1.41	4.65	4.65	1.8-2.4	1.8-2.4
FIRST CUSTOMER SHIPMENT	7/96			2Q97	3Q97
COMMENTS	10 disk magazine. *CD-ROM mode.	Kubota mechanism. *Network attach option.	Kubota mechanism.	128K buffer. PIO Mode 4. DMA Mode 2.	256K buffer. External mount.

MANUFACTURER	NAKAMICHI	NEC	NEC	NEC	NEC
OPTICAL LIBRARY	MJ5.16Se	N1137-58	OL5120	OL5220	OL5220H
DISK/TREND GROUP	50	52	52	52	52
MARKET	OEM, DIST	Captive	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	.650	1.3	1.3	1.3	2.6
Cartridge type	None	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO
DRIVE: Type	CD-ROM (16X)	Rewritable	Rewritable	Rewritable	Rewritable
Drive models		NEC N1137-57	NEC	NEC	NEC
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	
Minimum disk capacity (units)	5	4	20	20	20
Maximum disk capacity (units)	5	4	20	20	20
Number of drives: Maximum	1	1	1	2	2
Interface: Library	SCSI-2	SCSI	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2	SCSI	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	3.25	5.2	26	26	52
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)	4	6	5.5	5.5	5.5
Spin-up + drive ready time (sec)		8	8	8	8
Spin-down time (sec)		5	5	5	5
Average drive access time (msec)	120	42	29	29	29
Drive data transfer rate (MB/s)	1.8-2.4	3.0	5.0	5.0	5.0*
FIRST CUSTOMER SHIPMENT	3Q97	1993	10/95	10/95	1997
COMMENTS	256K buffer.				*Burst.

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
OPTICAL LIBRARY	N3661-XX	N7925-84	N7925-85	OL5260	OL5260H
DISK/TREND GROUP	53	53	53	53	53
MARKET	Captive	Captive	Captive	Captive	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	2.6	1.3	2.6	1.3	2.6
Cartridge type	ANSI/ISO	ANSI/ISO	ISO	ISO	ISO
DRIVE: Type	Rewritable-(MO)	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	NEC ODD160	NEC	NEC	NEC	NEC
LIBRARY CONFIGURATION: Attachment	Host	Host		Host	
Minimum disk capacity (units)	193	60	60	60	60
Maximum disk capacity (units)	889	60	60	60	60
Number of drives: Maximum	10	2	2	2	2
Interface: Library Drive	NEC Proprietary SCSI-2	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	2300	78	156	78	156
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	2	2	2	2
Average media exchange time (sec)		8	8	8	8
Spin-up + drive ready time (sec)	2.5	8	8	8	8
Spin-down time (sec)	5	5	5	5	5
Average drive access time (msec)	45	42	39	39	39
Drive data transfer rate (MB/s)	1.69-3.38	3.0	5.0*	5.0	5.0*
FIRST CUSTOMER SHIPMENT	9/96	1995	1997	1995	1997
COMMENTS			*Burst.		*Burst.

MANUFACTURER	NEC	NIPPON COLUMBIA (DENON)	NIPPON COLUMBIA (DENON)	NISTEC	NSM
OPTICAL LIBRARY	OL5453	DRD-1400	DRD-1408	ALW-501	CDR 100 Recordable
DISK/TREND GROUP	53	50	50	50	50
MARKET	Captive	DIST	OEM, DIST	DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	1.3	.650	.650	.650	.650
Cartridge type	ISO	None	None	None	Magazine
DRIVE: Type	Rewritable	CD-ROM	CD-ROM	CD-R	CD-R
Drive models	NEC		Plextor 8X	Philips CDD 2000	Plextor Px412
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	53	200	200	--	100
Maximum disk capacity (units)	53	200	200	50	100
Number of drives: Maximum	4	2	2	1	1
Interface: Library	SCSI-2	SCSI-2, RS232	SCSI-2	RS232C	RS232
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	69	130	130	N/A	65
Import/export module (disks)	1	1/100	1/100	1/50	1/50
PERFORMANCE					
Positioner type	Y axis	X axis	X axis	Y axis	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	8	25	19.5	NS	4.5
Spin-up + drive ready time (sec)	8	2		NS	1.5
Spin-down time (sec)	5	2		NS	1.0
Average drive access time (msec)	39	.3	150	300	190
Drive data transfer rate (MB/s)	5.0	.3	1.2	.6	.6 WR/1.8 RD
FIRST CUSTOMER SHIPMENT	1995	2Q96	1996	1996	3/94
COMMENTS				Recorder/ transport.	

MANUFACTURER	NSM	NSM	NSM	NSM	NSM
OPTICAL LIBRARY	CDR 100 XA	Mercury-22	Mercury-31	Mercury-40 Mercury-20	Satellite
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650	.65	.650	.650	.650
Cartridge type	Magazine	None	Magazine	Magazine	Magazine
DRIVE: Type	CD-ROM	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R
Drive models	TEAC	Plextor Px412	Plextor Px412	Plextor Px412	Plextor Px412
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	100	150	150	150	60
Maximum disk capacity (units)	100	150	150	150	135*
Number of drives: Maximum	1	4	4	4/2*	5
Interface: Library Drive	RS232 SCSI-2	SCSI-2 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	65	97.5	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)	4.5	3	>3	3	2.5
Spin-up + drive ready time (sec)	1.5	1.5	.150/.500	1.5	1.5
Spin-down time (sec)	1.0	1.0		1.5	1.5
Average drive access time (msec)	150	110/190	110/190	110	115/190
Drive data transfer rate (MB/s)	2.4	1.8 RD/.6 WR	1.8 RD/.6 WR	1.8	1.8 RD/.6 WR
FIRST CUSTOMER SHIPMENT	1/94	2Q98	4/95		3Q97
COMMENTS			Differential ended SCSI optional.	Differential ended SCSI optional. *Mercury-20 has 2 drives.	*With 1 drive. Multiple configurations.

