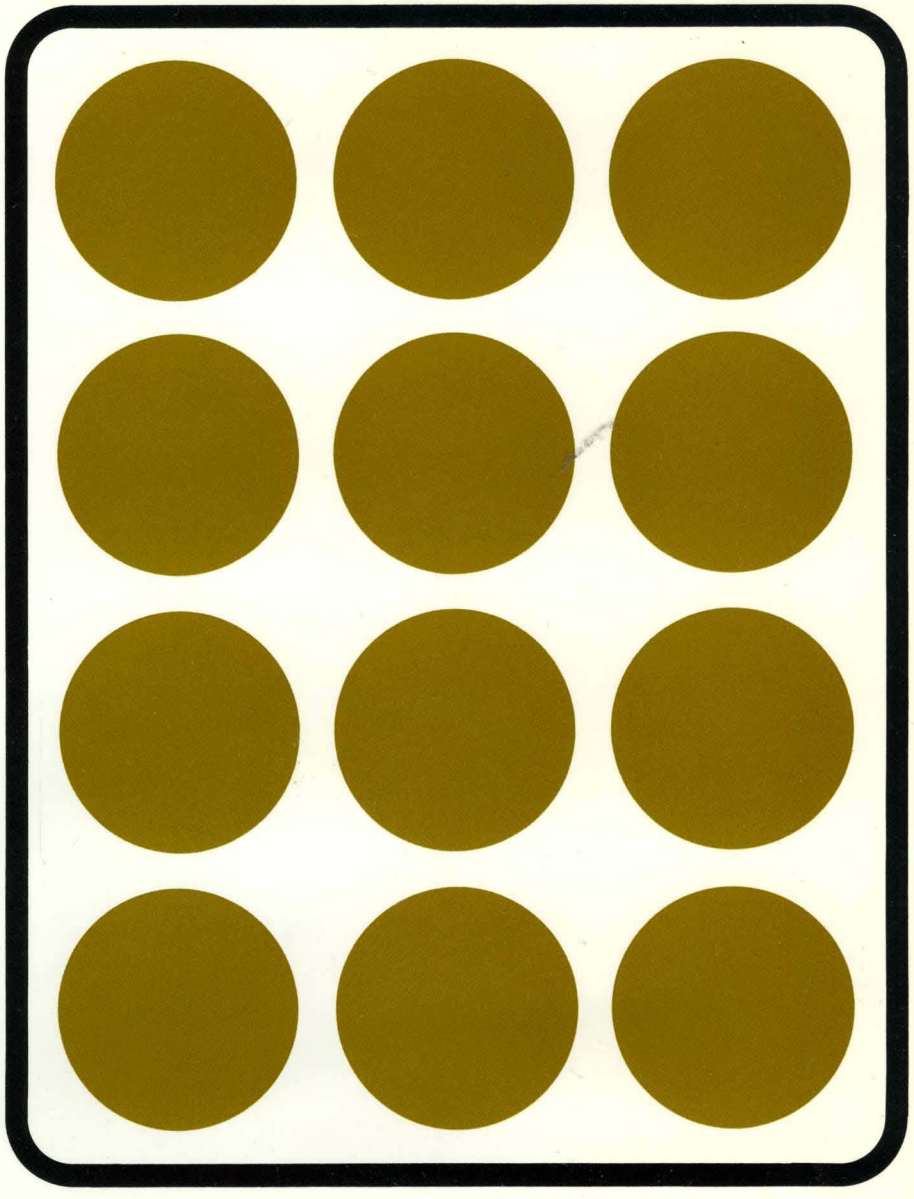
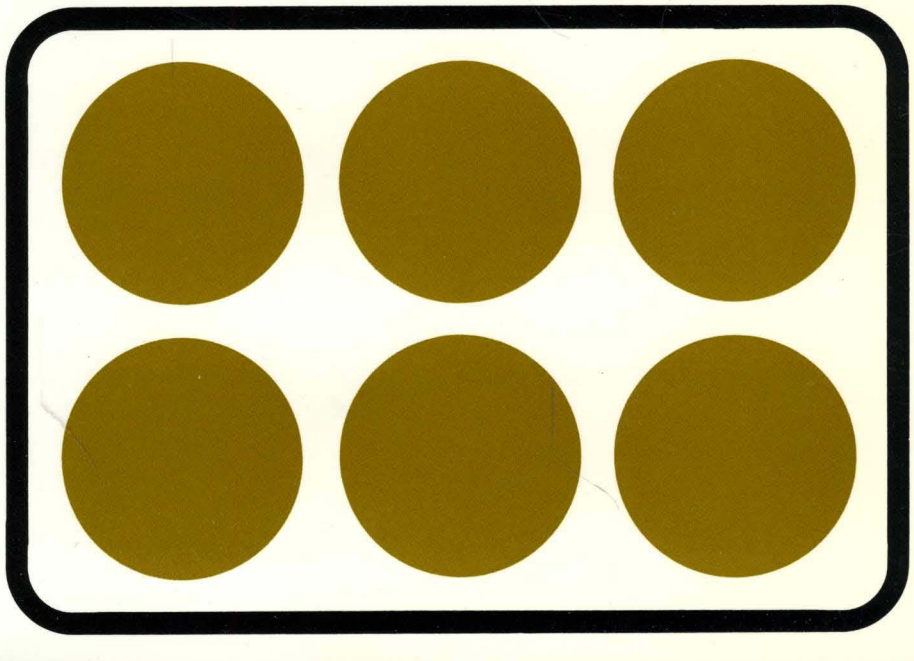


1996 DISK/TREND® REPORT



OPTICAL DISK DRIVES

1996 DISK/TREND® REPORT

OPTICAL DISK DRIVES

August, 1996

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

Telephone: 415-961-6209
Facsimile: 415-969-2560
E-mail: dtinfo@disktrend.com
Web: www.disktrend.com

© Copyright 1996 by DISK/TREND, Inc. All rights reserved. No portion of this report may be reproduced in whole or in part without written permission, including translation into another language or redistribution by any means or in any form. All information included is believed to be reliable but cannot be guaranteed to be complete or correct. DISK/TREND is a trademark registered in the United States Patent and Trademark Office.

FOREWORD

Turmoil in the optical disk drive industry continues, as CD-ROM drives speed through product generations in 6 months, and falling prices create a larger market for rewritable optical disk drives. The PD drive had a successful launch, and DVD-ROM drives are expected to be shipping this Fall, if patent licensing and copy protection issues are expeditiously settled. CD-E is also expected to begin shipments later in 1996. The CD-ROM autochanger market is on the way to annual shipments in the millions in a few years. And 12" drive shipments halted a multiyear decline.

There is a down side: 5.25" optical drives and small optical libraries are being displaced by high capacity magnetic rigid drives, and high capacity floppy and rigid cartridge drives are making inroads on the 3.5" MO market. In short, the predicted messy shoot-out between all of the competing forms of removable (and not so removable) storage seems to be occurring on schedule. So is industry restructuring: With small volume producers opting out of optical drive manufacturing, the field is becoming more concentrated. Even in the fast growing CD-ROM segment, the casualty list is building, and is expected to lengthen again in 1996, as firms with smaller shipments find they can't manage the fast paced generational changes while remaining competitive and profitable.

The fast growth in shipments of CD-R and CD-ROM autochangers is attracting new entrants to those product areas, and some of the firms that were unable to or unwilling to compete in the CD-ROM drive business have begun to reappear as manufacturers or assemblers in those product areas.

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

INTRODUCTION SUM-1

SUMMARY SUM-2

- Industry size SUM-2
- Marketing channels SUM-8
- Industry participation SUM-9
- Product mix SUM-12
- Noncaptive market SUM-20

TECHNICAL REVIEW SUM-32

- Optical disk drive technology and applications SUM-33
- Technical issues SUM-39
- Competing technologies SUM-50

DEFINITIONS SUM-57

CD FORMAT READ-ONLY OPTICAL DISK DRIVES DT20-1

CD FORMAT WRITABLE OPTICAL DISK DRIVES DT21-1

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES DT22-1

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES DT23-1

CD FORMAT OPTICAL DISK LIBRARIES DT50-1

READ/WRITE OPTICAL LIBRARIES, 1-39 CARTRIDGES DT51-1

READ/WRITE OPTICAL LIBRARIES, 40-69 CARTRIDGES DT52-1

READ/WRITE OPTICAL LIBRARIES, MORE THAN 70 CARTRIDGES DT53-1

CD FORMAT DISK DRIVE SPECIFICATIONS CDSPEC-1

OPTICAL DISK DRIVE SPECIFICATIONS OSPEC-1

OPTICAL LIBRARY SPECIFICATIONS LSPEC-1

MANUFACTURER PROFILES MFGR-1

DISK/TREND ON DISK DTDISK-1

LIST OF TABLES

Table		Page
1	CONSOLIDATED WORLDWIDE REVENUES, All Optical Disk Drive Groups	SUM-4
2	CONSOLIDATED WORLDWIDE REVENUES, All Optical Library Groups	SUM-5
3	CONSOLIDATED WORLDWIDE REVENUES, Optical Disk Drives, Market Class Review	SUM-10
4	CONSOLIDATED WORLDWIDE REVENUES, Optical Libraries, Market Class Review	SUM-11
5	CONSOLIDATED WORLDWIDE REVENUES, Optical Disk Drives, Product Group Review	SUM-14
6	CONSOLIDATED WORLDWIDE REVENUES, Optical Libraries, Product Group Review	SUM-15
7	CONSOLIDATED WORLDWIDE SHIPMENTS, Optical Disk Drives, Product Group Review	SUM-16
8	CONSOLIDATED WORLDWIDE SHIPMENTS, Optical Disk Libraries, Product Group Review	SUM-17
9	NONCAPTIVE WORLDWIDE REVENUES, Optical Disk Drives, Product Group Review	SUM-22
10	NONCAPTIVE WORLDWIDE REVENUES, Optical Disk Libraries, Product Group Review	SUM-23
11	NONCAPTIVE WORLDWIDE SHIPMENTS, Optical Disk Drives, Product Group Review	SUM-24
12	NONCAPTIVE WORLDWIDE SHIPMENTS, Optical Disk Libraries, Product Group Review	SUM-25
13	1995 ESTIMATED MARKET SHARES, Worldwide Manufacturers of Optical Disk Drives	SUM-28

LIST OF TABLES (Continued)

Table		Page
14	1995 ESTIMATED MARKET SHARES, Worldwide manufacturers of Optical Libraries	SUM-29
15	CURRENT PRODUCT LINES, Manufacturers of Optical Disk Drives	SUM-30
16	CURRENT PRODUCT LINES, Manufacturers of Optical Libraries	SUM-31
17	CD FORMAT READ-ONLY OPTICAL DISK DRIVES, Revenue Summary	DT20-15
18	CD FORMAT READ-ONLY OPTICAL DISK DRIVES, Unit Shipment Summary	DT20-16
19	CD FORMAT READ-ONLY OPTICAL DISK DRIVES, Revenue Breakdown by Data Transfer Rate	DT20-17
20	CD FORMAT READ-ONLY OPTICAL DISK DRIVES, Shipment Breakdown by Data Transfer Rate	DT20-18
21	CD FORMAT READ-ONLY OPTICAL DISK DRIVES, Applications Summary	DT20-19
22	CD FORMAT READ-ONLY OPTICAL DISK DRIVES, Market Share Summary	DT20-20
23	CD FORMAT WRITABLE OPTICAL DISK DRIVES, Revenue Summary	DT21-7
24	CD FORMAT WRITABLE OPTICAL DISK DRIVES, Unit Shipment Summary	DT21-8
25	CD FORMAT WRITABLE OPTICAL DISK DRIVES, Revenue Breakdown by Drive Type	DT21-9
26	CD FORMAT WRITABLE OPTICAL DISK DRIVES, Shipment Breakdown by Drive Type	DT21-10
27	CD FORMAT WRITABLE OPTICAL DISK DRIVES, Applications Summary	DT21-11
28	CD FORMAT WRITABLE OPTICAL DISK DRIVES, Market Share Summary	DT21-12
29	READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES, Revenue Summary	DT22-13

LIST OF TABLES (Continued)

Table		Page
30	READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES, Unit Shipment Summary	DT22-14
31	READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES, Revenue Breakdown by Disk Diameter	DT22-15
32	READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES, Shipment Breakdown by Disk Diameter	DT22-16
33	READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES, Applications Summary	DT22-17
34	READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES, Market Share Summary	DT22-18
35	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Revenue Summary	DT23-13
36	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Unit Shipment Summary	DT23-14
37	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Revenue Breakdown by Disk Diameter	DT23-15
38	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Shipment Breakdown by Disk Diameter	DT23-16
39	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Rewritable/Write-Once Drive Analysis	DT23-17
40	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Applications Summary	DT23-18
41	READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES, Market Share Summary	DT23-19

LIST OF TABLES (Continued)

Table		Page
55	READ/WRITE OPTICAL DISK LIBRARIES, 40 - 69 CARTRIDGES, Rewritable/Write-Once Drive Analysis	DT52-11
56	READ/WRITE OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES, Revenue Summary	DT53-7
57	READ/WRITE OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES, Unit Shipment Summary	DT53-8
58	READ/WRITE OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES, Revenue Breakdown by Disk Diameter	DT53-9
59	READ/WRITE OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES, Shipment Breakdown by Disk Diameter	DT53-10
60	READ/WRITE OPTICAL DISK LIBRARIES, 70 OR MORE CARTRIDGES, Rewritable/Write-Once Drive Analysis	DT53-11

LIST OF FIGURES

Figure		Page
1	CHANGING PRODUCT MIX Worldwide Optical Disk Drive Revenues	SUM-6
2	CHANGING PRODUCT MIX Worldwide Optical Library Revenues	SUM-7
3	WORLDWIDE SHIPMENT SUMMARY Optical Disk Drive Shipments	SUM-18
4	WORLDWIDE SHIPMENT SUMMARY Optical Disk Library Shipments	SUM-19
5	WORLDWIDE SHIPMENT SUMMARY Noncaptive Optical Disk Drive Shipments	SUM-26
6	WORLDWIDE SHIPMENT SUMMARY Noncaptive Optical Disk Library Shipments	SUM-27

LIST OF TABLES (Continued)

Table		Page
42	CD FORMAT OPTICAL DISK LIBRARIES, Revenue Summary	DT50-7
43	CD FORMAT OPTICAL DISK LIBRARIES, Unit Shipment Summary	DT50-8
44	CD FORMAT OPTICAL DISK LIBRARIES Revenue Breakdown by Library Size	DT50-9
45	CD FORMAT OPTICAL DISK LIBRARIES Shipment Breakdown by Library Size	DT50-10
46	READ/WRITE OPTICAL LIBRARIES, 1 - 39 CARTRIDGES, Revenue Summary	DT51-7
47	READ/WRITE OPTICAL DISK LIBRARIES, 1 - 39 CARTRIDGES, Unit Shipment Summary	DT51-8
48	READ/WRITE OPTICAL DISK LIBRARIES, 1 - 39 CARTRIDGES, Revenue Breakdown by Disk Diameter	DT51-9
49	READ/WRITE OPTICAL DISK LIBRARIES, 1 - 39 CARTRIDGES, Shipment Breakdown by Disk Diameter	DT51-10
50	READ/WRITE OPTICAL DISK LIBRARIES, 1 - 39 CARTRIDGES, Rewritable/Write-Once Drive Analysis	DT51-11
51	READ/WRITE OPTICAL DISK LIBRARIES, 40 - 69 CARTRIDGES, Revenue Summary	DT52-7
52	READ/WRITE OPTICAL DISK LIBRARIES, 40 - 69 CARTRIDGES, Unit Shipment Summary	DT52-8
53	READ/WRITE OPTICAL DISK LIBRARIES, 40 - 69 CARTRIDGES, Revenue Breakdown by Disk Diameter	DT52-9
54	READ/WRITE OPTICAL DISK LIBRARIES, 40 - 69 CARTRIDGES, Shipment Breakdown by Disk Diameter	DT52-10

INTRODUCTION

The DISK/TREND Report on optical disk drives and optical disk libraries is now in its 11th year. Reflecting industry changes, the organization of this year's report has been modified to include a new product group on writable CD format drives. The boundary between low and high capacity writable optical drives has been moved from one gigabyte to two gigabytes. And we have removed tables pertaining to write-once drives where shipments are no longer significant. Disk diameter tables have been modified to reflect anticipated new product introductions. Here are a few reminders to help in interpreting the information presented.

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

* Market share tables, usually included in DISK/TREND reports, are omitted for some product groups of this report, because the 1995 market was too small or too concentrated for market share figures to be meaningful.

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

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

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

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

SUMMARY: OPTICAL DISK DRIVES AND LIBRARIES

Industry size

1995 total optical disk drive revenues grew 31.8% to over $4.88 billion as CD-ROM drive sales leaped 39.8% to over $4 billion. Revenues in the new CD format writable drive group soared almost 213% to $279.3 million as declining prices spurred CD-R drive shipments, but sales revenues for both product groups of read/write drives declined. Revenues of read/write drives under 2 gigabytes dropped 22.2% to $515.2 million, and drives over 2 gigabytes slipped 6.3% to $85.9 million. 1999 total revenues are forecasted to exceed $10.6 billion. All product groups except drives under 2 gigabytes, impacted by the shift of 5.25" drive capacities to the over 2 gigabytes group, are expected to show revenue growth.

Shipments of 3.5" magneto-optic drives improved somewhat in 1995, but sales to large OEMs remained weak, and the prospects for growth in OEM 3.5" sales depend upon higher capacity and lower prices. Shipments of 5.25" drives declined due to pressure from competing technologies, while shipments of 12" drives grew slightly, as the result of higher capacities and improved manufacturing capabilities by a major supplier.

In 1995, 42.9 million optical drives were shipped. 41.7 million CD-ROM drives accounted for 97.2% of shipments. 514,000 CD format writable drives were shipped, including CD-R and PD drives. Shipments of read/write drives under 2 gigabytes expanded by 4% to 514,000 units, as shipment growth for 3.5" drives overrode the decline in 5.25" drive shipments. 1995 shipments for drives over 2 gigabytes (all 12" or 14") grew 12.3% to 6,400 units. 1999 total shipments are projected to exceed 90.8 million units, 85.2 million of which will be CD-ROM or DVD-ROM drives. CD format writable drives will exceed 4 million units, so all CD format drives together are forecasted to capture over 98% of 1999 shipments.

1995 optical library shipments made a huge 407% leap to 355,540 units, but almost 95% of the shipments were CD-ROM libraries. Of the CD-ROM libraries, over 98% were small CD-ROM autochangers. Further increases are anticipated, with CD format changers expected to account for over 98% of the units in 1999. Optical library sales revenues increased 13.9% to $347.1 million, led by libraries in the 70 or more cartridge category, which captured 42.1% of library revenues.

Libraries with 1-39 cartridges captured 24.1% of 1995 revenues, but actually lost share because of competition from high capacity magnetic disk drives and the growth of the CD format libraries, which had over 25% of optical library revenues. CD format libraries are forecasted to lead in 1999 revenues of $616 million, a 44.1% share, followed by the 70 or more cartridge group, with 29.1%.

U.S. manufacturers again lost revenue share in 1995 with a drop to 4.6% of worldwide optical disk drive revenues, reflecting minimal participation by U.S. firms in the CD-ROM market. However, U.S. companies gained 10 share points of total 1995 library revenues, capturing 56.8% of the worldwide total. The U.S. share of total drive shipments is insignificant, as a result of very large CD-ROM drive shipments from non-U.S. firms. U.S. manufacturers' 1995 share of library unit shipments fell because of the large increase in CD-ROM library shipments by non-U.S. suppliers, and is expected to decline further for the same reason.

Sales of optical disk drives to U.S. destinations in 1995 accounted for 41.5% of worldwide revenue, a slight decline from 1994. The U.S. market accounted for 56.7% of library revenues, also a decline from 1994, reflecting increasing interest in data storage automation outside the U.S. The U.S. optical drive market is expected to be 42.6% of a $10.6 billion drive market in 1999, while the proportion of the library market in the U.S. will grow slightly to 65.1% of $616 million in 1999, as the result of strong CD format library shipments to the U.S. that will compensate for strong growth of other types of libraries in non-U.S. markets.

U.S. optical library producers continue to do well with non-CD format libraries, as a result of aggressive new product development, a strong yen, and because of strengths in system integration and software support. Since optical libraries are used mostly on networked systems, a technology well understood by many U.S. companies, U.S. library producers are very effective in penetrating the domestic market. Non-U.S. producers are strengthening their positions in non-U.S. markets, where they are not hampered by unfavorable exchange rates.