MANUFACTURER	NSM	NSM	PHILIPS LMS	PHILIPS LMS	PHILIPS LMS
OPTICAL LIBRARY	Satellite 03	SERVEready TK	LF 6600 Rapid Changer	LF 6602 Dual Rapid Changer	Infinity 123
DISK/TREND GROUP	50	50	52	52	53
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	12"	12"	12"
Nominal disk capacity (GB)	.65	.65/4.7	12.0	12.0	12.0
Cartridge type	None	Magazine	Philips LMS	Philips LMS	Philips LMS
DRIVE: Type	CD-R/CD-RW	CD-ROM, DVD-ROM	Write Once	Write Once	Write Once
Drive models	12X Read 4X Write	Plextor (CD) (DVD) Seagate (HDD)	Philips LMS LD 6100	Philips LMS LD 6100	Philips LMS LD 6100
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	60	150	6	12	107
Maximum disk capacity (units)	135*	150	6	12	144
Number of drives: Maximum	3	5	1	2	6
Interface: Library	SCSI-2, RS232	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2	Ultra SCSI*	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	90	97.5	72	144	1728
Import/export module (disks)	1/15	1/50	6	6	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Moving Magazine	Moving Magazine	X-Y axis
Pickers per positioner	1	1	N/A	N/A	2
Average media exchange time (sec)	2.5	3	2.5	2.5	5.0
Spin-up + drive ready time (sec)	1.5	1.5	3	3	3
Spin-down time (sec)	1.5	1.5	1.5	1.5	1.5
Average drive access time (msec)		110/10*	100	100	100
Drive data transfer rate (MB/s)	1.8 RD/.6 WR	1.8/40*	2.7	2.7	2.7
FIRST CUSTOMER SHIPMENT	1998	1Q98	2Q95	2Q95	3Q98
COMMENTS	*With 1 drive.	Includes HDD buffer. *From HDD buffer.	Dual head drive	Dual head drive	Dual head drive. 1.284 TB with 6 drives. Purchased mechanism.

MANUFACTURER	PHILIPS LMS	PIONEER	PIONEER	PIONEER	PIONEER
OPTICAL LIBRARY	Infinity 50	DRJ-5004X	DRM-1004V40	DRM-1004X DRM-1004XR	DRM-1004X40 DRM-1004XR21
DISK/TREND GROUP	53	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	12"	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	12.0	.650	4.7	.650	.650
Cartridge type	Philips LMS	N/A	N/A	Magazine	Magazine
DRIVE: Type	Write Once	CD-ROM, CD-R	DVD-ROM	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Philips LMS LD 6100	Pioneer D504X Pioneer R504X	Pioneer	Pioneer	Pioneer
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	40	100	50	50	50
Maximum disk capacity (units)	50	500	100	100	100
Number of drives: Maximum	3	4	4	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)	600	325	470	65	65
Import/export module (disks)	1	100	1/50	1/50	1/50
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	1		1	1
Average media exchange time (sec)	5.0	18	6	7	6
Spin-up + drive ready time (sec)	3	3	4	4	4
Spin-down time (sec)	1.5	2	1.5	1.5	1.5
Average drive access time (msec)	100	300	150/120*	150 RD/650 WR*	110 RD/650 WR
Drive data transfer rate (MB/s)	2.7	.614	2.7/3.0*	.66 RD/.614 WR*	1.8 RD/.614 WR
FIRST CUSTOMER SHIPMENT	3Q98	3Q94	1998	1Q98	9/96
COMMENTS	Dual head drive 480 GB with 3 drives. Purchased mechanism.		*With CD-ROM.	4 CD-ROM or 2 CD-ROM plus 1 CD-R. *CD-R mode.	*4 CD-ROM (X40) 2 CD-ROM plus 1 CD-R (XR21).

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
OPTICAL LIBRARY	DRM-1804X	DRM-5002R2W	DRM-5003R1W	DRM-624X	DRM-6324X
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650	.650	.650	.650	.650
Cartridge type	N/A	N/A	N/A	N/A	None
DRIVE: Type	CD-ROM	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM	CD-ROM
Drive models	Pioneer (integrated with drive)	Pioneer	Pioneer	Pioneer 4.4X (integrated with drive)	Pioneer 24X
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	18	100	100	6	6
Maximum disk capacity (units)	18	500	500	6	6
Number of drives: Maximum	1	4*	4*	1	1
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)	11.7	325	325	3.9	3.9
Import/export module (disks)	18	100	100	6	6
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)	10	29	29	5	5
Spin-up + drive ready time (sec)	3	2	2	3	
Spin-down time (sec)	2	1	1	2	
Average drive access time (msec)	300			150	90
Drive data transfer rate (MB/s)	.614/.154			.676	1.8-3.6
FIRST CUSTOMER SHIPMENT	4Q93			3Q95	4Q97
COMMENTS		*2 CD-ROM, 2 CD-R.	*3 CD-ROM, 1 CD-R.	128K buffer.	128K buffer.

MANUFACTURER	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY	D120-22	D120-40	D240-42	D240-60	D480-42
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	.650	.650	.650	.650	.650
Cartridge type	None	None	None	None	None
DRIVE: Type	CD-ROM, CD-R	CD-ROM (24X)	CD-ROM, CD-R	CD-ROM (24X)	CD-ROM, CD-R
Drive models	Matsushita	Matsushita	Matsushita	Matsushita	Matsushita
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	120	120	240	240	
Maximum disk capacity (units)	120	120	240	240	480
Number of drives: Maximum	4*	4	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)	78	78	156	156	312
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		Drive dependent		Drive dependent
Spin-down time (sec)	Drive dependent		Drive dependent		Drive dependent
Average drive access time (msec)	85/175/450 WR	85	85/175/450 WR	85	85/175/450 WR
Drive data transfer rate (MB/s)	3.6/1.2/.6 WR	3.6	3.6/1.2/.6 WR	3.6	3.6/1.2/.6 WR
FIRST CUSTOMER SHIPMENT	1Q97	1Q97	1Q97	1Q97	1Q97
COMMENTS	*2 CD-ROM (8X), 2 CD-R (4X/8X). Network attach option.	Network attach option.	*4 CD-ROM, 2 CD-R. Network attach option.	Network attach option.	*4 CD-ROM, 2 CD-R. Network attach option.

MANUFACTURER	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY	D480-60	NetReady	D120-P4	D240-P6	M20-520
DISK/TREND GROUP	50	50	50	50	52
MARKET	DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	Various	120 mm	120 mm	130 mm
Nominal disk capacity (GB)	.650	Various	.650	.650	5.2
Cartridge type		None	None	None	ANSI/ISO
DRIVE: Type	CD-ROM (24X)	Various	PD	PD	Wr.Once,Rewrit.
Drive models	Matsushita	Various	Matsushita	Matsushita	
LIBRARY CONFIGURATION: Attachment	Host	Ethernet	Host	Host	Host
Minimum disk capacity (units)		--	120	240	20
Maximum disk capacity (units)	480	--	120	240	20
Number of drives: Maximum	6	--	4	6	2
Interface: Library	SCSI-2	--	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2	--	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	312	--	78	156	104
Import/export module (disks)	1/10	--	1/10	1/10	1
PERFORMANCE					
Positioner type	Y axis	--	Y axis	Y axis	Y axis
Pickers per positioner	2	--	2	2	1
Average media exchange time (sec)	3	--	3	3	5.4
Spin-up + drive ready time (sec)		--			3.6
Spin-down time (sec)		--			
Average drive access time (msec)	85	--	177/207	177/207	
Drive data transfer rate (MB/s)	3.6	--	9.0/1.441	9.0/1.441	3.7/4.8/5.1
FIRST CUSTOMER SHIPMENT	1Q97	6/98	1Q97	1Q97	2Q98
COMMENTS	Network attach option.	Network attach controller. 9GB HDD.	Reads CD-ROM at 6X. Network attach option.	Network attach option.	4 MB buffer. Direct overwrite.

MANUFACTURER		PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA
OPTICAL LIBRARY		M32-520	M104-520	M156-520	M258-520	M500
DISK/TREND GROUP		52	53	53	53	53
MARKET		OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA:	Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
	Nominal disk capacity (GB)	5.2	5.2	5.2	5.2	5.2
	Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE:	Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Rewritable
	Drive models					Sony
LIBRARY CONFIGURATION:	Attachment	Host	Host	Host	Host	Host
	Minimum disk capacity (units)	32	104	156	258	500
	Maximum disk capacity (units)	32	104	156	258	500
	Number of drives: Maximum	2	4	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)	166	540	812	1342	2600
	Import/export module (disks)	1	1			1
PERFORMANCE						
	Positioner type	Y axis	Y axis	Y axis	Y axis with pivot	Y axis with pivot
	Pickers per positioner	1	2	2	2	2
	Average media exchange time (sec)	5.8	2	2.45	2.65	2-4
	Spin-up + drive ready time (sec)	3.6	3.6	3.6	3.6	
	Spin-down time (sec)					
	Average drive access time (msec)					25
	Drive data transfer rate (MB/s)	3.7/4.8/5.1	3.7/4.8/5.1	3.7/4.8/5.1	3.7/4.8/5.1	3.7/4.8/5.1
FIRST CUSTOMER SHIPMENT		2Q98	2Q98	2Q98	2Q98	2Q98
COMMENTS				Network attach option.	Network attach option.	Network attach option.

MANUFACTURER	PLASMON DATA	PLEXTOR (SHINANO KENSHI)	SONY	SONY	SONY
OPTICAL LIBRARY	M52-520-X	MegaPleX	CDL 1100-20	CDL 2100-22 Fyla	CDL 2100-40 Fyla
DISK/TREND GROUP	53	50	50	50	50
MARKET	OEM, DIST	DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (GB)	5.2	.65	.650	.650	.650
Cartridge type	ANSI/ISO	None	None	None	None
DRIVE: Type	Wr.Once,Rewrit.	CD-ROM	CD-ROM 12X	CD-ROM, CD-R	CD-ROM
Drive models		Plextor 8X	Sony	Sony CDU 625, CDU 948S	Sony CDU 625
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	52	200		125	125
Maximum disk capacity (units)	52	200	100	125	125
Number of drives: Maximum	2	2	2	6*	6*
Interface: Library	SCSI-2		SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2		SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	270	130	65	81.25	81.25
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Rotary	Y axis	Y axis	Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	1.85		12.2	4	4
Spin-up + drive ready time (sec)	3.6		4	4	4
Spin-down time (sec)			2	2	2
Average drive access time (msec)		115	130	90, 220	90
Drive data transfer rate (MB/s)	3.7/4.8/5.1	1.2	1.2-1.8	1.8-3.6, 1.2/.6	1.8-3.6
FIRST CUSTOMER SHIPMENT	2Q98		6/97	6/97	2Q97
COMMENTS	Network attach option.	Purchased mechanism.		*4 standard.	*4 standard.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
OPTICAL LIBRARY	CDL 2200-04 Fyla	CDL 2200-22 Fyla	CDL 2200-40 Fyla	CDL 5000	OSL 2500-15
DISK/TREND GROUP	50	50	50	50	52
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (GB)	.650	.650	.650	.650	5.2
Cartridge type	None	None	None	None	ANSI/ISO
DRIVE: Type	CD-R	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R	Multifunction
Drive models	Sony CDU 948S	Sony CDU 625, CDU 948S	Sony CDU 625	Sony CDU 925, CDU 948S	Sony SMOF551
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	225	225	225	500	25
Maximum disk capacity (units)	250	250	250	550	25
Number of drives: Maximum	6*	6*	6*	6	1
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2	SCSI-2	SCSI-2		SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	146.25	146.25	146.25	325	130
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)	4	4	4	3.5 sec.	5
Spin-up + drive ready time (sec)	4	4	4	4	2.5
Spin-down time (sec)	2	2	2	2	2.2
Average drive access time (msec)		250		90, 220	33
Drive data transfer rate (MB/s)	1.2 RD/.6 WR	1.8-3.6, 1.2/.6	1.8-3.6	1.8-3.6, 1.2/.6	4.0, 5.0 synch.
FIRST CUSTOMER SHIPMENT	6/97	6/97	2Q97	3Q98	2Q97
COMMENTS	*4 standard.	*4 standard.	*4 standard.		

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
OPTICAL LIBRARY	OSL 2500-25	OSL 10000	OSL 15000	OSL 25000	OSL 6000-25 OSL 6000-45
DISK/TREND GROUP	52	53	53	53	53
MARKET	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST	OEM, DIST
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (GB)	5.2	5.2	5.2	5.2	5.2
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO/ANSI
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	Sony SMOF551	Sony SMOF551	Sony SMOF551	Sony SMOF551	Sony SMOF551
LIBRARY CONFIGURATION: Attachment	Host	Host	Host	Host	Host
Minimum disk capacity (units)	25				50
Maximum disk capacity (units)	25	104	156	258	60
Number of drives: Maximum	2	4	6	6	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2			SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	130	541	811	1342	811
Import/export module (disks)	1	1	1	1	1/10
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis with pivot	Y axis
Pickers per positioner	1	2	2	2	1
Average media exchange time (sec)	5	4	4	4	5
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	2.2
Average drive access time (msec)	33	33	33	33	29
Drive data transfer rate (MB/s)	4.0, 5.0 synch.	4.0/5.0 synch.	4.0/5.0 synch.	4.0/5.0 synch.	4.06
FIRST CUSTOMER SHIPMENT	2Q97	4Q96	4Q96	4Q96	3/96
COMMENTS		Purchased mechanism.	Purchased mechanism.	Purchased mechanism.	