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

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast							
	1996		1997		1998		1999			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	52.0	98.4	8.5	14.0	3.3	6.6	2.8	8.4	4.8	9.6
PCM/Distributor	63.7	91.6	51.9	75.1	46.9	71.2	45.0	67.9	44.4	69.9
OEM/Integrator	17.3	34.2	16.8	35.2	19.2	40.0	27.5	51.7	42.3	83.9
TOTAL U.S. REVENUES	133.0	224.2	77.2	124.3	69.4	117.8	75.3	128.0	91.5	163.4
Non-U.S. Manufacturers										
Captive	99.1	294.6	181.7	521.6	377.0	1,008.9	511.7	1,331.1	766.8	1,958.6
PCM/Distributor	510.9	1,412.6	679.0	1,506.7	895.0	1,732.3	1,041.0	2,097.0	1,050.6	2,534.6
OEM/Integrator	1,285.3	2,955.4	1,968.9	4,361.5	2,147.2	5,022.9	2,351.4	5,508.2	2,629.0	5,991.8
TOTAL NON-U.S. REVENUES	1,895.3	4,662.6	2,829.6	6,389.8	3,419.2	7,764.1	3,904.1	8,936.3	4,446.4	10,485.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,028.3	4,886.8	2,906.8	6,514.1	3,488.6	7,881.9	3,979.4	9,064.3	4,537.9	10,648.4

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES

OPTICAL LIBRARIES

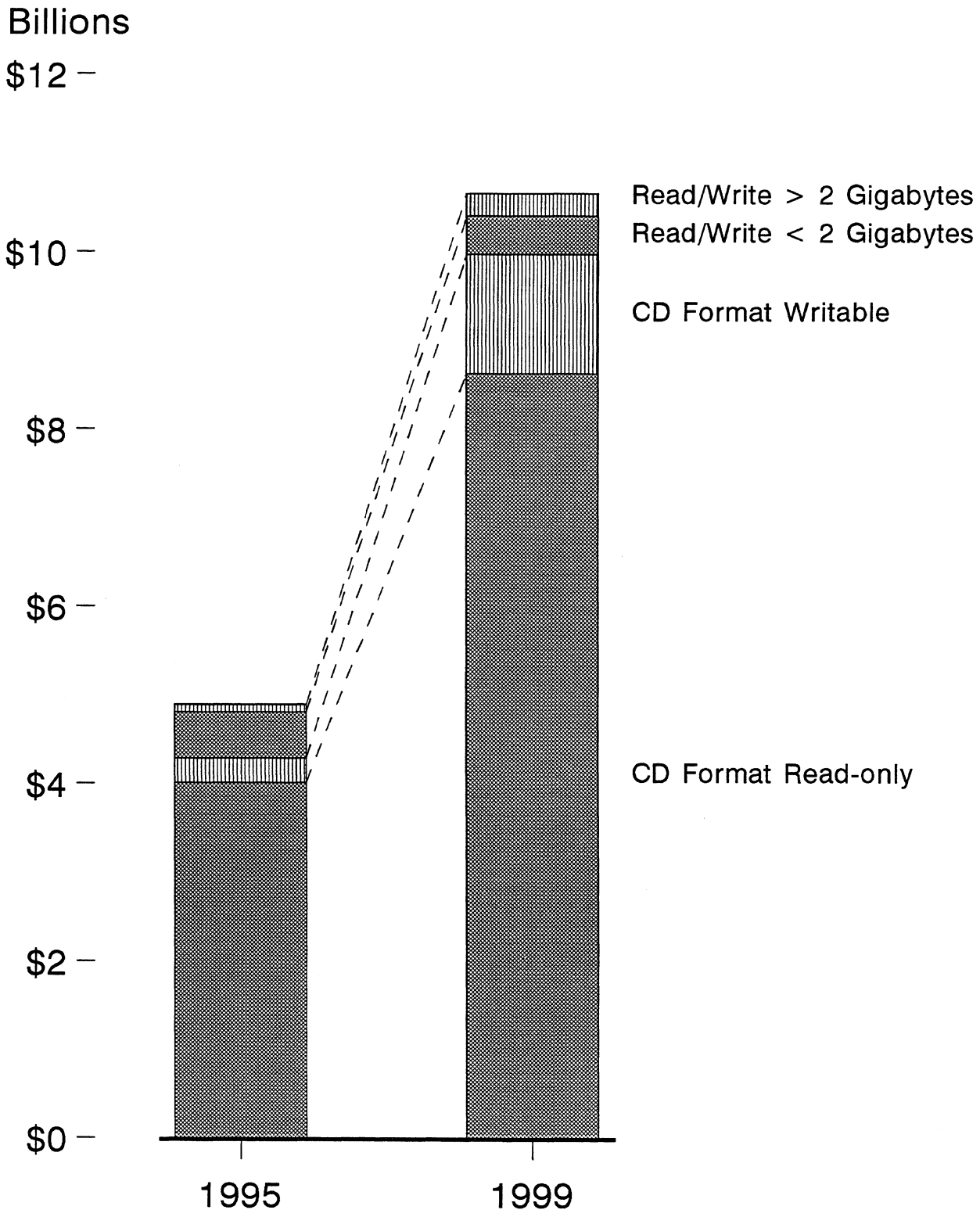
REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995		Forecast							
	Revenues		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	28.0	41.7	29.6	42.3	31.8	45.1	33.1	46.8	34.4	49.2
PCM/Distributor	28.1	40.1	32.0	45.3	34.7	49.0	36.5	52.0	38.6	55.3
OEM/Integrator	52.2	68.7	56.5	76.4	60.5	82.8	62.1	90.9	65.0	96.4
TOTAL U.S. REVENUES	108.3	150.5	118.1	164.0	127.0	176.9	131.7	189.7	138.0	200.9
Non-U.S. Manufacturers										
Captive	.2	15.4	.2	13.5	.2	13.6	.2	14.6	.3	16.1
PCM/Distributor	33.6	65.7	30.8	57.5	39.2	65.1	45.9	74.6	52.3	84.0
OEM/Integrator	55.1	115.5	96.6	170.2	138.1	221.2	175.3	268.8	210.3	315.0
TOTAL NON-U.S. REVENUES	88.9	196.6	127.6	241.2	177.5	299.9	221.4	358.0	262.9	415.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	197.2	347.1	245.7	405.2	304.5	476.8	353.1	547.7	400.9	616.0

Figure 1

CHANGING PRODUCT MIX

Worldwide Optical Disk Drive Revenue

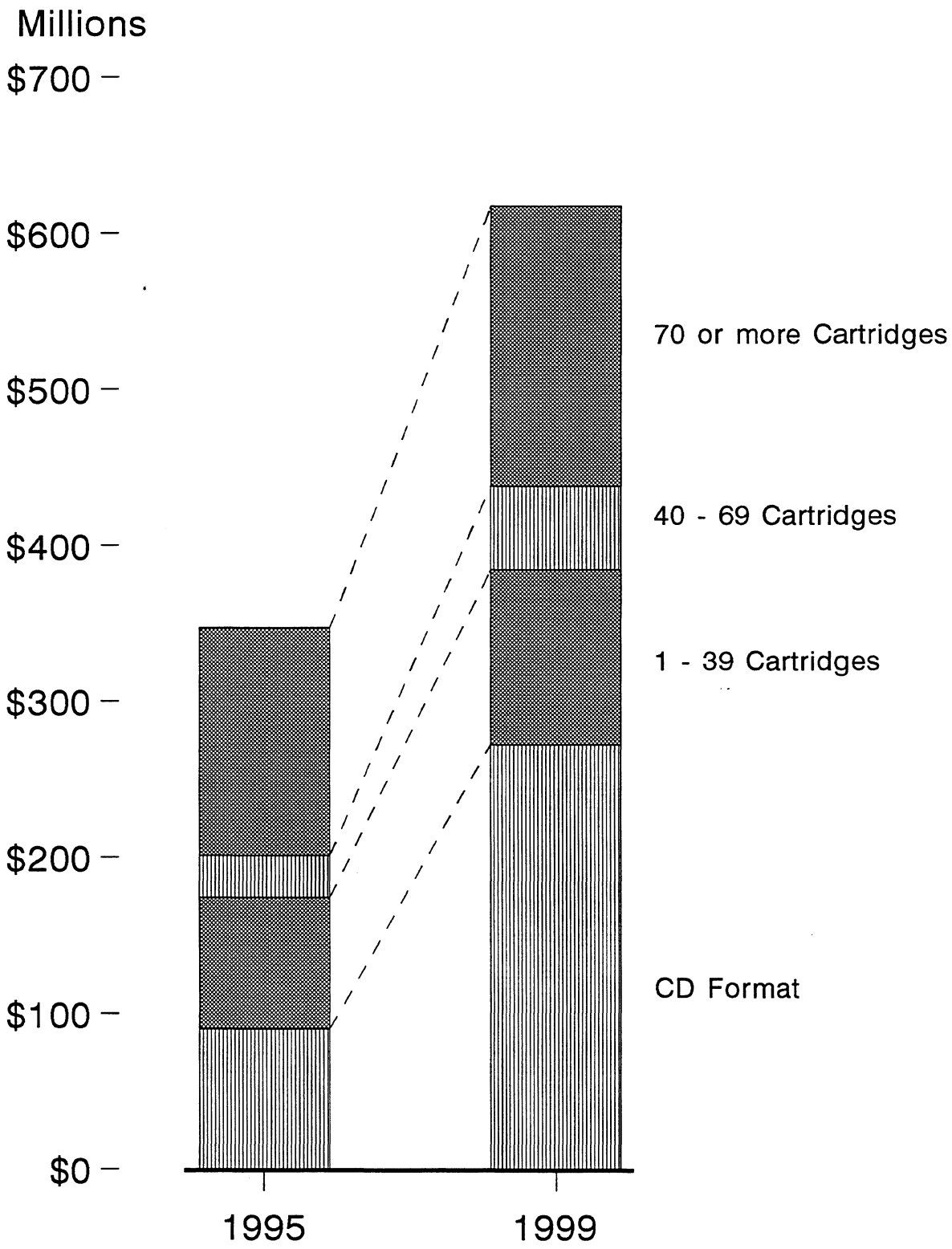


1996 DISK/TREND REPORT

Figure 2

CHANGING PRODUCT MIX

Worldwide Optical Library Revenue



Marketing channels

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

1995 OEM/Integrator optical disk drive revenues rose 62.5% to almost $3 billion, accounting for 61.2% of the worldwide sales revenue of nearly $4.9 billion. PCM/Distributor revenues grew 57.7%, and were 30.8% of total revenue, while revenues from the captive channel declined 57% and contributed only 8% of total revenue. The decline in captive contribution is expected to reverse as a consequence of increasing numbers of CD format drives sold on a captive basis, and the captive channel is expected to contribute 18.5% of total revenues of $10.6 billion in 1999. The OEM/Integrator channel will contribute 57% of total revenue, while the PCM/Distributor share is projected to shrink to 24.5%, forecasted to decline to 14% of 1999 revenues.

The contribution of 1995 optical disk library revenues of $347.1 million from the sales channels split 53% from OEM/Integrators, 27.2% from the PCM/Distributor channel, and 25.0% from the captive channel. Anticipated 1999 revenues of $616 million will be shared among OEM/Integrators with 66.8%, PCM/Distributor sales with 22.6% and captive sales with 10.6%. Because of the complex system integration and support requirements of libraries, only the simplest types are offered by many resellers, but some of the resellers handling libraries have acquired the characteristics of small OEMs as they increase the value-added content and perform increasing amounts of system integration. As a result, the OEM share of revenues is again forecasted to increase at a faster rate than PCM/Distributor revenues.

Revenues in this report are based on the price of the drive or library the first

time it is sold to an unaffiliated buyer, at captive end user, PCM/Distributor or OEM/Integrator levels. Drive prices are based on disk drives alone, without controllers or other accessories. Library prices are for the library only and do not include the disk drives or external controllers.

Industry participation

Industry participants are classified as U.S., Asian or European depending upon the geographical composition of their majority ownership. 7 U.S. companies, 46 Asian firms and 3 European manufacturers currently compete in the optical disk drive market. IBM was a notable departure from the roster of drive manufacturers. Over the years, Asian producers have steadily increased their presence, as many new producers in Asia announced CD-ROM drives. Most of the new CD-ROM manufacturers are in Singapore and Taiwan. Both U.S. and Asian firms are having their drives made on a contract basis by other Asian producers, with an increasing number being made in China.

As of mid-1996, 39 companies produce CD-ROM drives, the same number as in 1995, although the producer list has had additions and deletions. 36 are non-U.S. firms and 13 are Japanese organizations. 20 manufacturers make read/write drives less than 2 gigabytes: 19 of these make rewritable drives. 8 companies make, or have announced, optical disk drives of more than 2 gigabytes capacity. Only one firm offers a rewritable 5.25" drive, one supplies a 12" rewritable drive, and the remaining six firms produce only 12" write-once drives.

13 U.S. firms, 15 Asian manufacturers and 8 European suppliers offer optical libraries. Of the 35 companies, 24 make CD format libraries: 14 of these do not participate in other product groups. CD format libraries are now offered by Alps, Nippon Columbia, Hyundai and Regal Electronics, in addition to new production at other firms already manufacturing other types of libraries.

Of the 24 read/write library producers, 9 firms make only 5.25" libraries, while 8 make larger diameter libraries. Only two companies make a 3.5" library. Eight firms make read/write library models in two or more disk drive diameters. Two firms, Borett Automation and EMASS, manufacture libraries that can handle multiple types of drives and media simultaneously; others are expected to offer this capability. NK-EXA has stopped 5.25" optical library production.

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1995 Revenues $M	1995 Revenues %	1996 Forecast $M	1996 Forecast %	1997 Forecast $M	1997 Forecast %	1998 Forecast $M	1998 Forecast %	1999 Forecast $M	1999 Forecast %
U.S. Manufacturers										
Captive	98.4	2.0%	14.0	.2%	6.6	--	8.4	--	9.6	--
	+134.8%		-85.8%		-52.9%		+27.3%		+14.3%	
PCM/Distributor	91.6	1.8%	75.1	1.1%	71.2	.9%	67.9	.7%	69.9	.6%
	-18.2%		-18.0%		-5.2%		-4.6%		+2.9%	
OEM/Integrator	34.2	.6%	35.2	.5%	40.0	.5%	51.7	.5%	83.9	.7%
	-51.8%		+2.9%		+13.6%		+29.3%		+62.3%	
Total U.S. Manufacturers	224.2	4.4%	124.3	1.8%	117.8	1.4%	128.0	1.2%	163.4	1.3%
	-.3%		-44.6%		-5.2%		+8.7%		+27.7%	
Non-U.S. Manufacturers										
Captive	294.6	6.0%	521.6	8.0%	1,008.9	12.8%	1,331.1	14.6%	1,958.6	18.3%
	-66.3%		+77.1%		+93.4%		+31.9%		+47.1%	
PCM/Distributor	1,412.6	28.9%	1,506.7	23.1%	1,732.3	21.9%	2,097.0	23.1%	2,534.6	23.8%
	+67.8%		+6.7%		+15.0%		+21.1%		+20.9%	
OEM/Integrator	2,955.4	60.7%	4,361.5	67.1%	5,022.9	63.9%	5,508.2	61.1%	5,991.8	56.6%
	+67.0%		+47.6%		+15.2%		+9.7%		+8.8%	
Total Non-U.S. Manufacturers	4,662.6	95.6%	6,389.8	98.2%	7,764.1	98.6%	8,936.3	98.8%	10,485.0	98.7%
	+33.8%		+37.0%		+21.5%		+15.1%		+17.3%	
Worldwide Recap										
Captive	393.0	8.0%	535.6	8.2%	1,015.5	12.9%	1,339.5	14.8%	1,968.2	18.5%
	-57.0%		+36.3%		+89.6%		+31.9%		+46.9%	
PCM/Distributor	1,504.2	30.8%	1,581.8	24.3%	1,803.5	22.9%	2,164.9	23.9%	2,604.5	24.5%
	+57.7%		+5.2%		+14.0%		+20.0%		+20.3%	
OEM/Integrator	2,989.6	61.2%	4,396.7	67.5%	5,062.9	64.2%	5,559.9	61.3%	6,075.7	57.0%
	+62.5%		+47.1%		+15.2%		+9.8%		+9.3%	
Total All Manufacturers	4,886.8	100.0%	6,514.1	100.0%	7,881.9	100.0%	9,064.3	100.0%	10,648.4	100.0%
	+31.8%		+33.3%		+21.0%		+15.0%		+17.5%	

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

TABLE 4

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL LIBRARIES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1995 Revenues $M	1995 Revenues %	1996 $M	1996 %	1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %
U.S. Manufacturers										
Captive	41.7 -21.2%	12.0%	42.3 +1.4%	10.4%	45.1 +6.6%	9.4%	46.8 +3.8%	8.5%	49.2 +5.1%	7.9%
PCM/Distributor	40.1 +131.8%	11.5%	45.3 +13.0%	11.1%	49.0 +8.2%	10.2%	52.0 +6.1%	9.4%	55.3 +6.3%	8.9%
OEM/Integrator	68.7 -1.7%	19.7%	76.4 +11.2%	18.8%	82.8 +8.4%	17.3%	90.9 +9.8%	16.5%	96.4 +6.1%	15.6%
Total U.S. Manufacturers	150.5 +7.4%	43.2%	164.0 +9.0%	40.3%	176.9 +7.9%	36.9%	189.7 +7.2%	34.4%	200.9 +5.9%	32.4%
Non-U.S. Manufacturers										
Captive	15.4 -34.2%	4.4%	13.5 -12.3%	3.3%	13.6 +.7%	2.8%	14.6 +7.4%	2.6%	16.1 +10.3%	2.6%
PCM/Distributor	65.7 +.3%	18.9%	57.5 -12.5%	14.1%	65.1 +13.2%	13.6%	74.6 +14.6%	13.6%	84.0 +12.6%	13.6%
OEM/Integrator	115.5 +52.4%	33.5%	170.2 +47.4%	42.3%	221.2 +30.0%	46.7%	268.8 +21.5%	49.4%	315.0 +17.2%	51.4%
Total Non-U.S. Manufacturers	196.6 +19.4%	56.8%	241.2 +22.7%	59.7%	299.9 +24.3%	63.1%	358.0 +19.4%	65.6%	415.1 +15.9%	67.6%
Worldwide Recap										
Captive	57.1 -25.2%	16.5%	55.8 -2.3%	13.8%	58.7 +5.2%	12.3%	61.4 +4.6%	11.2%	65.3 +6.4%	10.6%
PCM/Distributor	105.8 +27.8%	30.5%	102.8 -2.8%	25.4%	114.1 +11.0%	23.9%	126.6 +11.0%	23.1%	139.3 +10.0%	22.6%
OEM/Integrator	184.2 +26.4%	53.0%	246.6 +33.9%	60.8%	304.0 +23.3%	63.8%	359.7 +18.3%	65.7%	411.4 +14.4%	66.8%
Total All Manufacturers	347.1 +13.9%	100.0%	405.2 +16.7%	100.0%	476.8 +17.7%	100.0%	547.7 +14.9%	100.0%	616.0 +12.5%	100.0%

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

Product mix

Nearly 43 million optical disk drives were shipped in 1995, a 73.2% gain, with CD-ROMs again contributing most of the growth. CD-ROM drive shipments of nearly 41.7 million units accounted for 97.2% of the 1995 worldwide shipment total, but the percentage of read-only CD format drives is forecasted to decrease to 93.9% in 1999 as a result of increasing shipments of writable CD format drives (1.2% of 1995 unit shipments) to 4.5% of unit shipments in 1999. CD format drive shipments include shipments associated with both computers and freestanding consumer equipment such as games and CD-I players, but not audio or video players. Due to strong growth in CD-ROM drive unit shipments, the share of read/write drives under 2 gigabytes declined to 1.6% of worldwide unit shipments in 1995. The share of read/write drives over 2 gigabytes was under .1%.

Within the less than 2 gigabytes group, 5.25" drive shipments shrank slightly due to competition from rigid magnetic drives, but this weak showing was offset by shipment growth of aggressively priced 3.5" drives. Shipments of MO drives in this group will be increasingly impacted by competition from high capacity 3.5" rigid and flexible removable magnetic disk drives and PD drives, plus CD-E drives and DVD-RAM drives in the future. CD format writable drive (CD-R and PD) shipments soared over 900% to 514,000 units as a result of lowered prices and new software for improved CD-R usability. Rewritable drives captured virtually all of the less than 2 gigabytes product group shipments in 1995 as write-once drives accounted for under 1% of shipments and revenues in that group.

5.25" drives have made their appearance in the more than 2 gigabytes product group, and beginning in 1997 are expected to rapidly increase their participation, exceeding 12"-14" unit shipments in 1997. DVD-RAM rewritable drives are expected to compete with drives in this group in 1998 and after, in applications where performance is subordinate to price.

Revenues for 1995 came predominantly from shipments in the CD format read-only product group, which contributed 82.2% of optical drive revenues. CD format writable drives contributed 5.7%, while read/write drives less than 2 gigabytes contributed 10.5% of revenues, followed by read/write drives more than 2 gigabytes, with 1.7%. The revenue share for CD format read-only drives is expected to remain in the same range throughout the forecast period. Writable CD format drive revenues will improve their share as DVD drives ramp up to-

wards the end of the forecast period, capturing 12.7% revenue share in 1999. Drives under 2 gigabytes will see their revenue share steadily decline as they are displaced by higher capacity drives. Correspondingly, the share for read/write drives over 2 gigabytes is expected to grow yearly starting in 1997, pushed by increasing 5.25" drive shipments.

CD-ROM and DVD-ROM drive shipments are expected to grow to over 85 million units in 1999, driven by acceptance of the devices as integral parts of personal computer and game systems. The performance requirements of multimedia capable systems and the demands of system manufacturers seeking product differentiation have rapidly shifted demand toward higher performance drives. The industry has shifted from 4X drives, through 6X drives, to 8X drives in the space of a year, delighting consumers, but creating inventory and ramp up problems, and depressing profitability. The 8X CD-ROM models are due for displacement by 10X, 12X and DVD-ROM models over the next 2 to 3 years, and 8X drives are forecasted to represent less than 5% of 1999 drive shipments.

1995 optical library shipments were again led by CD-ROM format optical libraries, particularly small autochangers with under 10 disk capacity, and reached a 94.9% share of total library shipments. The next largest segment was again the 1-39 disk cartridge library which captured a 3.6% share. Share for the 40-69 cartridge library group declined to .5%, while the share of libraries with 70 or more cartridges declined to 1%. The largest year-to-year growth rates were exhibited by CD-ROM format libraries (almost 540%) and the 70 or more cartridge group (48%). Shipments of small, inexpensive CD-ROM autochangers holding fewer than 10 disks (some internally mounted in a 5.25" half high form factor) are expected to grow strongly and exceed 1.5 million units in 1999.

Of the $347.1 million 1995 optical library sales revenues, 42.1% were held by the 70 cartridge or more group, followed by the CD format group with 25.9%, and the 1-39 cartridge group with 24.1%. The CD format libraries pushed the 1-39 cartridge group out of second place despite their lower share as a result of their lower prices. The 40-69 cartridge group captured only a 7.9% share, but this is expected to increase during the forecast period as increasing drive capacities allow some users to expand or maintain their data while requiring fewer disks. The share of CD format libraries is expected to increase annually, reaching 44.1% in 1999 due to strong shipments of small CD-ROM autochangers.