MANUFACTURER	TEAC				
OPTICAL LIBRARY	CD-C624E				
DISK/TREND GROUP	50				
MARKET	OEM, DIST				
MEDIA: Nominal disk diameter	120 mm				
Nominal disk capacity (GB)	.650				
Cartridge type	None				
DRIVE: Type	CD-ROM				
Drive models	TEAC				
LIBRARY CONFIGURATION: Attachment	Host				
Minimum disk capacity (units)	6				
Maximum disk capacity (units)	6				
Number of drives: Maximum	1				
Interface: Library Drive	IDE/ATAPI				
Library capacity (Gbytes) (with maximum disk capacity)	3.9				
Import/export module (disks)	1				
PERFORMANCE					
Positioner type	Y axis				
Pickers per positioner	1				
Average media exchange time (sec)					
Spin-up + drive ready time (sec)					
Spin-down time (sec)					
Average drive access time (msec)					
Drive data transfer rate (MB/s)	3.6				
FIRST CUSTOMER SHIPMENT	4Q97				
COMMENTS	4 MB buffer. Slot load.				

MANUFACTURER PROFILES

1998 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing optical disk drives or optical disk libraries, or those companies 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 relatively high level of optical library or disk drive sales in 1997, this figure is reported explicitly only for firms with major 1997 optical disk drive or library sales. "1997 total net sales" covers the fiscal year ending in 1997 for each manufacturer unless noted otherwise, or for the parent company if the manufacturer is a subsidiary. All fiscal years end on December 31, 1997, 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 1997 are used, as reported by the U.S. Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
Canada	Canadian dollar	1.38
France	French franc	5.84
Germany	Deutschmark	1.74
Hong Kong	Hong Kong dollar	7.74
Japan	Yen	121.1
Malaysia	Ringgit	2.82
Netherlands	Guilder	1.95
Singapore	Singapore dollar	1.46
South Korea	Won	950.8
Taiwan	Taiwan dollar	28.78
United Kingdom	Pound	0.61

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 firm's 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 has manufactured 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, but production has been delayed. 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 sold its products to manufacturers of CD towers, network integrators, and end users setting up their own networks, and was considered a significant supplier, but was unable to keep up with competitors and ceased operations in 1997.

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. Dynatek subsequently filed for bankruptcy. Cygnet is giving major marketing and manufacturing support to the CD-ROM oriented product line, and purchased the assets of Elms Systems in early 1998. The company is also reselling CD-R duplicating equipment.

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

1997 total net sales: $8,655,000 Net income: ($2,489,000)

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). 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 was a privately owned firm established in 1985 as a system integrator. Products included CD-ROM towers and disk drive arrays. The firm specialized 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. Dynatek subsequently ceased operations and went into receivership in 1998.

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1997 total net sales: $14,538,000,000 Net income: $5,000,000

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 produced its own 6X CD-R drive (Kodak also provides the media) using a purchased mechanism until 1998. Kodak 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, subsequently slipped to mid-1998. The drive will be able to read earlier Kodak 14" media. However, in early 1998, Eastman Kodak announced it planned to withdraw from the 14" drive business in early 1999. Media production will continue through 2002.

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 concentrated upon CD-ROM/CD-R servers for networks. Elms was 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. Elms achieved significant visibility as a CD library producer, but was unable to develop major volume. The company ceased operations in early 1998, selling its product line to Cygnet.

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. In mid 1998, the company agreed to be acquired by Advanced Digital Information Corporation (ADIC), another producer of tape libraries.

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

1997 total net sales: $251,425,000 Net income: ($5,526,000)

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 has offered some of the largest storage capacities available in a noncustomized optical library. Up to 340 disks could be stored in the largest FileNet system, but the increasing capacities of 12" drives caused FileNet to trim its largest library to handle up to 144 disks. FileNet has a major share of the 12" optical library market, and also supplies them under contract to Philips LMS. The firm also sells 5.25" purchased libraries.

FileNet 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

1997 total net sales: $42,895,000,000 (FY ending 10/31/97) Net income: $3,119,000,000

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, and while H-P also sells them to OEM accounts, the firm emphasizes sales through distributors.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1997 total net sales: $78,508,000,000 Net income: $6,093,000,000

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.

JES HARDWARE SOLUTIONS
2905 Northwest 82nd Avenue
Miami, FL 33122

JES, founded in 1994, is a storage subsystems integrator. Nearly all sales are in the U.S. The company produces CD towers, both host and network attached, using individual drives and minichangers. The firm also distributes jukeboxes.

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, NJ 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

1997 total net sales: $19,968,000 Net income: ($7,778,000)

Meridian was established in 1986 to create development tools for optical storage products, but broadened its interests to include CD-ROM/CD-R publishing tools, networked CD-ROM servers and networked CD-R recorders. 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. The firm has been a pioneer in the network attached and cached tower product segments.

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. MDI has also had some success with rigid drive cached CD-ROM towers.

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

1997 total net sales: $49,592,000 Net income: $323,000

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, adding a storage subsystems capability to its product line. The company also supplies CD-R/RW 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 continued to produce optical drive heads and mechanisms, most of which were 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 were deemphasized in favor of the higher capacity 5.25" models, but the company was unable to develop adequate volume and has ceased operations.

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.

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.

OPEN STORAGE SOLUTIONS
4 Paget Road
Brampton, Ontario L6T 5G3
Canada

OSS is a storage subsystem integrator, supplying a variety of RAID, Tape CD-ROM and other storage subsystems and servers to the Canadian and U,S, markets.

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
140 Technology Drive
Irvine, CA 92618

1997 total net sales: $31,124,000 (FY ending 12/27/97) Net income: ($30,229,000)

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 had started an optical drive factory, also in Colorado Springs, to produce complete high performance, high capacity 5.25" magneto-optical drives and other products, but shut this facility in 1997 due to financial reverses, and returned production to California. In addition to MO drives, Pinnacle Micro sells optical libraries using HP jukebox mechanisms and equipped with its own drives. The firm also remarkets CD-R and CD-RW drives.

In 1994, Pinnacle Micro introduced the Orray, an array of 5.25" optical drives with a controller that operated them concurrently, but did not develop a significant market for it. In 1995, the firm 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 initial customer interest. The Vertex, a more conventional 2.6 gigabyte drive, that went into production in mid-1996, was displaced by the Ultra 5.2 gigabyte drive in 1998. The Ultra drive is based on a purchased mechanism.

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

1997 total net sales: $109,300,000 (FY ending 7/31/97) Net income: $8,400,000

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. Procom is the largest producer of CD-ROM towers, including both host attached and network attached types, and pioneered rigid drive cached CD-ROM storage systems. Procom also manufactures disk drive array subsystems, tape backup systems and rigid disk drive storage subsystems.

QUINTA CORPORATION (Subsidiary of Seagate Technology)
1870 Lundy Drive
San Jose, CA 95131

Quinta, founded by several executives from the disk drive industry, originated as a U.S. start-up corporation planning to develop high capacity, high performance optical disk drives. Relatively little information about its specific target products was announced by Quinta. In July, 1997, Seagate announced it was acquiring Quinta for a minimum of 230 million dollars. Quinta continues to operate as a subsidiary corporation specializing in optical drive development activities, spinning off technology to Seagate's advanced development centers for use in future drive designs. Seagate is expected to announce its first products based on Quinta technology for delivery probably in 1999.

REGAL ELECTRONICS
4251 Burton Drive
Santa Clara, CA 95054

Founded in 1976, Regal is a supplier of connectors, cables, speakers and other parts to the computer industry. The company manufactures 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. However, the firm ended production in late 1997 due to competition from IDE interfaced minichangers and a perception that many firms now using minichangers would not require them once disk content was transferred to DVD-ROM.

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
2310 North 1st Street
San Jose, CA 95131

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, and licensed Quantum to manufacture drives in 1997. 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, Mitsumi for manufacturing and Yamaha (originally Seagate) for heads.

It is currently expected that TeraStor will ship 10 and 20 gigabyte drives in 1999, significantly delayed from original plans. The firm 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, announced an expansion 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, were to be able to be customized to user specifications. First shipments occurred in early 1997, but the firm has since decided to concentrate upon video tape libraries.

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, 1998, unless otherwise noted. All companies are in Japan unless otherwise noted.)

ACER PERIPHERALS
157 Shan Ying Road
Kweishan, Taoyuan 333
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 one of Taiwan's largest producer of CD-ROM drives.

ACTIMA TECHNOLOGY CORPORATION
12F, No. 2, Wu-Ling Road
Hsinchu 300
Taiwan

Actima, founded in May of 1997, is a member of the Chang Gu Group, a conglomerate active in building and construction. Actima was started as part of a group-wide diversification program, and currently manufactures CD-ROM drives. The firm's first product was a 24X drive, introduced in early 1998, followed by 32X and 36X models.

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, but ceased optical drive manufacturing in 1997.

AOPEN (Acer, Inc.)
88, Section 1, Hsin Tai Wu Road
Hsi Chih, Taipei Hsien 221
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, later converting to AOpen as the business unit name.

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

1998 total net sales: $4,171,214,000 Net income: $46,689,000

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 25% of revenues during the last year. 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 manufacturer 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. The company has recently entered the DVD-ROM library market, again targeting the broadcast industry.

ASUSTEK COMPUTER, INC.
150 Li-Te Road, Peitou
Taipei
Taiwan

A computer maker that entered the CD-ROM manufacturing arena in 1997, the firm introduced a 34X CD-ROM drive in 1998, the only one of its type. The firm has since introduced a 40 X model.

AZTECH SYSTEMS LTD.
31 Ubi Road 1
Singapore 1440

1997 total net sales: $158,869,799 (FY ending 12/31/97) Net income: $1,575,839

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 drives followed as mechanisms became available. However, in 1997, the firm determined that it would be unable to profitably compete without unrealistic shipment volume increases, and CD-ROM drive production ended at the end of 1997.

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.

CALIX TECHNOLOGY CO., LTD.
149 Wu Kung Road, Wuku Hsiang
Taipei Hsien
Taiwan

Calix started in 1965 as a manufacturer of audio equipment, notably turntables. The firm's current product line includes computer mice, speakers and CD-ROM drives, which started with a 24X model in 1997. A 36X model was added in 1998. Calix has a relationship with Hanpin Electronic Company, Located in Shenzen, China, which does the manufacturing of the Calix drives.

CANON INC.
3-30-2, Shimomaruko
Ohta-ku, Tokyo 146-8501

1997 total net sales: $22,799,546,000 (FY ending 12/31/97) Net income: $981,115,000

Canon is a major supplier of business machines, copiers, and cameras, but about 47% of the firm's business is in computer peripherals. Another 14% is in other data and communications equipment. Disk drive products include 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, leaving Canon manufacturing its optical drives only for use in its own Canofile document management systems. Drive production ended in 1997.

Canon introduced a line of fast scanners in 1998 that integrate a rigid disk drive cache and CD-R drive, allowing users to rapidly scan documents to hard disk and then create an archival image.

CYBERDRIVE (See Pan-International)

CHIA SHIN TECHNOLOGY CORP.
159 Sung Teh Road
Taipei
Taiwan

Chia Shin is a subsystem integrator producing CD towers and CD duplicators. The firm markets in Asia, the U.S. and Brazil under the Macally and Part II Research brands.

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.

ELITE PERIPHERALS (Subsidiary of 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. Elitegroup 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 sold through reseller channels under the Vertos brand name. Elite Peripherals is currently selling the drives under its own name.

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

1998 total net sales: $41,167,481,000 Net income: $46,135,000

Fujitsu is Japan's largest producer of computer systems and also manufactures a wide variety of other electronic equipment. Computer products represent about 69% 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. Discouraged by rapidly falling CD-ROM drive prices, the firm elected to withdraw from the CD-ROM drive market in 1998.

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

1998 total net sales: $69,503,171,000 Net income: $28,712,000

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 55% of 1998 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 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 and commencing volume shipments in 1998.

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. 32X and faster drives are currently available.

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

Hyundai 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 were 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. Production of CD-ROM drives ended in 1997.