TABLE 5

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1995		Forecast							
ALL MANUFACTURERS	Revenues		1996		1997		1998		1999	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT READ-ONLY	4,006.4	82.1%	5,038.9	77.5%	6,333.8	80.5%	7,393.3	81.7%	8,616.6	81.0%
	+39.8%		+25.8%		+25.7%		+16.7%		+16.5%	
CD FORMAT WRITABLE	279.3	5.7%	833.1	12.8%	901.9	11.4%	1,005.0	11.1%	1,350.9	12.7%
	+212.8%		+198.3%		+8.3%		+11.4%		+34.4%	
READ/WRITE	515.2	10.5%	545.5	8.4%	528.9	6.7%	497.2	5.5%	430.0	4.0%
LESS THAN 2 GIGABYTES	-22.2%		+5.9%		-3.0%		-6.0%		-13.5%	
READ/WRITE	85.9	1.7%	96.6	1.3%	117.3	1.4%	168.8	1.7%	250.9	2.3%
MORE THAN 2 GIGABYTES	-6.3%		+12.5%		+21.4%		+43.9%		+48.6%	
Total Worldwide Revenue	4,886.8	100.0%	6,514.1	100.0%	7,881.9	100.0%	9,064.3	100.0%	10,648.4	100.0%
	+31.8%		+33.3%		+21.0%		+15.0%		+17.5%	

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

Figure 3

WORLDWIDE SHIPMENT SUMMARY

Total Optical Disk Drives

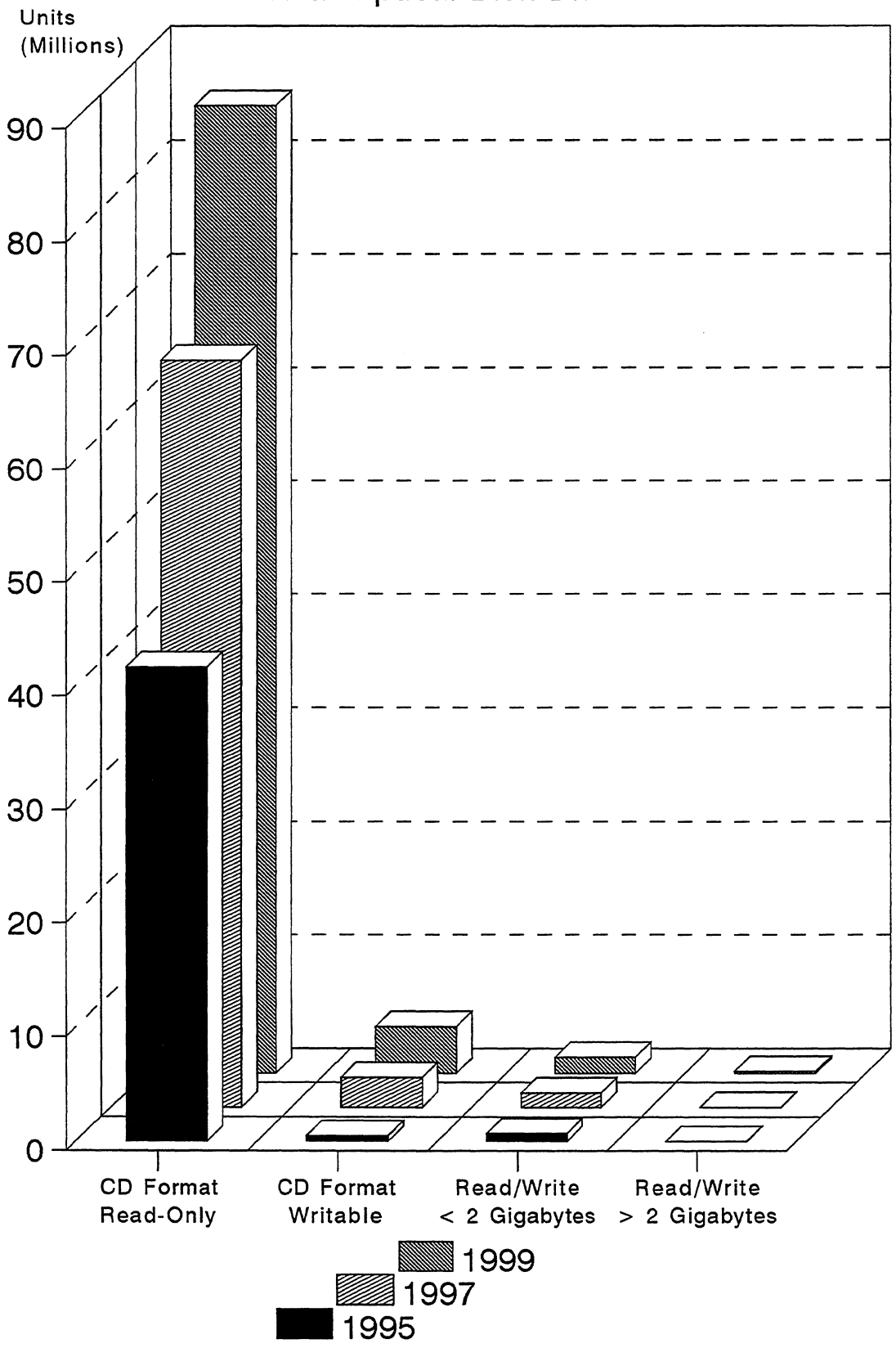


TABLE 8

CONSOLIDATED WORLDWIDE SHIPMENTS
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1995 Shipments Units	1995 Shipments %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %
CD FORMAT OPTICAL LIBRARIES	337,040	94.9%	651,123	97.0%	946,034	97.7%	1,247,700	98.1%	1,557,246	98.3%
	+538.9%		+93.2%		+45.3%		+31.9%		+24.8%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	12,799	3.6%	14,155	2.1%	15,447	1.6%	16,621	1.3%	17,642	1.1%
	+.5%		+10.6%		+9.1%		+7.6%		+6.1%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	1,632	.5%	1,936	.3%	2,247	.2%	2,586	.2%	2,914	.2%
	-10.9%		+18.6%		+16.1%		+15.1%		+12.7%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	4,069	1.0%	5,053	.6%	6,048	.5%	6,768	.4%	7,375	.4%
	+48.0%		+24.2%		+19.7%		+11.9%		+9.0%	
Total Worldwide Shipments	355,540	100.0%	672,267	100.0%	969,776	100.0%	1,273,675	100.0%	1,585,177	100.0%
	+407.4%		+89.1%		+44.3%		+31.3%		+24.5%	
% U.S. Manufacturers	3.6%		3.7%		3.2%		3.1%		2.9%	

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

TABLE 6

CONSOLIDATED WORLDWIDE REVENUES
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1995		Forecast							
ALL MANUFACTURERS	Revenues		1996		1997		1998		1999	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT OPTICAL LIBRARIES	90.0 +106.9%	25.9%	129.6 +44.0%	32.0%	174.1 +34.3%	36.5%	222.8 +28.0%	40.7%	271.5 +21.9%	44.1%
OPTICAL LIBRARIES 1-39 CARTRIDGES	83.7 -17.4%	24.1%	89.8 +7.3%	22.2%	97.8 +8.9%	20.5%	104.7 +7.1%	19.1%	111.7 +6.7%	18.1%
OPTICAL LIBRARIES 40-69 CARTRIDGES	27.3 -3.2%	7.9%	35.2 +28.9%	8.7%	42.5 +20.7%	8.9%	48.1 +13.2%	8.8%	53.5 +11.2%	8.7%
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	146.1 +10.8%	42.1%	150.6 +3.1%	37.1%	162.4 +7.8%	34.1%	172.1 +6.0%	31.4%	179.3 +4.2%	29.1%
Total Worldwide Revenue	347.1 +13.9%	100.0%	405.2 +16.7%	100.0%	476.8 +17.7%	100.0%	547.7 +14.9%	100.0%	616.0 +12.5%	100.0%

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

TABLE 7

CONSOLIDATED WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

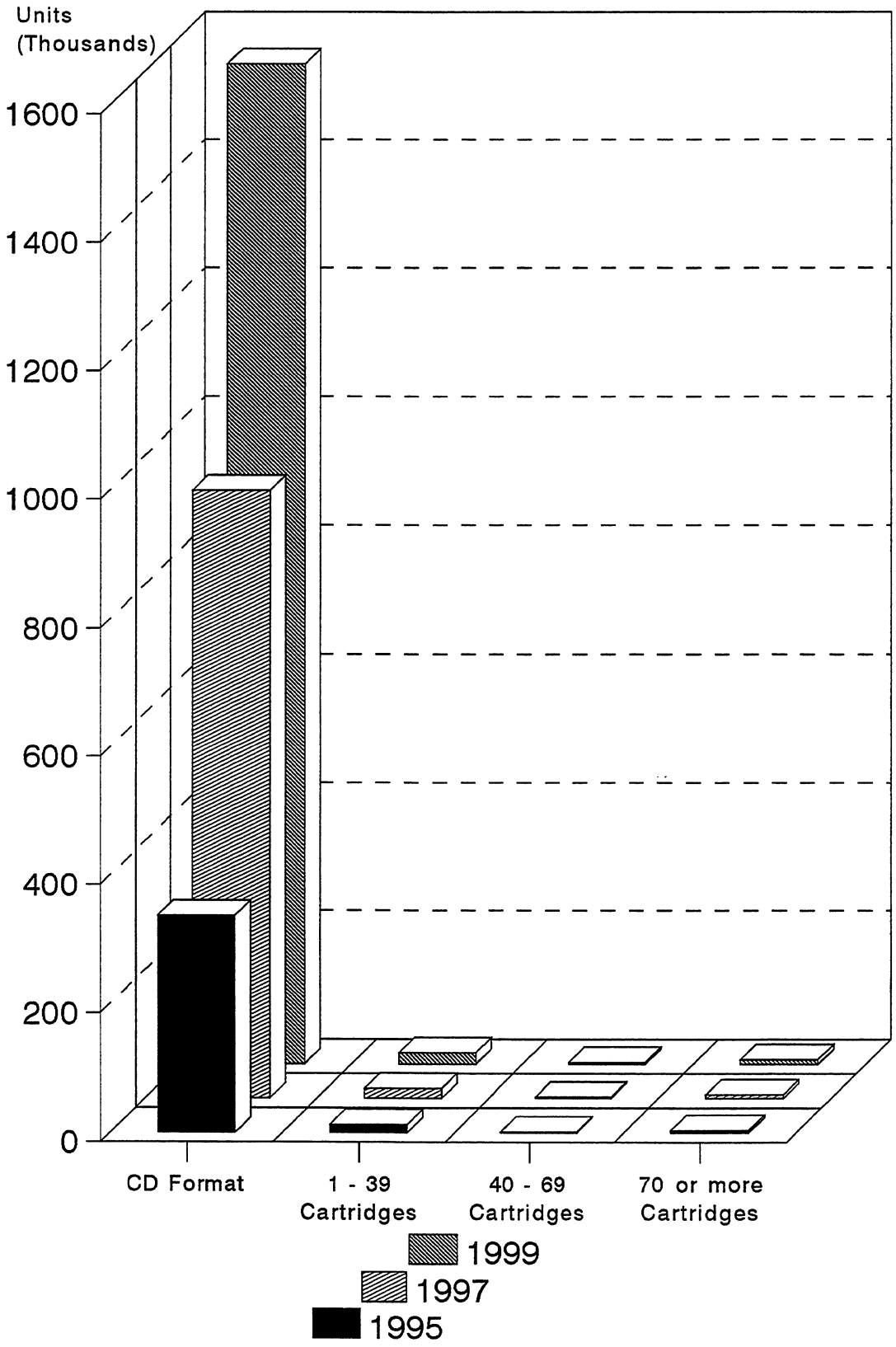
UNIT SHIPMENTS	1995		Forecast							
IN THOUSANDS	Shipments		1996		1997		1998		1999	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD FORMAT READ-ONLY	41,692.0	97.2%	54,492.2	94.6%	65,781.0	94.5%	76,116.9	94.3%	85,201.8	93.9%
	+73.4%		+30.7%		+20.7%		+15.7%		+11.9%	
CD FORMAT WRITABLE	514.0	1.2%	2,081.0	3.6%	2,617.0	3.8%	3,256.4	4.0%	4,085.4	4.5%
	+907.8%		+304.9%		+25.8%		+24.4%		+25.5%	
READ/WRITE	703.3	1.6%	1,074.2	1.8%	1,266.5	1.7%	1,367.4	1.7%	1,414.0	1.6%
LESS THAN 2 GIGABYTES	+4.0%		+52.7%		+17.9%		+8.0%		+3.4%	
READ/WRITE	6.4	--	7.5	--	18.8	--	69.0	--	171.6	--
MORE THAN 2 GIGABYTES	+12.3%		+17.2%		+150.7%		+267.0%		+148.7%	
Total Worldwide Shipments	42,915.7	100.0%	57,654.9	100.0%	69,683.3	100.0%	80,809.7	100.0%	90,872.8	100.0%
	+73.2%		+34.3%		+20.9%		+16.0%		+12.5%	
% U.S. Manufacturers	.4%		.2%		.1%		.1%		.2%	

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

Figure 4

WORLDWIDE SHIPMENT SUMMARY

Total Optical Libraries



Noncaptive market

CD-ROM drive shipments to system manufacturers repeated 1994's explosive growth in 1995, increasing the CD-ROM portion of the noncaptive drive total (OEM/Integrator and PCM/Distributor distribution channels) to 97.4% of the 41.5 million noncaptive units shipped in 1995. Shipments of CD format writable drives accounted for 1.2%, while the share of read/write drives less than 2 gigabytes shrank to 1.4% of noncaptive optical disk drive total unit shipments. The share for read/write drives over 2 gigabytes was less than .1%.

Strong demand from PC and game manufacturers is expected to continue growth in CD-ROM and DVD-ROM shipments, but the share of CD format read-only noncaptive shipments market share will decline slightly toward the end of the forecast period as shipments of higher capacity 3.5" and rewritable CD format drives accelerate shipments and recapture market share.

CD format read-only drives captured 84% of noncaptive revenues in 1995, while CD format writable drives collected 5.8% of the noncaptive revenues. The revenue share for read/write drives less than 2 gigabytes declined to 8.6%, while drives more than 2 gigabytes saw their share decline to 1.6%. For CD format read-only drives, very strong growth in unit shipments again exceeded the effects of price declines, resulting in a year to year share gain. 1999 noncaptive revenue of over $8.6 billion will again largely go to CD-ROM drives, which are expected to capture 78.3% of the total, followed by CD format writable drives with 14.5% and read/write drives less than 2 gigabytes with 4.7%. Drives more than 2 gigabytes will increase in noncaptive revenue share to 2.5%, as the result of increasing shipments of higher capacity 5.25" drives.

1995's leading OEM/Integrator drive revenue producers were Matsushita Electric, Sony, Mitsumi, NEC and Toshiba, in that order. The top five companies accounted for 72.7% of total OEM/Integrator sales of nearly $3.0 billion, down slightly from 1994. Matsushita Electric led with 24.7% of the OEM/Integrator total. The share held by the top five OEM channel manufacturers was down slightly from 1994, reflecting a strong market now being attacked by second and third tier drive suppliers. Lifted by strong CD-R shipments, Philips was the leading firm in PCM/Distributor revenues, followed by Toshiba, Matsushita Electric, Fujitsu, and LG Electronics, together holding a 56.5% (up from 52.7%) share of the $1.5 billion sales in this channel. U.S. producers captured only 1.1% of total 1995

OEM/Integrator revenues, a decline from 1995, and also saw their share of PCM/Distributor revenues decline to 6.1%.

Despite the very strong growth of the OEM oriented CD-ROM and DVD-ROM drive market, captive revenues are expected to grow at a slightly faster rate than noncaptive revenues due to generally higher captive price levels and new products from system makers incorporating drives of their own manufacture. Manufacturers contributing to this anticipated trend include Sony, Matsushita Electric, Hitachi, NEC and others.

CD format library shipments claimed 95.5% of the 337,040 noncaptive optical library units shipped in 1995, followed by the 1-39 cartridge library product group with 3.2% share. The CD format library is expected to retain its dominance through 1999, with the CD format library product group expanding to 98.5% share and the 1-39 cartridge libraries declining to 1.0%. Noncaptive shipments of the other library groups will also be declining as a result of the very strong projected growth of CD format library shipments.

1995 noncaptive library revenues rose to $290 million and are anticipated to exceed $550 million in 1999. Because of their higher prices, revenue shares for larger libraries exceeded their unit shipment shares. The more than 70 cartridge segment led with 38.9%, followed by CD format libraries with 31.1% and the 1-39 cartridge segment with 23.8% share. The 1-39 disk product group lost ground relative to other groups as a result of strong competition from high capacity 5.25" magnetic disk drives and the strong growth of the CD format libraries. The CD format optical libraries are expected to capture over 49% of noncaptive revenues in 1999, followed by the more than 70 cartridge group with 27.9%. Moderate share declines are forecasted for the other two groups as well.

U.S. library manufacturers captured 37.3% of the OEM/Integrator channel revenues and 40.1% of the PCM/Distributor channel revenues in 1995. Hewlett-Packard, Nakamichi and Sony were the leading OEM/Integrator suppliers, accounting for 74.1% of $184.2 million channel revenues between them. The three top OEM/Integrator supplier's share grew moderately from 1994. In the PCM/Distributor channel, Hewlett-Packard, Pioneer, Fujitsu, and Plasmon Data Systems were the leaders, together capturing 73.2% of nearly $106 million sales in the channel. Performing strongly, Hewlett-Packard held a 37% share.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1995		Forecast							
ALL MANUFACTURERS	Revenues		1996		1997		1998		1999	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT READ-ONLY	3,770.5	84.0%	4,608.1	77.2%	5,420.7	79.0%	6,196.5	80.3%	6,783.9	78.3%
	+84.3%		+22.2%		+17.6%		+14.3%		+9.5%	
CD FORMAT WRITABLE	261.7	5.8%	784.3	13.1%	849.6	12.4%	915.3	11.9%	1,261.1	14.5%
	+193.1%		+199.7%		+8.3%		+7.7%		+37.8%	
READ/WRITE	387.4	8.6%	503.9	8.4%	496.7	7.3%	466.0	6.0%	408.4	4.7%
LESS THAN 2 GIGABYTES	-32.7%		+30.1%		-1.4%		-6.2%		-12.4%	
READ/WRITE	74.2	1.6%	82.2	1.3%	99.4	1.3%	147.0	1.8%	226.8	2.5%
MORE THAN 2 GIGABYTES	-10.1%		+10.8%		+20.9%		+47.9%		+54.3%	
Total Worldwide Revenues	4,493.8	100.0%	5,978.5	100.0%	6,866.4	100.0%	7,724.8	100.0%	8,680.2	100.0%
	+60.8%		+33.0%		+14.9%		+12.5%		+12.4%	

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

TABLE 10

NONCAPTIVE WORLDWIDE REVENUES
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES	1995		Forecast							
ALL MANUFACTURERS	Revenues		1996		1997		1998		1999	
	$M	%	$M	%	$M	%	$M	%	$M	%
CD FORMAT OPTICAL LIBRARIES	90.0	31.1%	129.6	37.2%	174.1	41.7%	222.8	45.9%	271.5	49.4%
	+106.9%		+44.0%		+34.3%		+28.0%		+21.9%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	68.8	23.8%	75.5	21.6%	83.7	20.1%	90.8	18.7%	97.7	17.7%
	-14.6%		+9.7%		+10.9%		+8.5%		+7.6%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	18.2	6.2%	19.5	5.6%	22.9	5.4%	25.4	5.2%	27.5	5.0%
	-18.4%		+7.1%		+17.4%		+10.9%		+8.3%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	113.0	38.9%	124.8	35.6%	137.4	32.8%	147.3	30.2%	154.0	27.9%
	+37.6%		+10.4%		+10.1%		+7.2%		+4.5%	
Total Worldwide Revenues	290.0	100.0%	349.4	100.0%	418.1	100.0%	486.3	100.0%	550.7	100.0%
	+26.9%		+20.5%		+19.7%		+16.3%		+13.2%	

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

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS	1995		Forecast							
IN THOUSANDS	Shipments		1996		1997		1998		1999	
	Units	%	Units	%	Units	%	Units	%	Units	%
CD FORMAT READ-ONLY	40,389.0	97.4%	51,982.7	94.6%	61,381.0	94.3%	69,985.0	94.1%	77,336.8	93.6%
	+90.5%		+28.7%		+18.1%		+14.0%		+10.5%	
CD FORMAT WRITABLE	487.0	1.2%	2,006.0	3.6%	2,522.0	3.9%	3,069.4	4.2%	3,866.4	4.7%
	+854.9%		+311.9%		+25.7%		+21.7%		+26.0%	
READ/WRITE	619.6	1.4%	1,024.5	1.8%	1,211.7	1.8%	1,308.5	1.7%	1,354.0	1.6%
LESS THAN 2 GIGABYTES	-2.8%		+65.3%		+18.3%		+8.0%		+3.5%	
READ/WRITE	5.9	--	6.9	--	17.6	--	66.1	--	167.6	.1%
MORE THAN 2 GIGABYTES	+11.3%		+16.9%		+155.1%		+275.6%		+153.6%	
Total Worldwide Shipments	41,501.5	100.0%	55,020.1	100.0%	65,132.3	100.0%	74,429.0	100.0%	82,724.8	100.0%
	+89.5%		+32.6%		+18.4%		+14.3%		+11.1%	
% U.S. Manufacturers	.3%		.2%		.1%		.2%		.2%	

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

TABLE 12

NONCAPTIVE WORLDWIDE SHIPMENTS
OPTICAL LIBRARIES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

SHIPMENTS IN SINGLE UNITS	1995 Shipments Units	1995 Shipments %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %
CD FORMAT OPTICAL LIBRARIES	337,040	95.5%	651,123	97.3%	946,034	97.9%	1,247,700	98.3%	1,557,246	98.5%
	+538.9%		+93.2%		+45.3%		+31.9%		+24.8%	
OPTICAL LIBRARIES 1-39 CARTRIDGES	11,308	3.2%	12,630	1.9%	13,834	1.4%	14,979	1.1%	15,973	1.0%
	+.9%		+11.7%		+9.5%		+8.3%		+6.6%	
OPTICAL LIBRARIES 40-69 CARTRIDGES	1,391	.4%	1,626	.2%	1,882	.2%	2,170	.2%	2,450	.2%
	-15.5%		+16.9%		+15.7%		+15.3%		+12.9%	
OPTICAL LIBRARIES 70 OR MORE CARTRIDGES	3,624	.9%	4,619	.6%	5,595	.5%	6,293	.4%	6,872	.3%
	+65.4%		+27.5%		+21.1%		+12.5%		+9.2%	
Total Worldwide Shipments	353,363	100.0%	669,998	100.0%	967,345	100.0%	1,271,142	100.0%	1,582,541	100.0%
	+421.2%		+89.6%		+44.4%		+31.4%		+24.5%	
% U.S. Manufacturers	3.1%		3.5%		3.0%		2.9%		2.8%	