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

1998 total net sales: $7,566,515,000 Net income: ($38,827,000)

JVC, as it is commonly known, is a major manufacturer 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 went into sample production in late 1991, along with additional mastering subsystems. Full production began in the second quarter of 1992. CD-RW drives began production in late 1997. JVC also manufactures CD-ROM optical libraries, equipping many of them with CD-R and CD-RW drives.

KENWOOD
1-14-6, Dogenzaka
Shibuya-ku, 150 Tokyo

1998 total net sales: $2,577,828,000 Net income: $13,873,000

Kenwood is one of the largest manufacturers of audio equipment and also manufactures communications equipment. In an initiative to broaden into other electronics technologies, the company established Kenwood Technologies in 1997 to create and market products for computer systems.

Kenwood Technologies, in conjunction with development partner Zen Research (which provides pickup, ASIC and other technology), designed and is manufacturing a CD-ROM drive capable of reading and processing multiple tracks of data at a time, providing a data transfer rate well in excess of conventional CAV drive technology while maintaining CLV rotation rates. Production, which is scheduled to begin in the summer of 1998, is in the Philippines. Ken-

wood expects to sell the drives through distribution and to system OEMs. An eventual extension of the multitrack read approach to DVD drives is anticipated.

KONICA CORPORATION
1-26-2 Nishi-Shinjuku
Shinjuku-ku, Tokyo

Konica is a well known camera and photographic materials manufacturer, but about 31% of sales are non-photographic business and computer equipment. The firm made floppy disk drives for a few years, but then transferred its storage interests to 3.5" MO disk drives, which it manufactures on a contract basis for other firms. A 640 megabyte drive (which spins at 4500 RPM) is currently in production, and a 1.3 gigabyte drive is planned for 1999. Production is at Kofu and Yamanishi.

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

1998 total net sales: $8,500,718,000 Net income: $179,835,000

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 manufactured 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. Maxoptix became an independent company in 1997, as the result of a management buyout, but Kubota continues to supply libraries to Maxoptix.

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

1998 total net sales: $3,201,387,000 Net income: $27,655,000

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 73% 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 9.5 millimeters, to match the height of thin rigid drives used in portable computers.

LEOPTICS INC.
100-1 Ming Chuang Road
Hsin Tien City
Taipei, Taiwan

Founded in July of 1997, Leoptics is a member of First International Computer, Inc., Group, a major Taiwanese system manufacturer. The firm builds its drives around purchased mechanisms, adding the electronics and packaging to create a complete drive. Leoptics currently supplies CD-ROM and CD-RW drives, and intends to add DVD-ROM to the product line in 1998.

LG ELECTRONICS, INC.
20 Yoido-dong
Youngdungpo-gu
Seoul 150, South Korea

1997 total net sales: $9,718,100,000 (FY ending 12/31/97) Net income: $96,339,900

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 one of the world's largest producer of CD-ROM drives.

LITE-ON TECHNOLOGY CORPORATION
16 Nanking East Road, Section 4
Taipei, Taiwan

1997 total net sales: $1,885,000,000
(FY ending 12/31/97)

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 delayed its DVD plans due to component shortages, but expects to produce DVD-ROM drives starting in late 1998.

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

1998 total net sales: $65,158,233,000 Net income: $772,948,000

MEI's Panasonic, National, Technics, and Quasar brands are among the most widely known in the world for appliances, consumer electronics, and communications equipment. 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 remained the largest producer of CD-ROM drives until 1997. It is still the largest non-captive producer. The company also offers CD format libraries.

Building upon its experience with CD-ROM and phase change technology, and inspired by its prominent position in the entertainment industry, MEI has been among the more visible sponsors of DVD-ROM and DVD-RAM. Its DVD-RAM drives are expected to be in production in late 1998.

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. 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.
8-1, Furujin-machi
Takamatsu-shi 760-0025

1998 total net sales: $5,987,498,000 Net income: $165,954,000

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
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 designed, and marketed rewritable optical disk drives manufactured by Kubota. Kubota has worldwide manufacturing rights and exclusive sales rights in Japan for Maxoptix products. In late 1997, Maxoptix became an independent company again as a result of a management buyout, but the firm retains strong links with Kubota. Kubota continues to produce 5.25" optical libraries for Maxoptix.
Maxoptix has 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.

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

1998 total net sales: $31,390,124,000 Net income: ($874,699,000)

Mitsubishi is most noted for heavy machinery production, but is also active in defense electronics and consumer electronics. Data and communications systems represent about 45% of revenues.

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. However, in 1997, the firm decided to concentrate upon the AV market, and the DVD-ROM product was dropped.

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

1997 total net sales: $2,177,465,000 (FY ending 9/30/97) Net income: $83,914,000

Mitsumi, founded in 1949, is primarily a manufacturer of electronic components, but 46% of revenues are derived from computer and telecommunications equipment. 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 until 1998. 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, but has recently been losing market share to other competitors. Mitsumi and Philips jointly announced in mid-1998 that they were working together on advanced CD-RW and DVD-ROM drive development, and Mitsumi has been identified by TeraStor as a manufacturing partner for its near field recording MO drives.

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

1997 total net sales: $215,962,000 (FY ending 12/28/97) Net income: $12,081,000

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 61% of 1997 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. While the minichangers did well initially, inability to keep up with OEM performance and price demands led to major shipment declines, resulting in restructuring of the firm in 1998.

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

1998 total net sales: $40,471,693,000 Net income: $341,057,000

NEC has defined its product area as communications and computers, with computer products accounting for about 42% 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 gigabytes per side capacity began shipping in early 1996.

CD-ROM drives have been produced since 1992. 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 through its NEC Home Electronics business unit. 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.

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 5.25" drives, mostly sold in Japan.

NEWTECH CO., LTD.
1-3-6 Yushima, Bunkyo-ku
Tokyo 113

Established in 1982, Newtech is a storage systems integrator, producing disk drive arrays and CD-ROM towers built around Axis Communications controllers and Nakamichi minichangers. The company also provides a variety of technical and distribution serves for other electronic and computer products.

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

1998 total net sales: $3,073,039,000 Net income: $68,687,000

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 gigabytes per side erasable optical drive. 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. Shipments were weak, and the drive was discontinued in 1997. A 5.25" LIM-DOW MO drive, developed in conjunction with Hitachi, was introduced in 1996 and continues to be produced.

NIPPON COLUMBIA CO., LTD.
14-14, Akasaka 4-Chome
Minato-ku, Tokyo, 107-11

1998 total net sales: $849,554,000 Net income: ($62,444,000)

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.