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

Figure 5

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Disk Drives

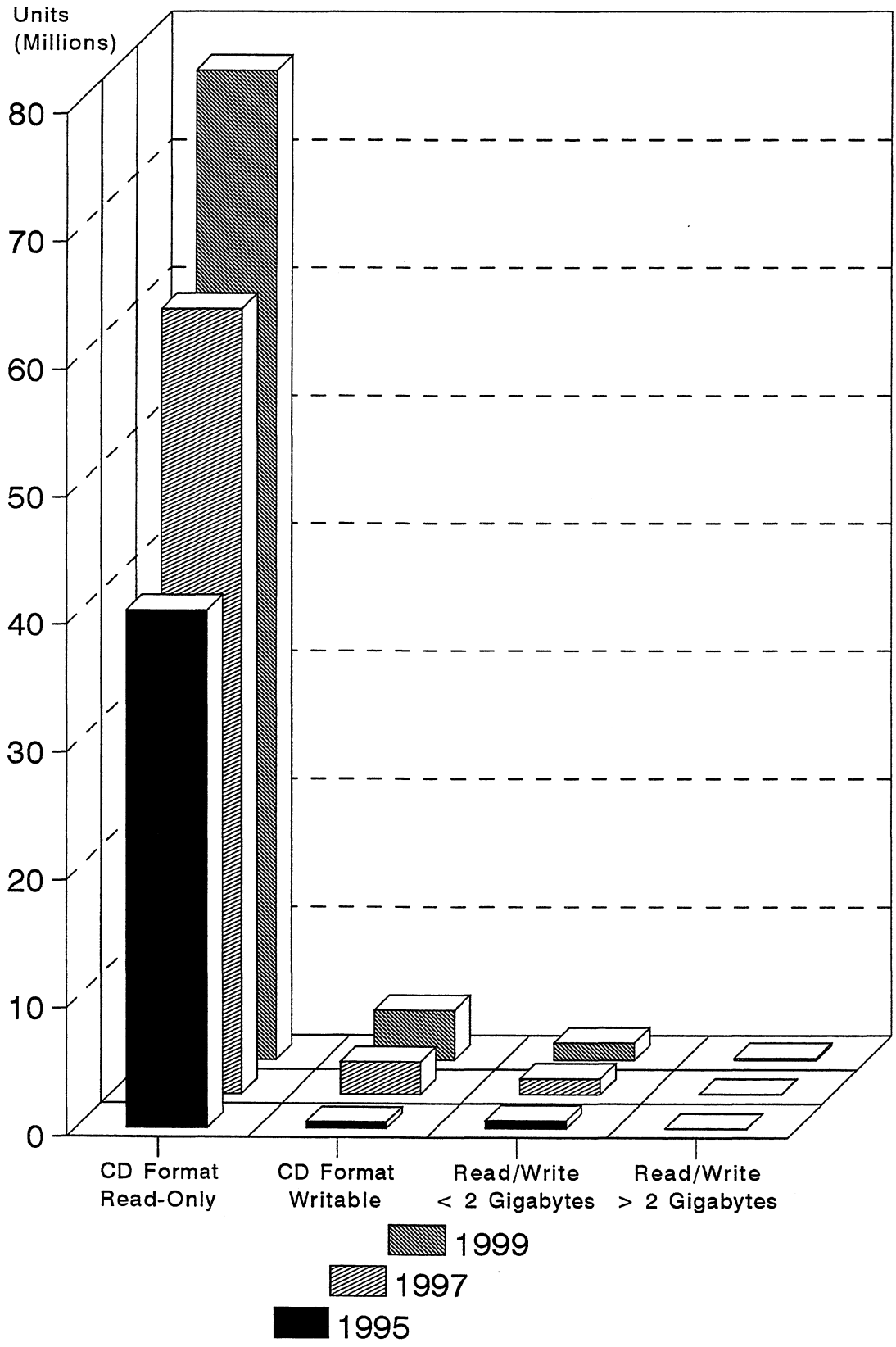


Figure 6

WORLDWIDE SHIPMENT SUMMARY

Noncaptive Optical Libraries

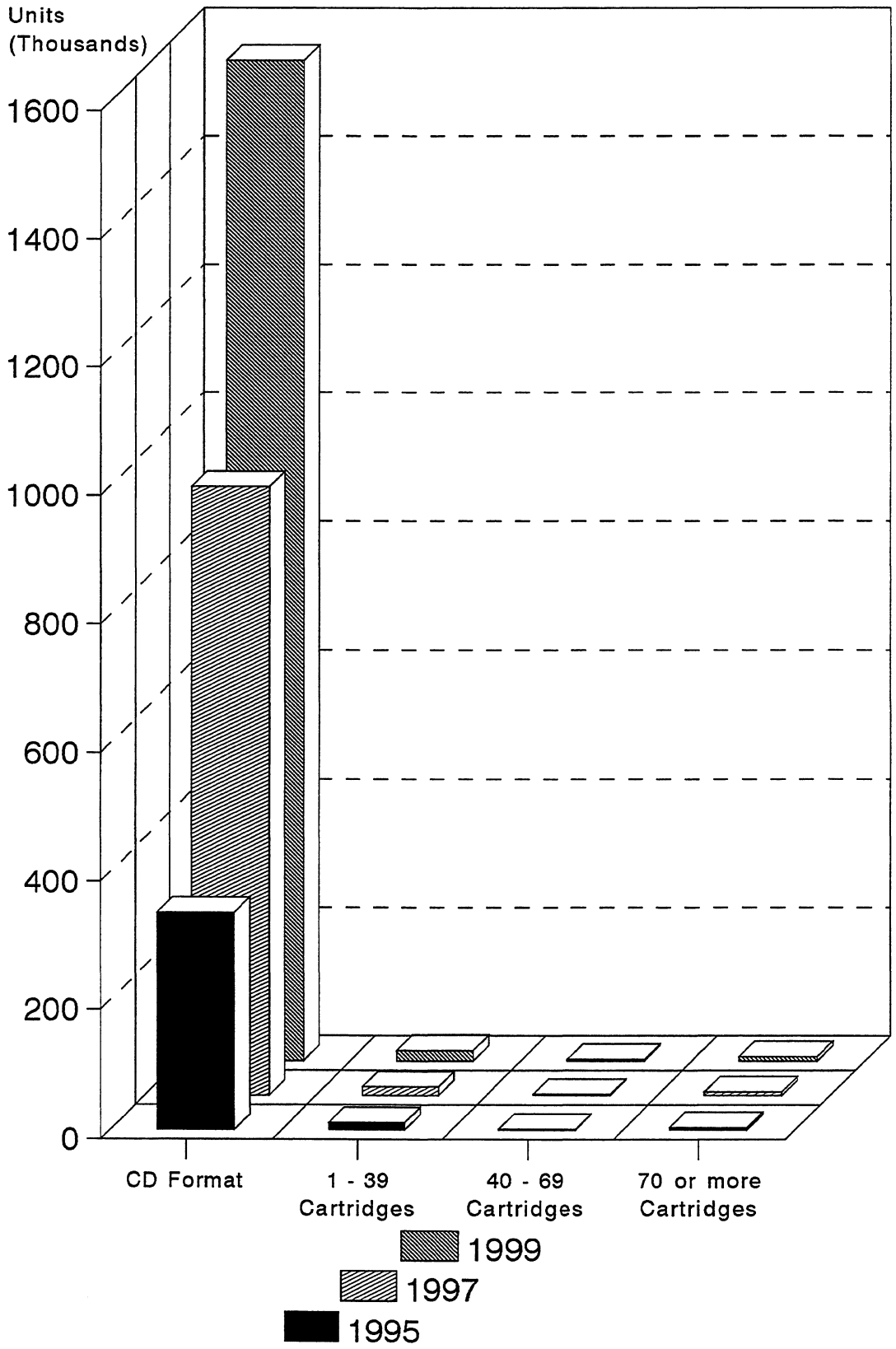


TABLE 13

1995 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL DISK DRIVES
(Value of non-U.S. currencies estimated at average 1995 rates)

	CAPTIVE		PCM/DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Hewlett-Packard	34.3	8.7	22.8	1.5	10.6	.4	67.7	1.4
IBM	60.4	15.4	16.2	1.1	10.0	.3	86.6	1.8
Other U.S.	3.7	.9	52.6	3.5	13.6	.5	69.9	1.4
U.S. Total	98.4	25.0	91.6	6.1	34.2	1.1	224.2	4.6
NON-U.S. MANUFACTURERS								
Acer Peripherals	--	--	19.2	1.3	56.1	1.9	75.3	1.5
Fujitsu	10.0	2.5	112.9	7.5	9.0	.3	131.9	2.7
LG Electronics	--	--	85.0	5.7	27.2	.9	112.2	2.3
Matsushita Electric Industrial	17.6	4.5	132.4	8.8	738.5	24.7	888.5	18.1
Mitsumi Electric	--	--	67.5	4.5	484.1	16.2	551.6	11.3
NEC	9.9	2.5	81.9	5.4	300.0	10.0	391.8	8.0
Philips	--	--	369.8	24.6	42.0	1.4	411.8	8.4
Sony	165.5	42.1	60.0	4.0	487.2	16.3	712.7	14.6
Teac	--	--	23.6	1.6	69.2	2.3	92.8	1.9
Toshiba	--	--	148.2	9.9	216.4	7.2	364.6	7.5
Other Non-U.S.	91.6	23.3	312.1	20.7	525.7	17.6	929.4	19.0
Non-U.S. Total	294.6	75.0	1,412.6	93.9	2,955.4	98.9	4,662.6	95.4
WORLDWIDE TOTAL	393.0	100.0	1,504.2	100.0	2,989.6	100.0	4,886.8	100.0

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

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

TABLE 14

1995 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL OPTICAL LIBRARIES
(Value of non-U.S. currencies estimated at average 1995 rates)

	CAPTIVE		PCM/DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Eastman Kodak	4.6	8.1	--	--	14.6	7.9	19.2	5.5
Filenet	19.7	34.5	--	--	1.8	1.0	21.5	6.2
Hewlett-Packard	17.5	30.6	39.1	37.0	33.7	18.3	90.3	26.0
Other U.S.	-.1	-.2	1.0	.9	18.6	10.1	19.5	5.6
U.S. Total	41.7	73.0	40.1	37.9	68.7	37.3	150.5	43.4
NON-U.S. MANUFACTURERS								
Fujitsu	--	--	13.3	12.6	12.6	6.8	25.9	7.5
Hitachi	6.2	10.9	.9	.9	12.2	6.6	19.3	5.6
Nakamichi	--	--	6.9	6.5	22.1	12.0	29.0	8.4
NSM Jukebox	--	--	6.5	6.1	4.2	2.3	10.7	3.1
Philips LMS	--	--	4.5	4.3	12.9	7.0	17.4	5.0
Pioneer Electric	--	--	14.4	13.6	14.8	8.0	29.2	8.4
Plasmon Data Systems	--	--	11.0	10.4	1.0	.5	12.0	3.5
Sony	.4	.7	.3	.3	18.3	9.9	19.0	5.5
Other Non-U.S.	8.8	15.4	7.9	7.5	17.4	9.4	34.1	9.8
Non-U.S. Total	15.4	27.0	65.7	62.1	115.5	62.7	196.6	56.6
WORLDWIDE TOTAL	57.1	100.0	105.8	100.0	184.2	100.0	347.1	100.0

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

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

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

TABLE 15

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL DISK DRIVES

DISK/TREND PRODUCT GROUP:		20	21	22	23
U.S. Manufacturers (7)	Type	CD Format Read-Only Drives	CD Format Writable Drives	Read/Write Optical Drives <2 GB	Read/Write Optical Drives >2 GB
CD-ROM, Inc.	P	12 cm			
Eastman Kodak	C,O,P		12 cm		14
Hewlett-Packard	C,O,P			5.25E	
MOST	O,P			5.25E	
Mountain Optech	O	12 cm		3.5E, 5.25E	
Pinnacle Micro	P	12 cm	12 cm	5.25E	5.25E
Sierra Technologies	O,P			5.25	
Asian Manufacturers (46)					
Acer	C,O,P	12 cm	12 cm		
Acer Peripherals	O,P	12 cm			
ADI	P	12 cm			
Asaca	O			5.25E	
Aztech Systems	O,P	12 cm			
Behavior Tech Computer	O,P	12 cm			
Canon	C,O			5.25E	
Chinon	O,P	12 cm			
Delta Electronics	O,P	12 cm	12 cm		
Diamond Flower (DFI)	O,P	12 cm			
Elitegroup Computer Systems	O,P	12 cm			
Fujitsu	C,O,P			3.5E, 5.25E	
Funai Electric	O	12 cm			
Hitachi	C,O,P	12 cm		5.25, 5.25E	12
Hopax Industries	O,P	12 cm			
IPC Peripherals	O,P	12 cm			
JVC	O		12 cm		
Konica	O			3.5E	
LG Electronics	O,P	12 cm			
Lion Optics	O,P	12 cm			
Lite-On	O,P	12 cm			
Matsushita Electric Ind.	C,O,P	12 cm	12 cm	3.5E,5.25,5.25E	
Maxoptix	O,P			5.25E	
Mitsumi Electric	O,P	12 cm	12 cm		
NEC	C,O,P	12 cm	12 cm	5.25E	12
Nikon	O			5.25E	12E
Ocean Office Automation	O,P	12 cm			
Olympus Optical	O,P			3.5E, 5.25E	
Optics Storage	O,P	12 cm			
Pioneer Electronic	O,P	12 cm	12 cm	5.25E	
Plextor (Shinano Kenshi)	O,P	12 cm			
Ricoh	C,O,P		12 cm	5.25E	
Samsung Electronics	O,P	12 cm			
Sanyo Electric	O,P	12 cm			
Seiko Epson	O	12 cm		3.5E	
Sharp	O,P			5.25E	
Sony	C,O,P	8 cm,12 cm	12 cm	2.5E,3.5E,5.25E	12
Tae-Il Media	O	12 cm			
Tatung	O,P	12 cm			
TEAC	O,P	12 cm	12 cm		
Toshiba	O,P	12 cm			
Umax Data Systems	O,P	12 cm			
Unitron	O,P	12 cm			
Wearnes Peripherals	O,P	12 cm	12 cm		
Yamaha	O,P		12 cm		
Yung Fu (Lxycon)	O,P	12 cm			
European Manufacturers (3)					
ATG Cygnet	O				12
Philips	O,P	12 cm	12 cm		
Philips LMS	O,P				12

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

TABLE 16

CURRENT PRODUCT LINES
MANUFACTURERS OF OPTICAL LIBRARIES

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

DISK/TREND PRODUCT GROUP:		50	51	52	53
U.S. Manufacturers (13)	Type	CD Format Optical Libraries	Read/Write Optical Libraries 1-39 Disks	Read/Write Optical Libraries 40-69 Disks	Read/Write Optical Libraries 70+ Disks
Borett Automation Tech.	O	12 cm			5.25, 12
CD International	O,P	12 cm			
DISC	O	12 cm			5.25
Dynatek Automation (Canada)	O	12 cm			
Eastman Kodak	C,O	12 cm			14
EMASS	O,P				5.25
FileNet	C,O			12	12
Hewlett-Packard	C,O,P		5.25	5.25	5.25
IBM	C,O,P		5.25	5.25	5.25
Kubik Enterprises	O	12 cm			5.25
Regal Electronics	O,P	12 cm			
TiltRac	O,P	12 cm			
Todd Enterprises	O,P	12 cm			
Asian Manufacturers (14)					
Alps Electric	O,P	12 cm			
Asaca	O				5.25
Fujitsu	C,O		3.5, 5.25		5.25
Hitachi	C,O,P			5.25, 12	5.25
Hyundai	O,P	12 cm			
Matsushita Electric Ind.	C,O	12 cm	5.25	5.25	5.25
Nakamichi	O,P	12 cm			
NEC	C	12 cm	5.25, 12	5.25	
Nippon Columbia (Denon)	P	12 cm			
Nistec (Nikkyo)	O,P	12 cm	5.25	5.25	
PFU	O,P		3.5		
Pioneer	O,P	12 cm			
Sanyo Electric	O	12 cm			
Sony	O,P	12 cm	5.25	5.25	12
European Manufacturers (8)					
ASM	O,P	12 cm			
ATG Cygnet	O		12		12
DSM	O,P	12 cm	12	5.25, 12	5.25, 12
K+S	O,P	12 cm	5.25		5.25
NSM	O,P	12 cm			
Optomedia Engineering	P	12 cm			
Philips LMS	O,P		12		
Plasmon Data Systems	O,P		5.25	5.25	5.25

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

TECHNICAL REVIEW

The pace of change in the optical disk drive industry has accelerated, with higher capacity drives and improved performance becoming available for both writable and read-only drives. The rate of change in the CD-ROM industry is dizzying--and probably detrimental to the industry. For writable drives, the higher capacities are welcome, although the rate of change still lags that of the magnetic drive industry.

Some of the key areas where improvements are occurring are:

* Higher power, higher frequency lasers, for higher areal densities.
* Improved ASICs to do specialized coding, compression, or other signal processing functions.
* Denser recording formats, for higher areal densities.
* Reduced susceptibility to hostile environments, especially dust.
* Higher data transfer rates, to support large files and full motion video.
* Direct overwrite for at least some magneto-optic drives and media.
* Fewer incompatibilities between optical drives and optical libraries.
* Smaller and lower power drives, for use with portable equipment.

Despite improvements, optical drives still face formidable competition from other technologies. Multigigabyte rigid disk drives continue to decimate the low end of the 5.25" optical drive and library markets, and the new generation of removable magnetic drives with capacities of one gigabyte or more per cartridge is creating heated competition in applications where removability is required.

With rigid disk drive technology expected to improve areal density at an average 60% annual rate for the next several years, optical disk drive technology is under strong pressure to improve, as it has shown at best an average 40% improvement rate in areal density. Still, as the success of CD-ROM drives and the optical library storage subsystem have shown, the technology is attractive for many applications.

Optical disk technology and applications

Three types of optical disk drives used as computer peripheral devices are discussed in the following sections: CD-ROM disk drives (including DVD-ROM), write-once disk drives (including CD-R, and DVD-R, and rewritable disk drives (including MO drives, phase change drives, CD-E and DVD-RAM).

* CD-ROM and DVD-ROM optical disks: The read-only optical disk group is dominated by 12 centimeter diameter CD-ROM drives, which have typical capacities of 550 to 680 megabytes depending upon the format used. An 8 centimeter proprietary format CD-ROM made its appearance in 1990 in the Sony "Data Discman", a portable data retrieval system. A few manufacturers attempted to launch an ISO format 8 centimeter CD-ROM drive capable of storing 180 to 200 megabytes of data, but with no great success to date, although most 12 centimeter drives read 8 centimeter disks. Most CD-ROM drives are sold to computer manufacturers and are equipped with IDE/ATAPI interfaces, although drives are also made with SCSI interfaces for use with servers, optical libraries or Apple computers.

  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 will offer 4.7 gigabytes per surface and should be widely available in 1997. "DVD" has no official meaning, but some have proposed "Digital Versatile Disk" and "Digital Video Disk" as official names to fit a DVD acronym.

  Two contending groups of manufacturers that proposed feasible, but incompatible, specifications for DVD drives reached general agreement in late 1995. The Multi Media CD (MMCD) format, proposed by Sony and Philips, and the Super Density (SD) format, sponsored by Toshiba and Matsushita were blended to reach a joint specification, avoiding a divisive format war.

  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. However, first generation DVD drives will spin at 3X-4X rates and are not expected to have low average access times, even though the data transfer rate is improved.

  Disagreement between major suppliers and between suppliers and content providers on specifications, standards and copy protection has delayed availability, although it appears that agreement on copy protection has been reached as of mid-1996.

  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 improve-

ments. During the last year, CD-ROM drives from the majority of drive manufacturers went from 4X to 8X in RPM and data transfer rate in order to improve video output, but the industry is reaching the point of diminishing utility to the user, as data transfer rates climb past 8X to 10X and 12X in 1996. At 8X sustained data rates, data will saturate a typical local area network, while 12X rates can saturate many processors. Average seek times are dipping under 180 milliseconds for some models. Most applications don't require even 6X or 8X performance, but computer manufacturers eager to improve system specifications create early demand for higher performance CD-ROM drives.

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

In optical read-only recording, the disk is normally mass produced using a mold which impresses the data upon the surface of the disk, followed by the deposition of a metal layer and a protective layer to establish the proper reflectivity. When scanned by a laser beam, the reflected beam is modulated by the data pattern on the disk, and the signal pattern is processed within the drive. Processing includes error correction and may include decompression if audio or video data is present.

Because mass production of read-only optical disks is done by a mastering and mass replication process, rather than by recording directly on the disk, the cost per disk can be low, usually under a dollar per disk. However, mastering costs and replication turnaround time can make production of single disks or very short runs economically unattractive, and have stimulated sales of CD-R drives. DVD type disks will require a few additional process steps and more complex equipment to accommodate dual layer media, but replication costs are not likely to be increased unduly by the new format.

Except for CD-ROM, (and laser videodisks, not covered in this report) optical read-only (OROM) solutions have not met with success. Read-only memory formats include OROM capability on 3.5" and 5.25" and 12" media, but of these only the 3.5" format has had even cursory consideration, as a vehicle for software distribution and multimedia presentations.

* Write-once disks: The first optical disk recording systems to enter the market were "nonreversible" or "write-once" systems. A few systems with

optical drives were sold in Japan in 1984, but it wasn't until 1986, after many years of costly development programs undertaken by manufacturers, that such devices began to move into production status.

With track densities typically in the range of 16,000 to 20,000 tracks per inch and bit densities in the range of 25,000 to 35,000 bits per inch, the first write-once drives (and rewritable drives) were capable of higher areal densities than magnetic recording drives then in use. However, because of the relatively slow rate of increase in optical drive areal density compared to the rate of improvement in rigid magnetic drives, magnetic drive areal density has now threatened to surpass optical drive areal density for both rewritable and write-once drives.

Write-once recording usually involves changing the reflectivity of an area of the disk, either by making a small hole or causing a surface reflectance change. Recording systems are available which alter the writing layer from an amorphous to a crystalline state, while others deform the surface of the media to cause a reflectance change at the point where a bit is written. A more recently developed write-once technology (known as Continuous Composite WORM, or CCW, or MO-WORM) uses magneto-optic media, which is normally rewritable, prestamped with information indicating that it is to be used only in a write-once mode. With the recent success of CD-R format write-once recording, media incorporating dye that absorbs the laser beam energy, changing its state and creating a mark, has become the most prevalent form of pure write-once media.

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

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

Extensive accelerated testing indicates that write-once disks should provide archival lives which equal or exceed those of magnetic tape, with 10 years being the minimum specification for archival life of the media. Some media suppliers specify a 30 year lifetime and claims of lifetimes exceeding 50 years have been made. Ablative write-once media is typically

based on tellurium films. Media based on dye or dye-polymer designs have no metallic films and are expected to be more corrosion resistant than the original generation of metallic films. Other optical media using platinum or tin alloys as recording layers offer corrosion resistance, but may trade off write sensitivity for the improved longevity obtained.

The largest application for write-once recording technology is still the archival storage of documents. The document is typically stored as a document image, rather than as character data. CD-R is used for a variety of applications, including archiving, data distribution and preparing master disks for subsequent replication. Obviously, the market for write-once optical disk systems will be limited to niche markets which can tolerate or desire nonreversibility. In some applications, the ability of write-once storage systems to maintain an audit trail or indicate whether or not stored data has been modified is a significant benefit. The 5.25" multifunction drives that have entered the market have gradually displaced dedicated write-once 5.25" drives, since the user is able to determine drive functionality simply by choice of media.