NORM PACIFIC AUTOMATION CORP.
182 Keng-Tzu-Kou, Hsin Fong Shiang
Hsinchu Hsien, Taiwan

Norm Pacific started in 1992 as a manufacturer of air conditioners, still a major business activity for the firm. The firm entered the CD-ROM business in late 1997, and production of 24X and 32X drives started in mid-1998.

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, were assembled with purchased mechanisms, but discontinued due to steep price declines in the CD-ROM market.

OLYMPUS OPTICAL CO., LTD.
22-2, Nishi-Shinjuku 1-chome
Shinjuku-ku, Tokyo

1998 total net sales: $3,013,889,000 Net income: $76,870,000

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 had 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 has expanded 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. The product line currently includes 640 megabyte 3.5" drives.

OPTICS STORAGE PTE. LTD.
135 Joo Seng Road, #05-04
Singapore 368363

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 aggressively developed the market for several generations of higher speed drives, but declining prices and margins led to a decision in 1997 to deemphasize CD-ROM drive production and concentrate on storage subsystems such as CD-ROM duplicators.

PAN-INTERNATIONAL CORPORATION (Cyberdrive)
504-2 Section 4, Chung Hua Road
Hsin-Chu, Taiwan

Formed in 1996, Cyberdrive began assembling CD-ROM drives using mechanisms procured from Japanese firms and electronics manufactured in Taiwan. 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. Pan-International rapidly built up CD-ROM production capabilities, achieving a place as one of Taiwan's larger CD-ROM drive producers. 24X and 32X drives are the firm's primary CD-ROM products. The firm has retained the Cyberdrive brand.

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

1998 total net sales: $4,622,964,000 Net income: $50,892,000

Pioneer, founded in 1947, is a major manufacturer of consumer electronic equipment. 89% of Pioneer's revenues come 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 established a separate division to make and sell the product. Pioneer 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. Subsequent models increased disk capacity, and libraries with capacities up to 500 disks have been shown. 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. Pioneer was also the first company to market DVD-R drives, and is a primary sponsor of the DVD-RW rewritable recording format.

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/RW storage subsystems, including towers and servers. The firm distributes its products in the United States through the trading company, Kanematsu.

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

1998 total net sales: $11,588,340,000 Net income: $248,811,000

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 accounts for 21% of current 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.

After several years of optical disk drive manufacturing activities involving write-once and MO drives, Ricoh has concentrated in recent years on CD-R and CD-RW drives. 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

1997 total net sales: $19,420,866,051 (FY ending 12/31/97) Net income: $129,895,781

Founded in 1969, Samsung Electronics is Korea's largest manufacturer of electronic products, which range from semiconductors, to telecommunications equipment, disk drives 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

1998 total net sales: $15,893,270,000 Net income: $101,734,000

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 32% 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. 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. Sanyo is also manufacturing CD-R drives, the latest an 8X write, 20X read introduced in 1998.

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

1998 total net sales: $2,738,274,000 Net income: $294,261,000

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

1998 total net sales: $14,785,648,000 Net income: $204,690,000

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 31% of sales are derived from computer or communications 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 has now phased out of this 5.25" MO product line.

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

1998 total net sales: $53,053,716,000 Net income: $1,833,757,000

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 55% 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 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. The firm is also one of the leading proponents of the DVD+RW recording format, and anticipates drive production in 1999.

Sony fields a product line of CD-ROM, CD-R, CD-RW, write-once and multifunction optical drives. 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, but the 12" line was discontinued in early 1997. In 1994, Sony introduced its first 5.25" library, a 20 disk model, followed by a 60 disk library in 1995. Sony manufactures its 5.25" libraries in the United States but has also 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 done well, 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.

SVEC COMPUTER CORP.
531-1 Chung Cheng Road
Hsin-Tien City
Taipei, Taiwan

Established in 1987, SVEC specializes in computer networking and subsystems, obtaining over 80% of its sales revenues from outside Taiwan through sales of routers, bridges, controllers and adapters. The firm announced a CD-ROM network adapter/server in late 1997.

TAE IL MEDIA COMPANY, LTD.
456-1 Moknae-dong
Ansan, Kyonggi-do, South Korea

Founded in 1983, Tae Il was a major producer of magnetic heads and media. The firm entered the floppy disk drive and CD-ROM drive markets, with production in China. A 6X drive was introduced in 1995, with subsequent addition of 16X and 20X models, but the firm experienced financial problems in 1997 and declared bankruptcy.

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 briefly marketed 12X and 16X drives, and then produced CD-ROM drive mechanisms, marketing primarily to Asian producers of CD-ROM drives. Declining drive prices led the firm to exit the field in 1997.

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 assembles CD-ROM 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

1998 total net sales: $1,142,956,000 Net income: $31,932,000

TEAC is best known for its leadership position in the flexible disk drive industry, but the firm also manufactures optical disk drives. About 75% of revenues come from sales of computer peripheral devices. TEAC has produced CD-ROM drives for several years, 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 and CD-RW drives, and is a PD drives licensee and producer.

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

1998 total net sales: $45,074,302,000 Net income: $60,586,000

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 68% 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 became the leading producer of CD-ROM drives in 1997, helped by a large production volume of slim drives for its own notebook computers. 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 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. The start of DVD-RAM drive shipments is anticipated in 1998.

ULTIMA ELECTRONICS CORP. (Artec)
18, Alley 1, Lane 768
Section 4, Pa Te Road
Taipei, Taiwan

Ultima was founded in 1983 as a manufacturer of keyboards, and has since branched out into peripheral equipment, perhaps best known for its scanners. 24X CD-ROM drives went into production in 1997, followed by 32X and 36X in 1998. CD-RW drive production is planned for late 1998.

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-1998, the USDrives product line extended from 16X to 32X 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 Corporation, a Taiwan company that has also produced 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

1998 total net sales: $5,028,819,000 Net income: $111,272,000

Yamaha is the world's largest manufacturer of musical instruments, which account for 55% 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. In 1998, Yamaha and TeraStor began joint development of heads for TeraStor's near field recording MO drive.

Yamaha was the first to develop CD-R systems capable of recording on write-once media and produced the first commercial write-once CD format drive.The firm followed up with a greatly cost reduced 4X recorder that went into production in 1994 and a 2X write/4X read model introduced in 1996. Faster models continue to be regularly introduced, and are frequently selected by manufacturers of CD format duplicating systems.

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 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, and modified its corporate name to ATG S.A. in mid-1997.