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

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

  Very high capacity rewritable drives require the availability of larger diameter rewritable media, which is difficult to fabricate with adequate yields within the current state of the art. The first 12" rewritable drive, with 2 gigabytes per side, was announced by Nikon in late 1991. Most manufacturers have concentrated on 5.25" and 3.5" drives. Sony, IBM, NEC, Maxoptix and Hewlett-Packard shipped second generation 5.25" drives with 650 megabytes per side capacity, and Hitachi developed drives with 1 gigabyte per side capacity. Drives and media with 1.3 gigabytes per side became available in late 1995 and early 1996, with MOST being the first company to formally announce such a drive. 2.6 gigabyte per side drives are expected to be announced in late 1996 and early 1997 with 1997 availability.

  Current magneto-optic drive designs use a low power laser to change the magnetic state of the active layer on a disk. The laser raises the temperature of the active layer into the range of the Curie point while a magnetic field is present, causing individual magnetic domains on the disk to align

with the direction of the external magnetic field. Changes in magnetic orientation are detected during reading, as the affected spot on the disk causes a small rotation in the polarized light reflected from the surface or transmitted through the disk. Because the polarization shift is small, it is harder to get adequate signal to noise ratios with MO media than it is with other types of media.

Magneto-optic media require less laser power for writing than write-once media because there is no need to physically deform the writing layer or cause it to melt, permitting the disk to rotate faster for a given available laser power. The faster rotation improves latency and data transfer rate. A few production magneto-optical disks employ light intensity modulation (LIM-DOW) to provide direct overwrite in place, avoiding the requirement that a complete sector must be erased before the sector can be rewritten.

Sony makes a CLV 2.5" audio magneto-optic disk drive using inexpensive media and not requiring a separate erase pass. It uses a flying magnetic head to write data while the laser heats the surface of the media above the Curie temperature. Sony has announced a computer peripheral version as the MD-DATA, with about 140 megabyte capacity, and 150 kilobyte per second data transfer rate, but has not emphasized the product.

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 DVD components to reduce cost. Capacity would be between 5 and 10 gigabytes on a single surface, 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 and no product would be available before late 1997. A drive specification is to be produced by the end of 1996.

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

magneto-optic drives in write mode. The drive does not require the bias magnet typically used in MO drives. Phase change recording appears to have the lead as the technique of choice for rewritable drives for DVD-R and DVD-RAM writable drives, especially for entertainment applications, 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.

* Optical libraries: Random-access libraries, commonly called "jukeboxes", are devices that automatically pick, load, unload and refile media units for an optical disk drive. While not part of the drive, they are frequently associated with the drive in high-end archival systems where large amounts of data must be accessed and maintained on-line. Current library units can store from 3 to over 1000 disk units in 12", 5.25", 4.72" or 3.5" formats. Typical retrieval and load times are a few seconds. Some libraries have multiple picking assemblies so that disk cartridge access/load operations can be overlapped, reducing the cartridge exchange time. The ratio of media units to drives in a library is crucial to providing appropriate access time, but the ratio is strongly influenced by drive performance, library disk exchange time, the nature of the application and the type and format of data to be handled.

  Early libraries used 12" drives and were too expensive to be attractive for use with lower capacity optical drives. However, libraries appropriate for use with small optical drives have been produced and are available for attachment on platforms ranging from personal computers to mainframes. Libraries with direct network attachment capability are also appearing in the marketplace. Numerous 5.25" libraries have been introduced by firms such as Plasmon and Hewlett-Packard. Random access disk libraries available for CD players have migrated to the computer world as an accessory for the CD-ROM. As of mid-1996, CD-ROM libraries with capacities ranging from 3 to 20,000 disks were available, and CD-ROM autochangers fitting into a standard half height slot and holding from 3 to 6 disks are shipping in significant volume.

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

minimize the formation of dust during cartridge insertion and withdrawal and avoid dust ingestion from external sources.

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

Technical issues

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

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

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

  If the 45 gigabit per square inch magneto-optic recording technique reported by Bell Laboratories in 1992 can be turned into a real product, optical recording areal density might recapture a commanding lead. Using a tapered fiber-optic tube to replace the conventional MO drive optics, the researchers achieved a 60 nanometer spot size, albeit at a writing rate of 10 kilobits per second. In 1993, Hitachi announced work with an optical fiber approach that could record an hour of HDTV signal on a 2.5" MO disk.

  The benefit of higher areal density is higher capacity and higher data transfer rate. The next generation of 5.25" drives will have capacity of 1.3 gigabytes per side (the Pinnacle Micro Apex drive will have 2.3 gigabytes per side), the next 3.5" generation will be 640/650 megabytes per side, with a move to 1.3 gigabytes per side proposed as the next step. DVD-ROM drives will offer up to 8.5 gigabytes per side, assuming double layer media is used.

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

  DVD-ROM will provide 4.7 GB per surface on a single layer surface or 8.5 GB on a 2 layer multisurface disk. On a two sided disk, per-disk capacities could be doubled.

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

  DVD drives currently are unable to read media written on CD-R drives because the media have insufficient reflectivity at the shorter laser wavelengths used in DVD drives. Sony has proposed a head incorporating long and short wavelength laser diodes to resolve the problem, but this approach adds weight and cost. Media companies are examining a CD-R disk with a broader reflectance spectrum that would be able to work with both types of laser.

  CD-E drives expected to be available starting in late 1996 use media not readable on any CD-ROM drive in production as of mid-1996 because of low reflectivity. Since compatibility can be achieved by adding an inexpensive automatic gain control circuit to the CD-ROM drive, it is likely that future CD-ROM drives will be able to read CD-E media.

* Recording heads: Optical recording heads are relatively complex devices incorporating a diode laser, detector, optics, and, frequently, a fine positioning mechanism. The typical first generation head assembly had relatively high mass, slowing access time and increasing head positioning power. Average access time in excess of 125 milliseconds was not unusual. However, the demands of data processing systems required faster average access time, leading to development of the split optic system, in which only the objective lens, focus and fine tracking mechanisms are mounted on the moving carriage, substantially reducing the total mass of the head assembly and, therefore, the seek time. The Maxoptix 5.25" rewritable drive, for instance, has an average seek time below 20 milliseconds.

The use of holographic optical elements to replace many of the heavier glass lenses and supporting structures is being explored by several firms. While providing simplicity, the transmission efficiency of holographic systems currently available is less than that of conventional optics, restricting the use of holographic optics to applications which require less write power at the surface of the media. MEI eventually expects to produce a head with unconventional optics for CD-ROM drives weighing only .2 grams.

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

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

Philips LMS brought the first two-headed drive to market. The introduction had a significant impact on the plans of other drive producers, and some other manufacturers have announced multiple heads in some models of their 12" optical drives.

* Lasers: The key issues for lasers are laser power, laser wavelength, and laser lifetime. The amount of power available from the laser governs the time required to write a spot on the disk, thus limiting the rotation speed and data transfer rate that can be obtained. As improved laser diodes are found to be economically and technically suitable, a significant increase in data transfer rates and a significant decrease in latency will be obtained. The faster 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.

  A second limitation related to the laser is spot size, which is a function of laser wavelength, among other factors. Shorter wavelength lasers likely to appear within the next few years should result in smaller spot sizes and an increase in bit and track density. Green and blue frequency doubled lasers are likely to be in wide use in the 1997-1998 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.

Low power blue lasers suitable for use with read-only drives may become available within the next three years. In 1993, Sony demonstrated an experimental pulsed blue semiconductor laser workable at room temperature, and IBM demonstrated a 2.5 gigabit per square inch areal density using a frequency doubled 856 nanometer laser and magneto-optic media with a blue sensitive active layer to reduce the writing power required. A read rate of 2 megabytes per second was achieved with this combination.

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

  There is substantial overcapacity among media suppliers, in the aggregate. However, because write-once optical disks from different manufacturers are not widely interchangeable among drives, media availability is still a concern where specific media is required and is available only from a single manufacturer. Manufacturers of rewritable drives claim a significant degree of media interchange capability between drives of differing manufacturers. This has been demonstrated for most 5.25" and 3.5" CCS format rewritable drives.

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

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

  Magneto-optic media will have to make a transition through one more generation to arrive at designs permitting direct overwriting in place of previously recorded data, rather than requiring a separate erase pass

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

In mid-1994, IBM announced the results of a research project which demonstrated a stacked disk approach to increasing the capacity of optical disks. By changing the focal plane of the lenses in the head, individual surfaces in the stack can be addressed. IBM believes that up to 10 disks can be stacked in this manner, but so far only a 4 layer read/write stack and a 6 layer read-only stack have been demonstrated. A 2 layer stack is supported by DVD drives at present.

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.

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

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

  Major increases in track density are expected as red lasers come into use, and TPI is expected to move above 20,000 TPI. The 5.25" 650 megabyte per side drives and media specify a 1.4 micron track pitch, or about 18,000 TPI. As manufacturers go to higher rotation rates to improve laten-

cy and transfer rates, it will be necessary to redesign tracking and focusing servo systems to operate at higher bandwidths.

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

* Packaging: Most early small optical drives were packaged to fit into a standard 5.25" form factor for easy mounting in personal computers widely produced in the second half of the 1980's. The next generation, offering 5.25" half-high profiles, has appeared. The first such products were CD-ROM drives, such as the ones introduced by Matsushita Electric and Toshiba, but half-high write-once and rewritable 5.25" optical drives are now being shipped. Most 3.5" rewritable optical disk drives fit into a 41.3 millimeter high space. Fujitsu announced a one inch high 3.5" drive in 1992 and this form factor is currently available from multiple manufacturers.

  Because small diameter optical drives are forced to conform to magnetic disk drive form factor standards, which continue to evolve, CD-ROMs and 3.5" optical drives are now being challenged to move to form factors thinner than 25.4 millimeters. Reduced drive height is necessary to be attractive to system integrators producing portable and desk top systems configured to accept magnetic drives in the small form factors. A few drives with 19 millimeter or less height have been announced. Sony, Matsushita and others have shown 17 millimeter high CD-ROM drives and Matsushita is able to package CD-ROM drives in 15 and 12.7 millimeter high formats.

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

* Power: The power requirements of many optical drives make them less suitable for use in portable systems, although a few systems, such as the Sony Data Discman and the Sony MMCD (multimedia compact disk) have appeared using CD-ROM drives, and a growing number of notebook computers also incorporate internal CD-ROM drives. Because the CD-ROM is usually used in conjunction with presentations that are given

where AC power is available, the power requirement is not always a serious disadvantage, but is, nevertheless, an issue for notebook system manufacturers.

* Interface: The most common interface encountered on writable optical drives is SCSI, covering the range from low-end 3.5" drives to larger drives intended for use with multiuser or document storage systems. Interfaces compatible with the IDE/ATAPI standard used with most personal computers are most common on CD-ROM drives because of the large number installed by computer OEMs. Drives used in certain document filing systems and with sound cards have frequently used proprietary interfaces, but these have faded away as a result of the installation of CD-ROMs by almost all personal computer manufacturers. Current SCSI drives usually embed the SCSI controller within the standard drive package, eliminating the need for a separate controller card for the drive.

  PC manufacturers began using CD-ROM drives with the ATAPI interface in 1994, because of its lower cost compared to SCSI and its ease of integration into personal computer systems. ATAPI has become the dominant form of interface for CD-ROM drives, displacing both SCSI and proprietary interfaces and has prospects for adoption in the next generation of high capacity 3.5" drives. P1394 is also being evaluated for future personal computers by makers of systems and mother boards.

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

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

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

  Initial recording format standards for CD-ROM were prepared by the High Sierra Group, an ad hoc organization consisting of several firms concerned with CD-ROM. The work of the High Sierra group moved through the formal standards making progress relatively quickly, and after only minor changes, became ISO standard 9660 in 1988.

  The Rock Ridge group, an ad hoc working group formed by companies with UNIX interests, completed specific recommendations for ISO 9660 extensions in 1991. The Frankfurt group, a similar body, prepared proposed extensions to ISO 9660 incorporating some of Rock Ridge concerns and support for the multisession recording format used by CD-R. ECMA 168/ISO 13490, CD-R recording standards, allow for the addition of one file at a time to a disk during multisession recording.

  Standards interest in the current generation of CD-ROM has now shifted to data compression and formatting for audio and video content, user interface standards for retrieval software, and standards for a universal cataloging method for CD-ROM. The new drives that spin the disks at higher RPM do not impact standards for CD-ROM media, but may require tighter quality and process control by replicators. Media for CD-R drives may need to be reformulated to record properly at higher spin rates. However, proposals for higher density CD-ROM media are reopening basic standards issues for CD-ROMs.

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

try arrive at a single compromise standard that adopted features from both proposed standards.

Aside from the DVD related conflicts mentioned above, multimedia formats remain an area of standards conflict. Multiple "standard" formats contend in the marketplace as well as proprietary designs from other companies such as 3DO and Sega. Some de facto standardization of compression formats for multimedia audio and video exist, but there are multiple contenders here, also. The JPEG and MPEG specifications are the most significant compression standards for still and motion video, respectively. The MPEG-1 encoding offers enough compression to enable 74 minutes of near VHS quality video to be stored on a current CD-ROM disk, but MPEG-2 is required for VHS or better quality on a single disk, requiring the use of DVD-ROM.

In early 1986, Sony and Philips released the CD-I (Compact Disc-Interactive) specification which defines a freestanding appliance rather than a computer peripheral. Another supplementary standard, CD-ROM XA was announced in 1988. XA is a supplement to the CD-ROM specification that applies to digital audio data interleaving with other types of data. Such interleaving permits rapid access to audio data associated with other recorded information without requiring head repositioning. CD-I has been aimed at consumer, education, and a few commercial applications, such as point-of-sale displays.

DVI was developed by RCA and acquired by General Electric when it acquired RCA. G.E. subsequently sold the DVI technology to Intel. DVI received support from Lotus, IBM and other firms having interest in business applications of multimedia, but its relatively high costs and competition from other approaches discouraged acceptance.

Read/write standards: The ANSI X3B11 technical subcommittee prepared unrecorded media standards for 5.25" write-once disks for ISO approval. X3B11 originally intended to propose only the continuous tracking servo approach, but the price for getting CCS (X3.211) through the committee was an agreement to also submit the sampled servo approach (X3.214) for inclusion in a "dual standard". X3B11 finally embraced both approaches as well as a third approach, sampled servo with RZ modulation (X3.191), sponsored by Literal. As a result, there is no universally accepted write-once standard for 5.25" drives.

A subcommittee of X3B11, X3B11.1 was established in 1989 to formulate a proposed standard for a logical file format. While the main work of the ANSI X3B11 group so far has been concerned with media interchange among drives, X3B11.1 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) is complete, as is the 3.5" standard (ISO 10090) based on CCS. Alternate formats, such as the discrete block format (DBF) proposed by some Japanese firms, remain to be addressed. The outlook is for eventual coexistence of multiple standards, but the marketplace has already decided that the existing standards are the winners. The rewritable standards effort has focussed heavily upon magneto-optic recording and has not yet formalized a standard for rewritable phase change. ISO 11560, covering MO-WORM, was approved in late 1992.

While IBM products frequently set de facto standards, IBM's early interest and activity level in the optical storage area was too weak to override the formal standards activities. Currently, IBM is very active within ANSI X3B11 in the formulation of next generation 3.5" standards and next generation 5.25" standards. With the announcement of IBM's own 5.25" and 3.5" rewritable drives, and particularly with the joint IBM/Sony high capacity proposal, IBM has influenced standards on both a de facto and formal level.

At present, there is little standardization of 12" media. There are already so many 12" drive designs in the field that standardization of this size is unlikely in the near future, although a standards project for 12" media exists. The diversity of existing designs makes it difficult for most manufacturers to agree to changes because of the major costs of product redesign. New generations of 12" drives may be standardized to a greater degree, as working groups have been set up within the American X3B11 subcommittee and the Japanese SC23 standards subcommittees to consider standards for newer products.

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

As a result of criticism of the slow pace of standards generation, the various national standards committees are adopting standards prepared by ECMA using a fast-track approach. While not providing the intensive peer review of the full formal process, it helps speed up standards generation where fundamental technical issues are not involved. 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 latency of the data retrieval process. Video and audio data require less error correction than other forms of data, as errors manifest themselves as a short transient in the data flow, with no lasting impact.

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

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

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

Competing technologies

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

Magnetic disk drives

* Rigid disk drives: Rigid magnetic disk drives are the mainstay of today's auxiliary storage devices. Because they generally exhibit advantages in price/performance, packaging and power when compared to optical drives, they appear largely immune from serious displacement by optical drives over the next few years. More pertinent, rigid disk drives offer serious competition to optical drives in some situations. SyQuest's 3.5" 270 megabyte removable drive competes strongly with 3.5" 230 and 128 megabyte optical drives. The one gigabyte Iomega Jaz drive competes with 640 megabyte 3.5" MO drives and 5.25" optical drives. And 5.25" drives, such as the 9 gigabyte Seagate Elite 9 and 23 gigabyte Elite 23, challenge the 650 megabyte per side 5.25" optical drives by offering several times the capacity at a fraction of the 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. 3.5" rigid magnetic disk cartridge drives are expected to offer capacities exceeding 5 gigabytes per cartridge in the year 2000.

  While optical drives have improved performance to the point where they can offer 30-40 millisecond average seek time on a 1.3 gigabyte drive, magnetic drives typically offer sub-12 millisecond times on drives of the same capacity or larger. Sub-10 millisecond times are offered by the most advanced rigid magnetic drives. Some optical disk drives are achieving 3,600 RPM rotation rates and one has reached 5,400 RPM, while magnetic drives are moving past 5,400 RPM to 7,200 RPM (and eventually to 10,000 RPM) at the high end of the performance range. Furthermore, magnetic drives do not require a separate erase pass. Even high performance optical drives do not match rigid magnetic drive performance.

  Most significantly, the highest areal densities of current magnetic drives, currently in excess of 1,300 megabits per square inch, now compete

against the areal density of optical drives and are expected to be at 10 gigabits per square inch or more by the end of the decade. Rigid drives with areal densities exceeding 2 gigabits per square inch are expected to be shipping by the end of 1997. It is unlikely, therefore, that the magnetic drive will be seriously threatened by optical disk drives in its role as a high performance system disk.

Where removability is important, the ability of an optical disk drive to perform the combined functions of a tape drive and a rigid disk drive, or to build large on-line data or multimedia libraries, may outweigh performance considerations. Such applications can include graphics design projects, video servers and video-on-demand, data distribution, save/restore of data, or use as a system disk in a security oriented environment. Here, the rewritable optical disk will make inroads on the uses of rigid magnetic disks.

* High capacity flexible disk drives: The 20 megabyte floptical disk drives from Iomega and Insite Peripherals did not offer serious competition to optical drives because of their limited capacity, but new high density floppy drives such as the 100 megabyte Iomega Zip drive and the 120 megabyte LS120 (derived from the floptical disk drive) have extended floppy drive capacities to a new level. While inferior in capacity to optical drives, their much lower relative pricing for both drives and media make them a threat to 3.5" optical drives. Future generations of high capacity floppy drives are expected to break the 200 megabyte barrier, probably by the end of 1996.

Alternative optical devices

* Optical cards: Three companies have announced optical cards: Drexler Technology Corporation, Optical Recording Corporation, and NTT. The optical card announced in 1981 by Drexler Technology offers up to 4.11 megabytes of read-only or write-once storage contained on a credit card sized plastic substrate. Capacity is 2.86 megabytes when formatted and with error correction. Drexler has sold licenses to produce optical cards to the Optical Memory Card Business Corporation, a Japanese organization formed by Dai Nippon Printing Corporation and three licensees, and to Canon. Over 25 companies have purchased licenses permitting them to make optical card drives using Drexler patents.

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

  Because of its relatively limited capacity and/or performance, the optical card is not a competitor to the optical disk drive. The optical card will make its mark in the development of new applications rather than displace

existing storage devices, and will compete in such markets as point-of-sale, portable personal records, and security access markets against other portable storage devices such as semiconductor memory cards.

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

* Electron trapping: An approach being developed by Optex Corporation, involves "electron trapping," by shifting the energy level of electrons in a material which holds them in a stable state for long periods in either the high or low energy state. A visible wavelength laser pulse moves an illuminated area to a high energy state. An infrared laser pulse causes the electrons to revert to the low energy state, emitting light as they do so. The presence or absence of light in response to a read (infrared) pulse yields a bit of information. The process is infinitely reversible, but is subject to interference from unwanted ambient light. In its current form, the design requires multiple lasers operating at different wavelengths. 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 throughout 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 re-writable forms are possible. Current media designs employ crystals fabricated from iron doped lithium niobate, barium titanate, strontium barium niobate and organic polymer materials. In general, the materials are not interchangeable. While some of these materials permit degradation of stored data due to the effect of read operations, temperature cycling can make the data permanent while still permitting further writing operations. Acousto-optical modulators are used to scan the laser beams. The deflected object beam used for writing is directed through a spatial light modulator (SLM) to create the bit stream to be stored. The SLM is typically a liquid crystal array with the bit pattern imaged upon it. A CCD sensor array is used as an output detector for data readback.

Because holographic storage systems have no moving mechanical parts, they have applications in military, industrial, and other applications where ruggedized storage is essential. If practical, holographic storage can virtually eliminate the current limitations on throughput caused by mechanical drives, and must be considered as having the potential to compete with magnetic and optical rotating disk drives in selected applications after the turn of the century.

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

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

While Tamarack's efforts did not result in a salable product, other companies and universities are working as a consortium on the HDSS (Holographic Data Storage System) to develop prototype holographic storage equipment or required components by the year 2000. Much of this effort is funded by a $32 million program jointly funded by NSIC (National

Storage Industry Consortium) and DARPA (Defense Advanced Research Project Agency), which is associated with the U.S. Department of Defense. The goal of HDSS is a capacity of at least a trillion bits and at least a one 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), one gigabit per second data transfer rate and an access time of less than one 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 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.

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

Magnetic tape drives

* High performance tape drives: Magnetic tape drives have shifted away from reel-to-reel format in favor of cartridge formats. The IBM 3480 set a standard for high-end tape drives and other firms have adopted that physical format. 3480 class products are competitive with the lower end of the optical disk product lines in terms of capacity and are superior in terms of data transfer rate, but are inferior in terms of average access time. DLT, a tape format originated by Digital Equipment Corporation, utilizing a serpentine recording format, has also made inroads in this segment of the tape drive market. Rewritable optical disk drives have the potential to displace a significant portion of the magnetic tape drives used

for save/restore applications as optical drive and media prices decline, but the lower cost per stored megabyte typical of tape keeps tape in contention.

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

Other helical scan tape drives are also able to compete for archival and save/restore applications. A variety of recording formats, all incompatible, are being offered, including modified VHS videotape recorders, 8 millimeter cartridge, and DAT (digital audio tape), offered by several companies. These products offer large capacities (from 1.2 to 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, rates under a megabyte per second are more typical. However, data compression techniques can multiply the effective capacity and transfer rate by a factor of 2 to 5.

Because all of these technologies are based upon consumer electronics designs, media is widely available. The availability of existing consumer products reduces the cost of developing and manufacturing derivative products as computer peripherals. However, much redesign is required to transform consumer grade helical scan tape products into reliable computer peripherals.

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

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

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

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

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

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

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

DEFINITIONS

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

Market classification

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

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

Examples:

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

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

Example:

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

PCM/Distributor: Disk drives and libraries sold in the "aftermarket" -- shipments by drive and library manufacturers to subsystem producers, value-added resellers, distributors, retail chains, mail-order firms and individual dealers. Also includes disk drives and libraries sold or leased by "plug compatible manufacturers" or their distributing organizations directly to end users for use with systems sold by another manufacturer. Includes drives and libraries 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 and libraries sold by the original producer to system manufacturers which resell them as part of complete computer systems. Also includes sales to system integrators which combine finished system components and software to provide complete systems for specific applications. Sales by a disk drive or library manufacturer to a second drive or library manufacturer for

resale are included only in shipment totals for the originating manufacturer, except when drives or libraries are produced on a contract manufacturing basis with a design supplied by the disk drive or library manufacturer which finally sells the drive to a third party.

Geographic classification

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

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

Examples:

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

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

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

Example

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

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

Units of measurement

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

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

Revenue: Based on sales of disk drives or libraries alone, as normally sold by individual manufacturers. Controllers and library units sold as separate units are not included in disk drive revenue, nor are spare parts or service. When individual disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Library revenue is reported without the value of installed drives unless the sale is always made on a "drives included" basis. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Distributor or OEM/Integrator levels. All prices are in 1996 constant dollars.

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

Examples:

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

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

Application classification

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

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

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

Network/midrange computers: Drives and libraries attached to general purpose processors typically serving multiple users, including network file servers. Examples: IBM System AS/400, Hewlett-Packard 3000, Compaq SystemPro.

Personal computers: Attached to a general purpose microcomputer normally for a single user. Examples: IBM personal computers, Apple Macintosh, Compaq DeskPro, Toshiba Satellite series.

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

Consumer, game and hobby systems: Systems sold primarily to consumers for nonbusiness applications. Examples: Sony Data Discman, Sony PlayStation. Multimedia systems for home use, such as the Sega Genesis, 3DO players and most CD-I players are also included in this category.

Other applications: Any application not included above.

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

1996 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	CD-767E, CD-787E
Acer Peripherals	CD-610, CD-685
ADI	CDP-6000
Aztech Systems	CDA 468, CDA 668, CDA 1068
Behavior Tech Computer	BCD-739, BCD-10X
CD-ROM, Inc.	CRI 1600, CRI 1800
Chinon	CDS-585
DFI	CR-600, CR-800
Elitegroup Computer Systems	Vertos 600, Vertos 800
Funai Electric	E2650, E2850
Hitachi	CDR 7730, CDR 7830 CDR 7930
Hopax Industries	HO-968, HO-808
IPC Peripherals	MCD268, MCD288
LG Electronics	GCD-R560B, GCD-R580B
Lion Optics	XC-800
Lite-On Technology	LTN-10XI, LTN-12XI
Matsushita Electric Industrial	CR-582, CR583, UJDCD6720
Mitsumi Electric	CRMC-FX600, CRMC-FX800
Mountain Optech	SC-680
NEC	CDR-602, CDR-1400, CDR-3460
Ocean Automation	CDR 688, CDR 810
Optics Storage	Stingray 8422, Stingray 8622
Philips	PCA 80SC, PCA 62CR
Pinnacle Micro	10Xtreme
Pioneer	DR-U124X, DR-S104X, DR-A10X
Plextor (Shinano Kenshi)	PX 63CS, PX 83CS
Samsung Electronics	SCDR-730, SCR-830
Sanyo	CRD-S54P,CRD-256P
Sony	CDU-76, CDU-311, PRD-250WN
Tae-Il Media	CDD-6001, CDD-6801
Tatung	CD-650E, CD652E
TEAC	CD-44, CD-56S, CD-58
Toshiba	XM-1402B, XM-3701B, XM-5402B
Umax Data Systems	CD-IS602, CD-IS801
Unitron	UCD08D, UCD08N
Wearnes Technology	CDD-620, CDD-820
Yung Fu (Lxycon)	CDX-600, CDX-800

8 centimeter (3.15") disk diameter

Sony	Data Discman

A standard CD-ROM or DVD-ROM optical drive is equipped only to read an appropriate optical disk. It does not have a laser capable of developing write power, a method to switch the laser into a writing mode, nor electronics required for writing data. The optical read-only drive is sometimes referred to generically as OROM (Optical Read-Only Memory), but all drives in this product group are of the CD-ROM or DVD-ROM type and use 12 centimeter (4.72") or 8 centimeter (3.15") media. 12 centimeter drives usually also accept 8 centimeter media. Recordable CD format drives (CD-R, CD-E, DVD-R, DVD-RAM) are covered in section DT-21 of this report, which follows this chapter. In this report, CD audio players equipped with electronics to read CD-ROM formatted disks are counted as CD-ROM drives. Drives of this type are most often used with electronic games or other consumer applications. While DVD video players are not covered in this report, it is useful to note that the high cost of TV and audio equipment needed to make full use of improved DVD player video and audio capabilities, lack of recording capability, and competition from VCRs will probably keep DVD video player sales low relative to DVD-ROM sales for several years.

CD-ROM/DVD-ROM drives and media are a form of electronic publishing. Data is placed on the disks during a mass replication process analogous to the printing of a book or the stamping of a phonograph record. The demand for CD-ROM storage is driven by the quantity and types of information that publishers provide. In addition to the more than 10,000 titles now sold to the public by CD-ROM publishers, there are numerous "titles" published by companies for internal use. Typical internal titles include catalogs, parts lists, policy/procedure manuals, and equipment maintenance documentation. The desire to publish internally distributed data has spawned a do-it-yourself CD-ROM publishing industry that continues to grow as the price of authoring tools and equipment comes down and usage is simplified.

Market status

The CD-ROM drive market had another very strong year in 1995, and 1996 is expected to again show aggressive growth. Although shipments have boomed, the rapid evolution from 4X drives through 6X drives to 8X drives has caused inventory and procurement problems for many manufacturers that adversely affected profitability. In particular, there was massive overproduction of 4X

drives, resulting in sales below cost in order to clear inventory. Prices for 6X and 8X drives have been impacted as a result. 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. Video game manufacturers, notably Sony, also increased drive usage. However, multimedia kits, typically incorporating a sound board and a CD-ROM drive, and sold through retail and mail order channels, are being displaced, as personal computer manufacturers increasingly bundle drives into systems at the factory. The industry is now completing a transition to 8X drives and anticipates a further transition to 10X/12X drives, although the value of faster transfer rates to many system end users is questionable.

1995 unit shipments rose 73.4% to nearly 41.7 million units, while worldwide revenues increased 39.8% to exceed $4.0 billion. Revenue growth was again limited by declining prices resulting from manufacturing economies, lower cost designs and competitive pressures. The rapidly growing market, which increasingly resembles the floppy drive business, continues to attract new entrants, many in Southeast Asia, and encourages the growth of contract manufacturing of CD-ROM drives in Southeast Asia, China and other locations. However, some smaller manufacturers, unable to keep up with declining prices, have ceased assembling CD-ROM drives. Most of the newcomers purchase the optical and mechanical mechanisms, and complete the drive by adding their own electronics and packaging. With the exception of 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.

Nearly all CD-ROM drives can use either 12 centimeter or 8 centimeter diameter media. Sony introduced an 8 centimeter (3.15") CD-ROM in the Data Discman in 1990, but the 8 centimeter format has not been very successful because of its low capacity (about 180 megabytes) and lack of published titles, although some manufacturers of notebook computers offer it as a feature.

The Matsushita companies, Mitsumi and Sony were again the leading non-captive CD-ROM drive producers in 1994, followed by NEC and Toshiba. Sega and Sony are the leading captive producers on the strength of sales of their game products, although it should be noted that Sega relies upon several contract manufacturers for assembly of proprietary designs.

Thin CD-ROM drives for use with notebook computers have entered the market, mostly with 15 millimeter or 17 millimeter drives, though some are only 12.7 millimeters in height.

Marketing trends

The growth trend for CD-ROM drive shipments is expected to continue, with shipments of DVD-ROM gradually replacing CD-ROM. DVD-ROM drives (expected to ship in small numbers in late 1996) are forecasted to account for almost 40% of shipments within this product category in 1999. Shipments of 8X drives are expected to peak in 1997, with shipments of 10X/12X drives peaking in 1998. Worldwide unit shipments are expected to exceed 85 million in 1999, while revenues are expected to exceed $8.3 billion. Average OEM prices are expected to remain in the low eighty dollar range due to the continuing phase in of new product generations. DVD drives will produce over 48 percent of sales revenues, reflecting the anticipated higher price points for DVD drives throughout the forecast period.

With the introduction of CD-E rewritable drives expected in late 1996, CD-ROM drives capable of reading CD-E media are anticipated, with announcements probable in late 1996 from drive manufacturers using the Philips mechanisms.

Non-U.S. firms will continue to be the major producers, but Asian countries other than Japan are competing for a share of the market, even as Japan is moving much of its own production offshore. Some contract production has moved from Japan to other Asian locations, and this is stimulating local manufacturing of CD-ROM drives. Wearnes Technology, Lion Optics, and Optics Storage are among the firms that have begun production in Southeast Asia in the last few years, while several Japanese firms have arranged to manufacture their drives in China. Korean manufacturers LG Electronics, Samsung Electronics and Tae-Il Media are also in production. In Taiwan, Acer, Acer Peripherals, Lite-On and others are in production using purchased mechanisms, with significant quantities produced by units of the Acer Group.

1999 OEM shipments are projected at about 73% of the total, down slightly from 76.2% in 1995 as a result of anticipated increases in captive shipments from

Asian producers of both drives and systems. Reseller shipments, 20.4% of 1995 shipments, are expected to decline to 18% in 1999. Captive shipments are expected to rise from 3.1% in 1994 to over 9% in 1999. OEM and distribution unit shipments are actually increasing, but will decline as a percentage of the total as captive sales are forecasted to increase at a faster rate.

Increasing numbers of freestanding game and multimedia players using CD-ROMs and DVD-ROMs are expected to be sold in future years. Nintendo has declined to offer CD-ROM based games, but Sega, Sony, and others had significant 1995 shipments, and 1996 shipments are expected to continue a strong growth pattern.

Formats employing compression will increasingly be employed, with JPEG and MPEG the most significant contenders for general acceptance. For instance, CD-I supports full screen full motion video with the addition of an MPEG-1 decoder chip to the drive controller. Personal computers equipped with MPEG-1 decoders can also play back CD-ROM video content. MPEG-2 will be used in DVD drives.

Video CD, also using MPEG-1, has attracted some industry interest, with players available from several sources. Image quality is (roughly) similar to VHS video playback. However, the format can hold only 74 minutes of video and audio, insufficient for many movies but useful for karaoke. Because Video CD and CD-I are based upon a common format, Video CD disks will play on CD-I and compatible equipment. Video CD may have a short life, as the DVD high density formats able to hold two or more hours of video content are expected to displace them in the next 1-2 years.

Applications

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

CD-ROM has the inherent capability to store and recover digitized images and audio, a characteristic which suggests many applications in the field of

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

83.4% of CD-ROM drive units shipped in 1995 were attached to personal computers. Consumer computer and other applications, notably games such as Sega's and CD-I players, decreased to 6.5% because of the strong growth in PC usage. CD-ROM drive use with network servers rose slightly to 4.8% in 1995, largely due to the increasing use of CD-ROM towers attached to file servers or directly attached to the network. Many of these servers are used to supply business data across a corporate "Intranet", a local area network supporting Internet addressing conventions. Single user personal computers will remain the largest application for CD-ROM drives in 1999, capturing 78.1% of the drive shipments. Consumer applications, led by entertainment and education uses, are expected to be the second largest application area, with 13.7% of the units sold. Network servers will use 3.1% of the drives shipped.

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 drives and computer based systems which incorporate a CD-ROM player in a relatively inexpensive home computer.

Many software producers now preferentially distribute their software and documentation on CD-ROM because the cost of replication and packaging is substantially less than when floppy disks are used. Installation is also (usually) easier 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 manu-

als 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 several firms provide data-bases of phone numbers, maps and other reference materials.

Education and industrial training are current areas of applications strength for CD-ROM, and these segments have become early and significant users of CD-ROM multimedia capabilities. A broad range of titles are being marketed to both consumer and education markets, and many companies have their service manuals on CD-ROM to take advantage of multimedia capabilities.

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

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

works. Video and audio data bases containing static images (clip art), video sequences and sound sequences are also available.

Technical trends

Until recently, the basic technology utilized in this product group was relatively stable, as it was derived from the consumer CD player, with significant product differentiation based primarily on performance and embedded features. However, beginning in late 1996, DVD-ROM drives are expected to become available, as a result of pressures to increase the ability of the disk to contain increased video and audio content. The areas receiving the most attention are:

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

Multimedia support: Integration of audio and video content into CD published materials is increasing. Both hardware and software development are required. The XA format, which permits interleaving of audio and data, is now supported by most drives. Many sound boards for use in personal computers include CD-ROM drive interfaces on the card, but these interfaces often support only the CD-ROM drives of a particular supplier. DVD drives are designed specifically for multimedia applications and will offer better interface standardization.

Capacity: Pressure for increased capacity per disk is mounting. Legal data bases may span several disks, and game manufacturers are eager for the new video features increased capacity will make possible. IBM has developed a stacked disk approach in which several recording layers are bonded together, with the desired surface addressed by varying the focal point of the pickup lens. This approach has been adopted in the DVD drive specification, which defines disks that have 1 or 2 recorded surfaces on each side of the disks. The DVD drives employ shorter wavelength red lasers (635-650 nanometers), higher track densities (over 30,000 TPI) and higher bit densities.

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 mount-

ing in other than a horizontal position, and permits the drive to be used in vehicles or to be mounted in a vertical position within a system enclosure.

Because of cost pressures, 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 be able to handle unenclosed disks satisfactorily. Higher performance drives (8X and up) may require the caddy to position the disk for reliable operation at higher spin rates.

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

ISO 9660 required modification to fit the needs of the UNIX operating system, and an ad hoc task force called the Rock Ridge group prepared proposals to that end. A further extension to cover multisession recording was prepared by the Frankfurt group, a similar organization. This latter proposal became the ECMA 168 standard, which is used by the Kodak Photo CD system.

The XA format proposed by Philips, Sony and Microsoft in 1988 extended the ISO 9660 standard to provide improved interactive capabilities. For some of the drives marketed that initially claimed XA compliance, there were unfavorable interactions between the drive and the controller preventing full compliance. While early drives that could read a Photo CD disk were XA compliant, many could read only the first session on multisession disks. As of 1996, manufacturers offered drives capable of dealing with XA and multisession Photo CD formats.

Standards for motion video compression being worked out by MPEG (Motion Picture Experts Group) have been adopted for CD-I, with the first MPEG decoder chips available in 1992. More complex encoder chip sets made their appearance by mid-1993. However, full screen picture quality using MPEG-1 is considered by many to offer inferior image quality compared to conventional VHS videotape, so an improved version, MPEG-2 was developed to fully activate the CD-ROM based video market.

A similar group, JPEG, is concentrating on compression standards for still video images. These standards, while important for multimedia software generally, will apply regardless of the storage device used.

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

Performance: Average access times have dipped to well under 300 milliseconds and seek times have gone to well under 200 milliseconds. Users are getting faster data transfer rates by means of faster rotation rates. CD-ROM drive producers routinely manufacture drives with at least eight times the original 150 KB/second data transfer rate, with the improvement in performance achieved by increasing the rotation rate. Most firms have announced 8X drives and some have begun shipping small quantities of 10X drives. 12X drives are expected to be in production by late 1996.

While most CD-ROM/DVD-ROM drives operate with constant linear velocity, some manufacturers, notably Pioneer, are beginning to offer dual CLV/CAV capabilities. Average access time using constant angular velocity is much shorter than when CLV is used and the average data transfer rate can also be significantly faster.

The presence of a large buffer is becoming increasingly important for adequate multimedia performance. 128 kilobyte buffers are a minimum requirement, but drives with 256 kilobyte or larger buffers are increasingly preferred for multimedia applications. The larger buffers are appropriate for applications requiring smooth full motion video and/or higher data transfer rates. Higher performance drives also increase pressure for higher capacity, because the faster drives encourage increasing the video content of the application stored on the disk.

Software: Development of software to support use with major operating systems and application programs, such as text search and the spectrum of multimedia applications, continues. While drivers are available for support of CD-ROM on most computing platforms, specific combinations of drives, operating systems and drivers still exhibit incompatibilities, although the situation has improved greatly over the last year. Additional driver development is needed to support new generations of data compression/decompression techniques. Additional software is needed to support the new generation of high capacity DVD drives as they enter the marketplace. Newer operating systems, such as Windows 95, can support CD-ROM drives without the addition of third party software.

Interface: Initially, CD-ROM drives have typically been designed with SCSI interfaces, with the SCSI-2 command set and small connector widely

adopted in current CD-ROM drives. SCSI-2 is likely to remain the interface most used on servers because of its ability to handle many devices. Cost pressures prompted the appearance of drives with interfaces specific to a sound card incorporated in a personal computer that also connects to the CD-ROM drive. Dedicated use systems, such as the CD-I players, use a proprietary interface, as do some multimedia add-on kits.

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

Cost reduction: Cost reduction programs are continuing and accelerating. Plastic molded lenses, for instance, have replaced polished glass lenses. In some low performance CD-ROM drives, stepping motors are used rather than more expensive positioning methods. Superfluous components, such as audio jacks and related circuitry, will be removed in some designs. Plastic has replaced sheet metal in some low end drive packaging. The cost of the electronic elements used are also declining with increasing CD-ROM drive shipment volume and use of more complex ASICs.

Packaging: The packaging of CD-ROM drives has changed rapidly. In 1986, most of the drives shipped were not compatible with the full height and half high form factors that have been adopted for 5.25" magnetic disk drive products. Today, CD-ROM drives are mostly half high models, but 25.4, 17 and 15 millimeter high models have appeared, and even thinner units (some only 12.7 millimeters thick) capable of fitting under the keyboard of a notebook computer have been announced by manufacturers. However, since the computer industry has moved to the 3.5" packaging profile, CD-ROM drives are frequently mounted externally to the desktop computers and internally in tower configurations. CD-ROM autochangers with up to 6 disk capacities have become available for installation in a single half high 5.25" drive bay.

Authoring systems: Publishers of CD-ROMs require tools to help them prepare various types of content including text, data bases, audio and video for mastering and replication. Multimedia projects, in particular, are complex and require sophisticated tools to help nonexperts prepare multimedia titles. The advent of write-once CD drives (CD-R) encouraged products that include all software and hardware tools needed, and easy to

use production tools for use with CD-R drives began appearing in 1994. CD-R drives are more fully discussed in chapter DT-21.

Networks, libraries and CD-ROM towers: System integrators are increasingly adding CD-ROM capabilities on file servers. As a result, there is interest in jukeboxes for CD format drives, but the slow access time of the CD-ROM has led most server designers to adopt multiple drive configurations, or CD-ROM towers. The CD-ROM tower typically holds from 4 to 28 drives, although 7 drives is the most common size. The tower typically has a SCSI interface to a server, although some controllers, such as the inexpensive controller offered by Compact Devices, attach directly to a local area network and can be configured to operate with one of several available network protocols.

An increasing number of firms have announced autochangers for CD-ROM: The number of manufacturers is increasing, with libraries ranging in storage capacity from three disks to several thousand disks. However, the relatively slow bandwidths and throughput obtained from heavily loaded networks may make it impractical for servers containing multimedia formatted disks to adequately respond to user expectations for image motion and audio continuity. Fiber optic based networks may be needed to use multimedia in a network environment efficiently.

Reliability: Early CD-ROM drives experienced failures due to the accumulation of dust on the lens. The industry has responded with a variety of solutions, including lens cleaning kits and self-cleaning drives. The best solution seems to be avoidance of designs that allow dust-laden air to be pulled through the drive. Dust resistant designs began appearing in 1990 and 1991 and are now commonplace. Other reliability problems seem to be connected to drives operating at 8X and higher speeds, which require tighter tolerances on media and media production processes.

There remains some concern about disk reliability. Accelerated environmental testing shows a wide variety of resistance to temperature and humidity, with the major variation the result of imperfect sealing of the protective layer of the disk, especially at the edges. There have been problems with both CD-ROM and CD-R media that operate correctly on low spin rate drives but develop unacceptable error rates on high spin rate drives. Media replicators and drive producers seem to be overcoming these problems, but the arrival of multilayer DVD disks and higher spin rates seem likely to exacerbate the situation.

Writable CD: Writable CD-format (CD-R) media and systems are expensive but are becoming more affordable. Philips, Sony, Yamaha, JVC and Ricoh are among the firms currently shipping drives, often as part of a complete recording system. Many companies are exploring the internal uses of rewritable CD-ROM format recording because of the large numbers of CD-ROM drives already installed or anticipated within their organizations. The CD-E (CD-erasable) drives proposed by Philips are expected

to begin shipping in 1996. See the section on read/write drives under a gigabyte for a full discussion.

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

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

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-E drives, CD-R drives and their DVD equivalents, which might capture from 1% to 5% of the available drive slots in 1999.

Forecasting assumptions

1. CD-ROM drive production capability will substantially meet demand, although short term component shortages may recur in 1996 and 1997 due to rapid transitions from 8X to 10X to 12X and onward.
2. The ISO formatted disk interchange standard for CD-ROM will continue to be accepted by drive manufacturers and publishers.
3. Non-U.S. suppliers will continue to dominate the CD-ROM hardware market. There will be no significant production by U.S. firms.
4. DVD generation CD-ROM drives will begin shipments starting in late 1996. There will be no significant DVD-ROM standards issues unresolved by the end of the third quarter of 1996.
5. There will be little impact on CD-ROM or DVD-ROM shipments from competing technologies throughout the forecast period.
6. Most consumers will prefer to use CD-ROM based games and educational materials with personal computers rather than with free-standing players.
7. Media mastering and replicating capacity will be adequate and will not restrict growth for CD-ROM optical memory markets. Replication quality will be sufficient for 8X and higher operating rates. Replication capability for DVD drives will be adequate.