ATG 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 1998 shipment, as is a six disk 12" optical library unit.

AXIS COMMUNICATIONS AB
Scheelevagen 16
S-223 70 Lund
Sweden

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. Recent development focused 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.

CYCMA, S.L.
Parque Empresarial Zuatzu, Edificio Igeldo, 1
20009 Donostia-San Sebastian
Spain

CYCMA is an integrator of towers, arrays and other storage products. The firm also distributes optical libraries and other storage related products for a number of manufacturers.

DETERNER STEURERUNGS UND MACHINENBAU GMBH & CO. (DSM)
Birkenstrasse 2
D-2951 Deternerlehe
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, and 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

1997 total net sales: $39,206,667,000 Net income: $2,940,000,000

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. Philips, along with Sony and others, is also a sponsor of the proposed DVD+RW format.

Manufacturing of CD-ROM drives, CD-R/RW drives (and mechanisms) is the responsibility of Philips Components, 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 and discussed separately below.

CD type drive mechanisms are sold on an OEM basis by Philips Components, which also provides drive mechanisms to other Philips business units such as Philips Consumer Electronics, which sells drives through aftermarket channels. In mid-1998, Philips and Mitsumi announced a joint development effort aimed at advanced CD-RW and DVD-ROM drives.

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 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

1998 total net sales: $54,926,230 (FY ending 3/31/98) Net income: ($13,437,705)

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.

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 secured several major OEM customers in 1995 and 1996, including IBM, and is currently 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.

DISK/TREND ON DISK

1998 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. Systems running Windows 3.x and Windows 95/98 are also supported. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility.

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.

The statistical tables are provided in ASCII format and can be used with any spreadsheet program that can import ASCII text files. The specification tables have been prepared 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 1998 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1998 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., Roswell, GA.

Trademarks

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MS-DOS, Windows, Windows 95 and Windows 98 are trademarks of Microsoft Corporation.
AutoImport is a trademark of White Crane Systems, Inc.

Getting started

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

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

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

DISK/TREND ON DISK is normally shipped on 3.5" 1.44 megabyte diskettes, but is also available on 1.2 megabyte 5.25" diskettes if requested. There will be two diskettes in a set, one containing statistical tables and one containing specification tables.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked "Tables" in a floppy disk drive able to read 3.5" disks. This is usually 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. 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: On your hard disk, create a directory named AIMP (You could use other names if you prefer) and log into that directory. 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.

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. After doing the translations, 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 3,4,7,10 to 12	Tables 3 to 6, 11,12,24,25	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			N/A
MASKE	N/A	Drive height Drive capacity	Write-Once/ Erasable Analysis, Host/Net Attach Analysis	N/A
MASKF	N/A	Table 23	N/A	N/A
MASKG	N/A	Tables 32,43,49	N/A	N/A
MASKH	Tables 8,9	Table 29	N/A	N/A
MASKI	<----- Product Group -----> Price/Megabyte		N/A	N/A
MASKJ	N/A	Table 39	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	1998 Rigid Report	1998 Removable Report	1998 Optical Report	1997 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
7	--	--	MASKC	MASKC
8	MASKH	--	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKA	MASKC	MASKA
11	MASKC	MASKC	MASKC	MASKA
12	MASKC	MASKC	MASKC	--
13	--	--	--	--
14	--	MASKI	--	--
15	MASKA	--	--	--
16	MASKA	MASKI	--	MASKA
17	--	--	MASKA	MASKA
18	--	MASKI	MASKA	--
19	--	--	--	--
20	MASKD	MASKI	--	--
21	MASKI	--	MASKD	MASKD
22	--	MASKA	--	--
23	MASKA	MASKF	MASKA	MASKA
24	MASKA	MASKC	MASKA	MASKA
25	--	MASKC	--	--
26	--	MASKA	--	--
27	--	MASKA	MASKD	--
28	MASKD	MASKA	--	--
29	MASKI	MASKH	MASKA	MASKA
30	--	--	MASKA	MASKA
31	MASKA	MASKA	--	--
32	MASKA	MASKG	--	--
33	--	--	MASKD	--
34	--	--	--	--
35	--	MASKI	MASKA	
36	MASKD	MASKD	MASKA	
37	MASKI	--	--	
38	--	MASKA	--	
39	MASKA	MASKJ	MASKD	
40	MASKA	MASKD	--	
41	--	--	MASKA	
42	--	MASKA	MASKA	
43	--	MASKG	--	
44	MASKD	--	--	
45	MASKI	--	MASKE	
46	--	MASKD	MASKD	
47	MASKA	--	--	

Cross-reference (continued)

Table Number	1998 Rigid Report	1998 Removable Report	1998 Optical Report	1997 Array Report
48	MASKA	MASKA	MASKA	
49	--	MASKG	MASKA	
50	--	--	--	
51	--	--	--	
52	MASKD	MASKE	MASKA	
53	MASKI	MASKE	MASKA	
54	--	MASKD	--	
55	MASKA	--	--	
56	MASKA		MASKE	
57	--		MASKA	
58	--		MASKA	
59	--		--	
60	MASKD		--	
61	MASKI		MASKE	
62	--		MASKA	
63	MASKA		MASKA	
64	MASKA		--	
65	--		--	
66	--		MASKE	
67	--			
68	MASKD			
69	MASKI			
70	MASKA			
71	MASKA			
72	--			
73	--			
74	--			
75	MASKD			
76	MASKI			
77	MASKA			
78	MASKA			
79	--			
80	--			
81	--			
82	MASKD			
83	MASKI			

-- 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.

2. Now start AutoImport by typing AI, then the ENTER key. When the opening screen appears, select the "File" menu bar item using the mouse 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 select the name of the mask you want from the displayed list. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. 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: RT4.98R OT14.98O AT19.98A VT6.98V

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.

   Examples: RT4 OT14 AT19 VT6

6. The default spreadsheet type to which translation is made is Lotus 1-2-3 version 2.x. If you wish to translate to a different spreadsheet format you may choose it by selecting Format from the File Selection Menu and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. 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: OT10.98O

   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 top left 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. Name the output file as described in the previous section.

   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. 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. 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.

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. 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)

In the case of the Optical Data Storage Report, there will be separate tables for CD format Drives, Read/Write optical drives, CD towers and Libraries.

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: OS198 Optical disk drive specification table.
LS198 Optical library specification table.
TS198 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.

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.

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.