TABLE 17

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast							
	1996		1997		1998		1999			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	14.7	14.7	13.2	13.2	13.5	13.5	11.9	11.9	11.0	11.0
TOTAL U.S. REVENUES	14.7	14.7	13.2	13.2	13.5	13.5	11.9	11.9	11.0	11.0
Non-U.S. Manufacturers										
Captive	96.9	235.9	179.7	430.8	374.5	913.1	495.6	1,196.8	744.1	1,832.7
PCM/Distributor	407.2	1,111.7	472.7	998.1	647.4	1,137.0	758.8	1,443.6	708.6	1,739.9
OEM/Integrator	1,097.6	2,644.1	1,521.8	3,596.8	1,699.6	4,270.2	1,937.2	4,741.0	2,135.3	5,033.0
TOTAL NON-U.S. REVENUES	1,601.7	3,991.7	2,174.2	5,025.7	2,721.5	6,320.3	3,191.6	7,381.4	3,588.0	8,605.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,616.4	4,006.4	2,187.4	5,038.9	2,735.0	6,333.8	3,203.5	7,393.3	3,599.0	8,616.6
OEM Average Price ($000)		.082		.085		.084		.083		.081

TABLE 18

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995		Forecast							
	Shipments		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	46.0	46.0	47.1	47.1	53.0	53.0	54.0	54.0	55.0	55.0
TOTAL U.S. SHIPMENTS	46.0	46.0	47.1	47.1	53.0	53.0	54.0	54.0	55.0	55.0
Non-U.S. Manufacturers										
Captive	545.0	1,303.0	1,046.8	2,509.5	1,765.0	4,400.0	2,527.8	6,131.9	3,159.7	7,865.0
PCM/Distributor	3,792.0	8,453.0	4,601.1	10,076.5	6,538.0	11,005.0	7,277.0	13,285.0	7,483.3	15,263.0
OEM/Integrator	13,068.0	31,890.0	17,585.6	41,859.1	19,925.0	50,323.0	23,163.0	56,646.0	26,279.8	62,018.8
TOTAL NON-U.S. SHIPMENTS	17,405.0	41,646.0	23,233.5	54,445.1	28,228.0	65,728.0	32,967.8	76,062.9	36,922.8	85,146.8
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	17,451.0	41,692.0	23,280.6	54,492.2	28,281.0	65,781.0	33,021.8	76,116.9	36,977.8	85,201.8
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	40.1	82.4	63.4	136.9	91.7	202.7	124.7	278.8	161.7	364.0

TABLE 19

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DATA TRANSFER RATE

	1995 Revenues			Forecast																
				1996					1997				1998				1999			
	< 4X	4X	6X-8X	< 4X	4X	6X-8X	>8X	DVD-ROM	4X	6X-8X	>8X	DVD-ROM	4X	6X-8X	>8X	DVD-ROM	4X	6X-8X	>8X	DVD-ROM
U.S. MANUFACTURERS																				
PCM/Distributor	--	14.7	--	--	13.2	--	--	--	--	13.5	--	--	--	10.8	1.1	--	--	4.0	7.0	--
TOTAL U.S. REVENUES	--	14.7	--	--	13.2	--	--	--	--	13.5	--	--	--	10.8	1.1	--	--	4.0	7.0	--
NON-U.S. MANUFACTURERS																				
Captive	181.8	43.0	11.1	44.0	162.4	209.7	14.7	--	22.7	263.8	234.6	392.0	17.6	288.3	433.5	457.4	17.6	132.8	441.8	1,240.5
PCM/Distributor	203.6	783.3	124.8	35.4	75.4	772.0	115.0	.3	3.1	440.3	648.7	44.9	--	188.0	713.1	542.5	--	119.3	503.3	1,117.3
OEM/Integrator	328.7	2,068.4	249.0	--	280.3	3,101.6	209.9	5.0	1.9	2,396.5	1,803.2	68.6	--	259.0	3,722.0	760.0	--	47.6	3,007.4	1,978.0
TOTAL NON-U.S. REVENUES	712.1	2,894.7	384.9	79.4	518.1	4,083.3	339.6	5.3	27.7	3,100.6	2,686.5	505.5	17.6	735.3	4,868.6	1,759.9	17.6	299.7	3,952.5	4,335.8
WORLDWIDE RECAP																				
Captive	181.8	43.0	11.1	44.0	162.4	209.7	14.7	--	22.7	263.8	234.6	392.0	17.6	288.3	433.5	457.4	17.6	132.8	441.8	1,240.5
	-77.0%	+44.3%	--	-75.8%	+277.7%	--	--	--	-86.0%	+25.8%	--	--	-22.5%	+9.3%	+84.8%	+16.7%	--	-53.9%	+1.9%	+171.2%
PCM/Distributor	203.6	798.0	124.8	35.4	88.6	772.0	115.0	.3	3.1	453.8	648.7	44.9	--	198.8	714.2	542.5	--	123.3	510.3	1,117.3
	-55.3%	--	--	-82.6%	-88.9%	+518.6%	--	--	-96.5%	-41.2%	+464.1%	--	--	-56.2%	+10.1%	--	--	-38.0%	-28.5%	+106.0%
OEM/Integrator	328.7	2,068.4	249.0	--	280.3	3,101.6	209.9	5.0	1.9	2,396.5	1,803.2	68.6	--	259.0	3,722.0	760.0	--	47.6	3,007.4	1,978.0
	-77.3%	--	--	--	-86.4%	--	--	--	-99.3%	-22.7%	+759.1%	--	--	-89.2%	+106.4%	--	--	-81.6%	-19.2%	+160.3%
Total Revenues	712.1	2,909.4	384.9	79.4	531.3	4,083.3	339.6	5.3	27.7	3,114.1	2,686.5	505.5	17.6	746.1	4,869.7	1,759.9	17.6	303.7	3,959.5	4,335.8
	-73.5%	--	--	-88.8%	-81.7%	+960.9%	--	--	-94.8%	-23.7%	+691.1%	--	-36.5%	-76.0%	+81.3%	+248.2%	--	-59.3%	-18.7%	+146.4%
ANNUAL SHARE	17.8%	72.7%	9.5%	1.6%	10.5%	81.1%	6.7%	.1%	.4%	49.3%	42.4%	7.9%	.2%	10.1%	66.0%	23.7%	.2%	3.5%	46.1%	50.2%

Note: 1. 4X, 6X, 8X refer to data transfer rates relative to 150 kilobytes per second.
2. Figures include 12 centimeter and 8 centimeter drives.

TABLE 20

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DATA TRANSFER RATE

	1995 Shipments			1996					1997 Forecast				1998 Forecast				1999 Forecast			
	< 4X	4X	6X-8X	< 4X	4X	6X-8X	>8X	DVD-ROM	4X	6X-8X	>8X	DVD-ROM	4X	6X-8X	>8X	DVD-ROM	4X	6X-8X	>8X	DVD-ROM
U.S. MANUFACTURERS																				
PCM/Distributor	--	46.0	--	--	47.1	--	--	--	--	53.0	--	--	--	49.0	5.0	--	--	20.0	35.0	--
TOTAL U.S. SHIPMENTS	--	46.0	--	--	47.1	--	--	--	--	53.0	--	--	--	49.0	5.0	--	--	20.0	35.0	--
NON-U.S. MANUFACTURERS																				
Captive	923.0	309.0	71.0	157.1	880.6	1,397.9	73.9	--	189.0	2,028.0	1,203.0	980.0	141.0	2,402.0	2,281.9	1,307.0	135.0	1,207.0	2,388.0	4,135.0
PCM/Distributor	1,876.0	5,510.0	1,067.0	354.0	1,211.9	7,676.9	832.6	1.1	70.0	5,234.0	5,497.0	204.0	--	2,506.0	7,924.0	2,855.0	--	1,988.0	6,292.0	6,983.0
OEM/Integrator	4,399.0	25,130.0	2,361.0	--	6,644.9	33,390.2	1,793.4	30.6	64.0	30,062.0	19,601.0	596.0	--	3,500.0	45,391.0	7,755.0	--	951.0	38,067.8	23,000.0
TOTAL NON-U.S. SHIPMENTS	7,198.0	30,949.0	3,499.0	511.1	8,737.4	42,465.0	2,699.9	31.7	323.0	37,324.0	26,301.0	1,780.0	141.0	8,408.0	55,596.9	11,917.0	135.0	4,146.0	46,747.8	34,118.0
WORLDWIDE RECAP																				
Captive	923.0	309.0	71.0	157.1	880.6	1,397.9	73.9	--	189.0	2,028.0	1,203.0	980.0	141.0	2,402.0	2,281.9	1,307.0	135.0	1,207.0	2,388.0	4,135.0
	-66.1%	+159.7%	--	-83.0%	+185.0%	--	--	--	-78.5%	+45.1%	--	--	-25.4%	+18.4%	+89.7%	+33.4%	-4.3%	-49.8%	+4.6%	+216.4%
PCM/Distributor	1,876.0	5,556.0	1,067.0	354.0	1,259.0	7,676.9	832.6	1.1	70.0	5,287.0	5,497.0	204.0	--	2,555.0	7,929.0	2,855.0	--	2,008.0	6,327.0	6,983.0
	-49.7%	--	--	-81.1%	-77.3%	+619.5%	--	--	-94.4%	-31.1%	+560.2%	--	--	-51.7%	+44.2%	--	--	-21.4%	-20.2%	+144.6%
OEM/Integrator	4,399.0	25,130.0	2,361.0	--	6,644.9	33,390.2	1,793.4	30.6	64.0	30,062.0	19,601.0	596.0	--	3,500.0	45,391.0	7,755.0	--	951.0	38,067.8	23,000.0
	-73.1%	--	--	--	-73.6%	--	--	--	-99.0%	-10.0%	+993.0%	--	--	-88.4%	+131.6%	--	--	-72.8%	-16.1%	+196.6%
Total Shipments	7,198.0	30,995.0	3,499.0	511.1	8,784.5	42,465.0	2,699.9	31.7	323.0	37,377.0	26,301.0	1,780.0	141.0	8,457.0	55,601.9	11,917.0	135.0	4,166.0	46,782.8	34,118.0
	-68.4%	--	--	-92.9%	-71.7%	--	--	--	-96.3%	-12.0%	+874.1%	--	-56.3%	-77.4%	+111.4%	+569.5%	-4.3%	-50.7%	-15.9%	+186.3%
ANNUAL SHARE	17.3%	74.4%	8.3%	.9%	16.1%	78.0%	5.0%	--	.5%	56.9%	40.0%	2.6%	.2%	11.1%	73.1%	15.6%	.2%	4.9%	55.0%	39.9%

Note: 1. 4X, 6X, 8X refer to data transfer rates relative to 150 kilobytes per second.
2. Figures include 12 centimeter and 8 centimeter drives.

TABLE 21

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	85.2	.1
MAINFRAME SYSTEMS				
General purpose	--	--	170.4	.2
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	1,992.9	4.8	2,641.1	3.1
PERSONAL COMPUTERS				
Business and professional, single user	34,754.4	83.4	66,539.7	78.1
WORKSTATIONS				
Engineering and office, single user	1,550.9	3.7	2,896.7	3.4
CONSUMER, GAME AND HOBBY COMPUTERS	2,726.7	6.5	11,672.1	13.7
OTHER APPLICATIONS	667.1	1.6	1,192.8	1.4
Total	41,692.0	100.0	85,198.0	100.0

TABLE 22

CD FORMAT READ-ONLY OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	< 4X	4X	6X	8X	Total		< 4X	4X	6X	8X	Total	
Matsushita Electric	1281.0	2178.0	--	--	3459.0	20.5	3278.0	5570.0	--	--	8848.0	21.9
Mitsumi Electric	--	2905.0	--	--	2905.0	17.2	--	7205.0	--	--	7205.0	17.8
Sony	85.0	1670.0	215.0	--	1970.0	11.7	177.0	3992.0	815.0	--	4984.0	12.3
NEC	--	2130.0	584.0	--	2714.0	16.1	--	3474.0	775.0	--	4249.0	10.5
Toshiba	257.0	1670.0	--	--	1927.0	11.4	553.0	3640.0	--	--	4193.0	10.4
LG Electronics	50.0	500.0	--	--	550.0	3.3	276.0	935.0	--	--	1211.0	3.0
Other U.S.	--	46.0	--	--	46.0	.3	--	46.0	--	--	46.0	.1
Other Non-U.S.	588.0	1650.0	1097.0	--	3335.0	19.5	1991.0	5824.0	1833.0	5.0	9653.0	24.0
TOTAL	2261.0	12749.0	1896.0	--	16906.0	100.0	6275.0	30686.0	3423.0	5.0	40389.0	100.0

Note: 1. See section DT-21 for CD-R drives.
2. Includes 12 centimeter and 8 centimeter drives.

CD FORMAT WRITABLE OPTICAL DISK DRIVES

1996 DISK/TREND REPORT

CD FORMAT WRITABLE OPTICAL DISK DRIVES

Coverage

Examples of disk drives in this group include:

12 centimeter disk diameter

Acer	CD-1420C
Delta Electronics	ODR-4121
Eastman Kodak	PCD Writer 200, PCD Writer 600
Hewlett-Packard	4020i
JVC	XR-W2001, XR-S201
Matsushita Electric Industrial	CW-7501, LF-1000AB, LF-1004AB (E)
Mitsumi Electric	CR2600TE
NEC	ODX651, ODX652 (E)
Philips	CDD2000, CDD2600
Pinnacle Micro	RCD5040
Ricoh	RS-1420C, RO-1060C
Sony	CDW-900E, CDU-924S, CDU-921S
TEAC	CD-R50S
Wearnes Technology	CDR-230, CDR-432
Yamaha	CDR-100, CDR-102

Drives included in this group (which appears separately for the first time in the 1996 DISK/TREND Report) use CD-ROM or DVD-ROM formats, and have the ability to record in either write-once or rewritable mode. This includes CD-R (write-once), CD-E (rewritable), and DVD-R (write-once) and DVD-RAM (rewritable) drives when they appear. PD drives are also included: Although their writing format is not CD compatible, they do have CD-ROM read capabilities and are included here for convenience. The drives discussed in this section are typically used with small and midrange computer systems of the mini and micro class and with intelligent workstations.

Market status

1995 was a very good year for this product group. Shipments grew to 514,000 units from 51,000 in 1994, an increase of 908%. CD-R shipments grew 327.5%, to 218,000 units, while shipments of PD drives, produced for the first time in 1995, reached 296,000 units. PD sales were assisted by Matsushita's use of them in its own computing systems, but sales to distributors and OEMs exceeded sales of CD-R drives worldwide. NEC is expected to begin production

of its own PD drive in late 1996. A standard for PD drive media was approved in mid-1996 as ECMA-240.

1995 shipments of CD-R drives were strengthened by declining prices and improvements in software that made them easier to integrate and use in personal computer systems. Another positive factor is the increasing number of companies publishing CD-ROMs. The CD-R drives can be used to transmit finished content to testers and CD-ROM replicators. Despite shortages of CD-R media that have occurred in 1996, sales of drives seem unaffected by media shortages.

Revenues for the group rose from $89.3 million to $279.3 million, a gain of 213%. About 56% of sales were made to the U.S. Worldwide OEM sales accounted for 61% of unit shipments and 54.9% of revenues. 33.4% of shipments were to distributors, which provided 38.8% of revenues. The balance was derived from captive sales.

Philips, JVC and Yamaha were the leading CD-R producers, accounting for over 78% of unit shipments between them. Matsushita Electric was the only manufacturer to supply PD drives in quantity.

Marketing trends

Strong growth for this group is expected to continue through 1999, but the structure of the group will become more complex as CD-E drives enter the mix in late 1996, to be joined by DVD-R and DVD-RAM drives in following years. As rewritable drives appear, they are expected to displace the write-once versions, offering the use of either write-once or rewritable media at the users' discretion.

1999 shipments for the group are expected to exceed 4 million units, while revenues are forecasted to exceed $1.35 billion. CD-R shipments, 42.5% of the group in 1995, are expected to decline to 7.9% of the group in 1999, as the result of displacement by CD-E and DVD writable technology. Unit sales will peak in 1997, while CD-E shipments are expected to peak in 1998, increasingly displaced by DVD-R and DVD-RAM thereafter. The DVD technologies are expected to capture over a third of group shipments in 1999. OEM revenues are expected to decline in 1997, due to rapid price reductions caused by competitive forces, but will recover as higher priced DVD products go into production in 1998 and later.

Applications

CD-R drives are mostly used for short run disk duplication where volume does not warrant replication one time costs. They are frequently installed in CD-ROM libraries to automate disk handling when multiple disks must be produced, to reduce manual handling of disks and reduce labor costs. CD-R drives are expected to be displaced by CD-E drives beginning in 1997. Users of CD-E drives will be able to use either CD-R media or rewritable CD-E media and can obtain the same storage utility functions currently provided by floppy disk drives or inexpensive tape drives, albeit at a higher price.

PD drives have been positioned by Matsushita as backup, archival and save/restore drives that can also read CD-ROM media. They have been adopted for use in some of Compaq's high end desktop computers. They also have applications in small servers, where their combined capability for archiving, backup and installing CD-ROM based software across a network makes them attractive. PD drives compete against CD-E drives, and PD manufacturers, which will benefit from a lead in entering production, are expected to compete aggressively against CD-E to protect their position.

Attachments to personal computers accounted for 67.6% of the units shipped in 1995, but this percentage will decrease to about 46% in 1999 as usage in servers and workstations increases. Workstations used to prepare CD-ROMs and Web pages are expected to be major users of drives in this group, with their 13.2% share in 1995 expanding to 31% in 1999.

Technical trends

The major events anticipated for this product group include the shipment of CD-E drives in late 1996, shipment of the first DVD-R drives in late 1997 or early 1998, and shipment of DVD-RAM drives in 1998. PD drives are expected to be displaced by DVD-RAM after it enters its ramp-up phase in 1999. Some of the key aspects of this product progression are reviewed below:

> Capacity: The capacity of CD-E drives will be the same as CD-R and CD-ROM. However, due to technical limitations, the capacity of DVD-R and DVD-RAM drives will be limited to 2.6 gigabytes per side in their initial

expected releases. The capacity increase 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.

Write-once recording: The technology used for CD-R recording is dye-based, while the technology used for DVD-R will probably be phase change. In either method, the writing laser causes a change in media reflectivity which can be sensed during the readback process. Unfortunately, the CD-R media currently used today will not be readable by DVD-ROM or other DVD types because the CD-R media, written with a 780 nanometer laser, is essentially transparent at the shorter 650 nanometer wavelengths used by DVD drives. The industry has not done a good job of briefing the user community, and the resulting confusion and anger when DVD-ROM user "surprises" appear has the potential to significantly harm DVD sales.

Rewritability: Phase change technology will be used for CD-E drives and probably for DVD-RAM as well, although there is a consortium of companies 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.

The CD-E media cannot be read by any existing CD-ROM drives because of differences in media reflectivity, but addition of an automatic gain control circuit to the CD-ROM drive can resolve this incompatibility.

Magneto-optic technology 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 in the 6 to 7 gigabyte range and performance substantially better than that projected for DVD-RAM using phase change media. The drives will also read CD-ROM and DVD-ROM media, but probably will not read other magneto-optic media formats. It is not yet decided if the MO recording format will be identical to the phase change DVD-RAM format. The group is expected to develop a working specification by the end of 1996.

Like MO technology, phase change technology permits the interchange of write-once and erasable media on a single drive. It also provides direct overwrite capability with simpler drive designs than for MO drives. However, phase change media has a limitation on the number of write/erase cycles substantially lower than MO media.

Recording format: The recording format and related error correction schemes used in CD-ROM compatible CD-R and CD-E is optimized for sequential writing in a CLV mode. To make writing to CD-R and CD-E disks more efficient, a recording scheme is required that permits writing in sector-like blocks with ECC sector related rather than spread across several blocks. Such methods, known as packet writing, have been proposed as a standard by Sony, Philips, Hewlett-Packard and Adaptec,

resulting in OSTA's (Optical Storage Technology Association) adoption of the UDF packet writing file format in mid-1996.

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

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

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

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

Forecasting assumptions

1. CD-E drives will be announced and commence shipments in late 1996. Prices will rapidly approach CD-R prices after introduction.
2. DVD-R drives will be announced and commence shipments in late 1997.
3. DVD-RAM drives will be introduced and commence shipments in 1998, impacting shipments of PD, CD-R and CD-E drives thereafter.
4. CD-E drives will impact shipments of CD-R and PD drives, starting in 1996.

TABLE 23

CD FORMAT WRITABLE OPTICAL DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995		Forecast							
	Revenues		1996		1997		1998		1999	
	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	--	17.6	--	48.8	--	52.3	13.8	89.7	20.5	89.8
PCM/Distributor	51.7	108.3	115.1	245.3	149.1	320.1	183.7	371.9	241.9	512.2
OEM/Integrator	103.5	153.4	335.6	539.0	332.9	529.5	301.7	543.4	390.7	748.9
TOTAL NON-U.S. REVENUES	155.2	279.3	450.7	833.1	482.0	901.9	499.2	1,005.0	653.1	1,350.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	155.2	279.3	450.7	833.1	482.0	901.9	499.2	1,005.0	653.1	1,350.9
OEM Average Price ($000)		.486		.367		.301		.256		.278

TABLE 24

CD FORMAT WRITABLE OPTICAL DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	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	--	27.0	--	75.0	--	95.0	30.0	187.0	50.0	219.0
PCM/Distributor	92.3	171.9	265.2	541.0	365.0	764.0	476.0	953.4	565.6	1,178.4
OEM/Integrator	198.3	315.1	860.2	1,465.0	1,019.5	1,758.0	1,170.0	2,116.0	1,448.0	2,688.0
TOTAL NON-U.S. SHIPMENTS	290.6	514.0	1,125.4	2,081.0	1,384.5	2,617.0	1,676.0	3,256.4	2,063.6	4,085.4
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	290.6	514.0	1,125.4	2,081.0	1,384.5	2,617.0	1,676.0	3,256.4	2,063.6	4,085.4
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	.3	.5	1.4	2.6	2.8	5.2	4.5	8.5	6.5	12.6

TABLE 25

CD FORMAT WRITABLE OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DRIVE TYPE

	1995 Revenues		Forecast															
			1996			1997				1998				1999			
	CD-R	PD	CD-R	CD-E	PD	CD-R	CD-E	PD	DVD-R/E	CD-R	CD-E	PD	DVD-R/E	CD-R	CD-E	PD	DVD-R/E
U.S. MANUFACTURERS																	
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS																	
Captive	--	17.6	--	--	48.8	--	--	52.3	--	--	--	59.8	29.9	--	--	40.6	49.2
PCM/Distributor	76.0	32.3	152.5	1.8	91.0	157.0	64.2	96.8	2.1	91.1	133.0	83.8	64.0	35.4	102.0	61.7	313.1
OEM/Integrator	103.8	49.6	304.2	12.6	222.2	224.6	61.2	243.1	.6	85.1	165.5	201.6	91.2	47.9	114.1	163.5	423.4
TOTAL NON-U.S. REVENUES	179.8	99.5	456.7	14.4	362.0	381.6	125.4	392.2	2.7	176.2	298.5	345.2	185.1	83.3	216.1	265.8	785.7
WORLDWIDE RECAP																	
Captive	--	17.6	--	--	48.8	--	--	52.3	--	--	--	59.8	29.9	--	--	40.6	49.2
	--	--	--	--	+177.3%	--	--	+7.2%	--	--	--	+14.3%	--	--	--	-32.1%	+64.5%
PCM/Distributor	76.0	32.3	152.5	1.8	91.0	157.0	64.2	96.8	2.1	91.1	133.0	83.8	64.0	35.4	102.0	61.7	313.1
	+240.8%	--	+100.7%	--	+181.7%	+3.0%	--	+6.4%	--	-42.0%	+107.2%	-13.4%	--	-61.1%	-23.3%	-26.4%	+389.2%
OEM/Integrator	103.8	49.6	304.2	12.6	222.2	224.6	61.2	243.1	.6	85.1	165.5	201.6	91.2	47.9	114.1	163.5	423.4
	+54.9%	--	+193.1%	--	+348.0%	-26.2%	+385.7%	+9.4%	--	-62.1%	+170.4%	-17.1%	--	-43.7%	-31.1%	-18.9%	+364.3%
Total Revenues	179.8	99.5	456.7	14.4	362.0	381.6	125.4	392.2	2.7	176.2	298.5	345.2	185.1	83.3	216.1	265.8	785.7
	+101.3%	--	+154.0%	--	+263.8%	-16.4%	+770.8%	+8.3%	--	-53.8%	+138.0%	-12.0%	--	-52.7%	-27.6%	-23.0%	+324.5%
ANNUAL SHARE	64.5%	35.5%	54.9%	1.7%	43.4%	42.4%	13.9%	43.5%	.2%	17.5%	29.8%	34.3%	18.4%	6.2%	16.0%	19.7%	58.1%

TABLE 26

CD FORMAT WRITABLE OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DRIVE TYPE

	1995		Forecast															
	Shipments		1996			1997				1998				1999				
	CD-R	PD	CD-R	CD-E	PD	CD-R	CD-E	PD	DVD-R/E	CD-R	CD-E	PD	DVD-R/E	CD-R	CD-E	PD	DVD-R/E
U.S. MANUFACTURERS																		
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS																		
Captive	--	27.0	--	--	75.0	--	--	95.0	--	--	--	122.0	65.0	--	--	99.0	120.0	
PCM/Distributor	73.9	98.0	249.0	2.0	290.0	308.0	107.0	346.0	3.0	217.0	266.0	381.0	89.4	104.0	255.0	343.0	476.4	
OEM/Integrator	144.1	171.0	619.0	18.0	828.0	591.0	153.0	1,013.0	1.0	304.0	517.0	1,120.0	175.0	218.0	496.0	1,090.0	884.0	
TOTAL NON-U.S. SHIPMENTS	218.0	296.0	868.0	20.0	1,193.0	899.0	260.0	1,454.0	4.0	521.0	783.0	1,623.0	329.4	322.0	751.0	1,532.0	1,480.4	
WORLDWIDE RECAP																		
Captive	--	27.0	--	--	75.0	--	--	95.0	--	--	--	122.0	65.0	--	--	99.0	120.0	
	--	--	--	--	+177.8%	--	--	+26.7%	--	--	--	+28.4%	--	--	--	-18.9%	+84.6%	
PCM/Distributor	73.9	98.0	249.0	2.0	290.0	308.0	107.0	346.0	3.0	217.0	266.0	381.0	89.4	104.0	255.0	343.0	476.4	
	+624.5%	--	+236.9%	--	+195.9%	+23.7%	--	+19.3%	--	-29.5%	+148.6%	+10.1%	--	-52.1%	-4.1%	-10.0%	+432.9%	
OEM/Integrator	144.1	171.0	619.0	18.0	828.0	591.0	153.0	1,013.0	1.0	304.0	517.0	1,120.0	175.0	218.0	496.0	1,090.0	884.0	
	+253.2%	--	+329.6%	--	+384.2%	-4.5%	+750.0%	+22.3%	--	-48.6%	+237.9%	+10.6%	--	-28.3%	-4.1%	-2.7%	+405.1%	
Total Shipments	218.0	296.0	868.0	20.0	1,193.0	899.0	260.0	1,454.0	4.0	521.0	783.0	1,623.0	329.4	322.0	751.0	1,532.0	1,480.4	
	+327.5%	--	+298.2%	--	+303.0%	+3.6%	--	+21.9%	--	-42.0%	+201.2%	+11.6%	--	-38.2%	-4.1%	-5.6%	+349.4%	
ANNUAL SHARE	42.5%	57.5%	41.8%	1.0%	57.2%	34.5%	9.9%	55.6%	--	16.0%	24.0%	49.9%	10.1%	7.9%	18.4%	37.6%	36.1%	

TABLE 27

CD FORMAT WRITABLE OPTICAL DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	16.3	.4
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	29.9	5.8	637.3	15.6
PERSONAL COMPUTERS				
Business and professional, single user	347.4	67.6	1,891.5	46.3
WORKSTATIONS				
Engineering and office, single user	68.0	13.2	1,266.5	31.0
CONSUMER, GAME AND HOBBY COMPUTERS	59.2	11.5	167.5	4.1
OTHER APPLICATIONS	9.5	1.9	106.3	2.6
Total	514.0	100.0	4,085.4	100.0

TABLE 28

CD FORMAT WRITABLE OPTICAL DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	CD-R	PD	Total		CD-R	PD	Total	
Matsushita Electric	--	148.0	148.0	50.9	--	269.0	269.0	55.2
Philips	56.0	--	56.0	19.3	76.0	--	76.0	15.6
JVC	49.0	--	49.0	16.9	64.0	--	64.0	13.1
Yamaha	13.3	--	13.3	4.6	31.1	--	31.1	6.4
Other U.S.	--	--	--	--	--	--	--	--
Other Non-U.S.	24.3	--	24.3	8.3	46.9	--	46.9	9.7
TOTAL	142.6	148.0	290.6	100.0	218.0	269.0	487.0	100.0

READ/WRITE OPTICAL DISK DRIVES LESS THAN 2 GIGABYTES

1996 DISK/TREND REPORT

READ/WRITE OPTICAL DISK DRIVES LESS THAN 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

2.5" disk diameter

Sony	MDH-10, MDM-111

3.5" disk diameter

Fujitsu	M2512A, M2513A, M2541S
Konica	OMD-7060
Matsushita Electric Industrial	LF-3100, LF-3294
Mountain Optech	CS-250 R/W
Olympus	230MO Plus, MOS320E, MOS330E
Seiko Epson	OMD 6020
Sony	RMO-S330, HS-D650

5.25" disk diameter

Asaca	AMD-1341NS
Canon	MO-5001S, OM-500D
Fujitsu	F6445A11, IFD1300A
Hewlett-Packard	C1113F
Hitachi	OD 101-1 (WORM), OD172 LIMDOW
Matsushita Electric Industrial	LF-7394, LF-5300 (WORM)
Maxoptix	T4-1300, T4-2600
Mountain Optech	CS-1000 M/F, RM-2000 M/F
NEC	N1137-57, ODD-160
Olympus	MOS525E, MOS540E
Pinnacle Micro	Vertex
Pioneer	DE-SH7101
Ricoh	RO-5060E
Sharp	JY 800, JY-750
Sierra Technologies	525GB+ (WORM)
Sony	RMO-S580, SMO-F541

All drives are rewritable unless otherwise indicated.

Two types of drives are included in this group: Write Once Read Many, (WORM) and Rewritable. Multifunction drives capable of using either rewritable or write-once media are considered rewritable drives for purposes of this report. This includes MO multifunction drives (MO-WORM or Continuous Composite WORM), certain phase change drives, and multifunction magneto-optic/ablative media drives.

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

Because capacities of optical drives have generally increased, this product group has been redefined to include drives with on-line capacities less than 2 gigabytes, rather than the one gigabyte range previously employed. Also note that CD format writable drives have been removed from this group and now have their own product group in the DISK/TREND Report.

Market status

1995 was another boring year for 5.25" drives in this group, but it was a lot more lively for 3.5" drives. Overall unit shipments saw a 5% increase from 672,100 units to 703,300 units, but almost all of the gain was in 3.5" drives. 5.25" drive shipments shrank from 190,400 units in 1994 to 184,800 in 1995, and would not have reached that level but for IBM's bargain rate closeout sale as it exited the optical drive business in 1995. Shipments of write-once drives have become statistically insignificant: Just about all reported sales were of rewritable drives. 3.5" drive shipments rose from 481,700 units in 1994 to 517,900 in 1995, a 7.5% gain. 3.5" optical disk drives would probably have done better if they were not competing with so many other technologies. Other causes of this group's mediocre showing include poor cost/performance trade-offs compared to high capacity magnetic disk drives such as the Iomega Zip drive, removable rigid disk cartridge drives and the 9 gigabyte 5.25" Seagate Elite 9, depressing sales of small optical libraries and single optical drive subsystems.

OEM demand remains small, with integrators and resellers moving most of the drives shipped. The Apple Macintosh add-on market, where there is less price sensitivity, remains the healthiest 3.5" market segment. Shipments of 3.5" drives remained strongest in Japan where the lack of networks (3.5" optical disks are frequently used for data exchange) and a relatively weak SyQuest presence in Japan also helped sustain strong demand for this product in that country.

Sony, Maxoptix, and Hewlett-Packard were the leading noncaptive producers of 5.25" drives in 1995, while Fujitsu again produced more 3.5" drives than all other 3.5" drive producers.

Worldwide sales revenues declined from $652.4 million in 1994 to $515.2 million in 1995, with declines for both 5.25" and 3.5" drives, due to 5.25" drive shipment declines and 3.5" drive price reductions. U.S. firms accounted for 39.2% of 1995 revenues, again reflecting a relatively weak market for 3.5" drives in the U.S.

Marketing trends

Rewritable 5.25" drives with capacities of over two gigabytes per side are expected to be available next year, and this will result in declining OEM shipments of 5.25" drives in this product group, beginning in 1997. Sales through distribution are expected to peak in 1997, as existing stocks of older drives are liquidated. Competition from magnetic disk drives, with both fixed and removable disks, offering low OEM and distribution pricing during future years will continue to contribute to the decline. The inability of the optical disk drive industry to match the 60% per year areal density growth rate of the magnetic disk drive industry will continue to hurt optical disk drive sales. Optical libraries have become increasingly significant in the application mix, with over 10% of the 5.25" drives in this class now going into libraries.

By late 1996, 3.5" drives with capacities of 640 megabytes or higher will be in production at several companies. These drives, if properly priced, may be attractive to OEMs and integrators. However, the 3.5" MO drive will be challenged by SyQuest's and Iomega's new families of 3.5" removable rigid disk cartridge gigabyte plus drives which will be available with higher capacity, very competitive prices and superior performance in the coming year. The PD drive, and later the CD-E drive and the DVD-RAM drive, will also compete in the same capacity segment of the market, probably with lower prices but also with inferior performance.

In May of 1991, Sony made a preliminary announcement of a 2.5" magneto-optic drive for the audio market, and followed up with a proposed standard for

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

1996 shipments of 703,300 units for the entire product group are expected to increase to over 1.4 million drives in 1999, based on anticipated growth in 3.5" optical disk drive shipments. Sales revenues for the group are actually expected to decline, falling from $545.5 million forecast for 1996 to $430 million in 1999, as a consequence of the predominance of lower priced 3.5" drives in the product mix.

Applications

5.25" write-once and rewritable optical drives under 2 gigabytes are used primarily to store images in office, medical, design, video editing, security and other specialized systems. When attached to file servers, often as an element of an optical library, the 5.25" drive may provide a second tier storage capability in a hierarchical storage subsystem. Users of magnetic disk drive arrays are displaying increasing interest in optical library subsystems operating with hierarchical storage management software for use in data and video servers.

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

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

Specific applications for drives in this product group include:

Save/restore operations

* Archival storage of files.

Temporary image and other file storage

* Storage of downloaded Internet files

* Image storage from security systems

Hierarchical storage systems

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

Document storage and processing

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

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

* Convenient storage of files related to a particular document.

Data distribution

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

Graphic presentation and multimedia

* Large files required for complex graphics, audio and video presentations.

* Editing of files with digital video or digital audio content.

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

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

3.5" drives are used to provide project oriented storage on a single volume,

and are often used 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.

Personal computers were again the largest application platform for this product group in 1995, accounting for 72.3% of the units shipped. The share attached to networks will decline as user interest shifts to higher capacity drives in the over 2 gigabyte range, resulting in slight share increases for personal computer and workstation attachment rates.

During the forecast period, about 15 to 20% of the production of 5.25" drives in this product group is expected to be used in optical library subsystems, such as those sold by Hewlett-Packard, Plasmon Data Systems, Sony and others. Only a small percentage of 3.5" drives will be installed in optical libraries.

Technical trends

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

Capacity: The capacity of 5.25" rewritable drives is expected to reach 2.6 gigabytes per side by late 1996 or early 1997. Similar improvements in write-once phase change technology are possible, though less certain. The increases will be due to a combination of factors, including improved optics and shorter laser wavelength permitting smaller spots and higher BPI and TPI, reduction of track pitch from 1.6 microns to 1.4 microns (about a 40% improvement), the adoption of pulse width modulation (100% improvement), zoned recording (about a 33% improvement), land and groove recording (50-100% improvement), and variable track pitch (about 40-50% improvement). If blue lasers become commercially available in 1999 from Nichia Chemical and other sources, small optical drives will be able to provide several gigabytes of capacity in a 3.5" form factor.

Changes in encoding methods might also modestly improve capacity. For drives dedicated to image storage, embedded data compression implemented in a single chip or small chip set should be feasible and advantageous. It is unlikely that all of these possibilities will be implemented on any one drive in the near term, but they are expected to be standard features of some drives. Some capacity improvement techniques, such as zoned recording, are used on current optical disk drives.

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, although more sophisticated drives capable of detecting media type could accommodate some degree of interchange. Because of the interchange problems, these methods have been displaced by the MO based CCW (Continuous Composite Worm) format.

Hewlett-Packard, Sony and several other drive and media companies offer CCW, a form of magneto-optic media which 5.25" drives can recognize and treat as write-once media by virtue of a prestamped pattern on the disk. This approach has the benefit of allowing erasable drives capable of recognizing the pattern to operate as multifunction drives. It has gradually become the dominant form of write-once recording on 5.25" drives in this product group.

Rewritability: There are several technologies contending for acceptance in rewritable optical media, but magneto-optic media is the most commonly used method capable of meeting user demands for sensitivity, erasability, and stability. The most challenging problem at present is the elimination of the need for a separate erase pass before writing. Technical problems and uncertainty about adequate yields for the complex media structures delayed wide use of direct MO overwrite until 1996, when MOST, Nikon and Hitachi began offering 5.25" drives using light intensity modulation to provide direct overwrite capability.

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

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

Phase change technology permits the interchange of write-once and erasable media on a single drive. It also provides direct overwrite capability and may permit simpler drive designs than for MO drives. Efforts to create specific standards for phase change media are in progress.

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

Media lifetime: While accelerated life tests indicate that media lifetimes of 10 years or more are achievable, this aspect of media performance remains unproven until actually demonstrated. Some suppliers are claiming in excess of 30 year lifetimes, but archivists remain concerned about media lifetime and whether future generations of drives will be compatible with today's media and recording formats.

Because organic recording layers such as dyes seem to have better corrosion resistance than the metal films typically used, they may eventually displace the original metal film types used for write-once recording. Whatever reservations may exist about the archival life of magnetic media, it is regarded as superior to magnetic tape in this respect as it requires no retensioning while in storage and is less subject to damage than magnetic tape.

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

Glass substrates are free of birefringence effects that distort the optical path, are nonpermeable to moisture, are flat, and distortion free. The flat glass surface, coupled with high purity materials, reduces defect levels, which has the advantage of reducing overall latency in the drive due to the reduced need to perform error correction during data reads. Glass also is less likely to deform at high spin rates, reducing runout and servo tracking difficulties. However, glass is denser than plastic, resulting in longer spin-up and spin-down times, a disadvantage when used in optical libraries and is also more costly than plastic substrates.

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' T3-1300, introduced in 1993, offers a seek time below 20 milliseconds. Newer 3.5" optical disk drives typically have average access times below 40 milliseconds due to their smaller size and shorter stroke lengths, with Olympus going under the 30 millisecond level. Increasing rotational speed has also helped to improve performance.

Long access times for optical disk drives are less significant when the drive is used in an automated library, because the disk exchange and

drive spin-up times are lengthy in comparison to the drive access time. Reduction of drive spin-up time is important when the drive is used in a library based system in order to minimize the length of the waiting-for-access queue. Spin-up times of 2 seconds or less are desirable. Plastic substrates have less mass than do glass substrates, so are preferable to minimize spin-up time, but are less likely to match glass for long archival life.

Erasable media requires slightly less write power than write-once media, an advantage which can be translated into higher rotation speeds for erasable drives. RPM has increased to 3,000-3,600 RPM for newer drive designs, and one, Fujitsu's 5.25" drive, operates at 5,400 RPM. Maxoptix, Pinnacle Micro and NEC also offer drives with RPM exceeding 3,600 RPM.

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

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

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

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

3.5" models fit the 41.3 mm profile, but difficulties in reducing the size of the optics have delayed development of smaller profile drives. Fujitsu is the first company to announce and ship a 25.4 mm high 3.5" drive, followed by a 17 millimeter drive in late 1995.

Drive producers are improving packaging and reducing costs through integration of logic functions into custom designed VLSI chips or using chip sets available from semiconductor companies for interface functions as well as by redesign of mechanical components.

Standards: ANSI X3B11, ECMA TC31, ISO TC91/SC23 are all involved in standardization programs for 5.25" and 3.5" media. ISO standards 9171-1 and 9171-2 cover write-once media in CCS and sampled servo formats. ISO international standards 10089 and 10090 cover rewritable 5.25" and 3.5" media respectively. ISO 11560 covers MO-WORM. The ANSI version does not cover the sampled servo format. The 5.25" rewritable cartridge borrows from the work done on the write-once standard, but the same conflicts on the track following servo that bedeviled the write-once standards caused enough conflict to delay the appearance of erasable 5.25" and 3.5" drive standards. Most 5.25" rewritable drives adhere to the CCS format, as do all the 3.5" drives formally announced to date.

Standards for 5.25" 650 megabyte per side media have been approved by ECMA (ECMA standard 184) and ISO as ISO 13549. Several companies, including IBM, Sony, Olympus, Hewlett-Packard and Maxoptix are supporting a downward compatible 1.3 gigabyte per side 5.25" media proposed standard, which is being addressed by the standards committees. A proposal for triple capacity media has been approved as ECMA 195 and ISO 13842. The standards for 230 megabyte 3.5" media are ECMA 201 and ISO 13963. Participants in the standards making process are taking advantage of "fast-track" procedures to release standards on a more timely basis than has been the prevailing pattern in the past.

The X3B11.1 technical subcommittee prepared a standard for a logical interchange format, now designated as ECMA 167 and ISO 13346. The format proposed is transparent to track following approach, operating system used, or whether the media is rewritable, write-once or read-only (OROM). This is an important standard, because, at present, media written on the same model drive but on different systems using different controllers and driver software could be incompatible. It does not cover sequential file organization of the type used in CD-ROM drives.

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

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

* Write-once disks require nonstandard file management utilities and drivers. File updates may result in degraded performance if files and directories are dispersed across the disk.

* Magneto-optical disks require modified system software to handle the overwrite requirement, or must have this function performed by the disk electronics or controller.

* File management functions in the computer operating system must be modified so that the optical disk appears to the operating system to be identical to a magnetic disk drive.

Competing Products: Strong competition for the 3.5" drives is provided by a range of products, including new gigabyte range rigid magnetic disk cartridge drives being delivered by Iomega and announced by SyQuest, at prices substantially under current prices for 3.5" MO drives. And fixed magnetic drives with gigabyte capacities are being advertised at retail prices in the $100 to $200 range as of mid-1996.

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

Forecasting assumptions

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

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

3. 600+ megabyte 3.5" optical disk drives will be in production from multiple major producers with shipments beginning in 1996.

TABLE 29

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	48.5	94.9	5.5	8.0	--	--	--	--	--	--
PCM/Distributor	44.2	69.7	34.2	52.9	28.0	47.6	24.3	41.9	15.6	27.3
OEM/Integrator	17.3	34.2	16.6	34.8	16.8	36.0	15.0	31.1	9.9	22.0
TOTAL U.S. REVENUES	110.0	198.8	56.3	95.7	44.8	83.6	39.3	73.0	25.5	49.3
Non-U.S. Manufacturers										
Captive	.3	32.9	--	33.6	--	32.2	--	31.2	--	21.6
PCM/Distributor	44.7	180.8	82.2	248.1	86.1	254.6	82.5	249.7	78.3	239.1
OEM/Integrator	47.0	102.7	72.6	168.1	71.3	158.5	60.7	143.3	47.0	120.0
TOTAL NON-U.S. REVENUES	92.0	316.4	154.8	449.8	157.4	445.3	143.2	424.2	125.3	380.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	202.0	515.2	211.1	545.5	202.2	528.9	182.5	497.2	150.8	430.0
OEM Average Price ($000)		.918		.746		.634		.519		.423

TABLE 30

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	25.2	52.2	2.6	3.8	--	--	--	--	--	--
PCM/Distributor	36.1	58.5	23.4	35.5	20.0	34.0	18.0	31.0	12.0	21.0
OEM/Integrator	13.8	31.9	12.4	26.4	14.0	30.0	13.0	27.0	9.0	20.0
TOTAL U.S. NONCAPTIVE	49.9	90.4	35.8	61.9	34.0	64.0	31.0	58.0	21.0	41.0
TOTAL U.S. SHIPMENTS	75.1	142.6	38.4	65.7	34.0	64.0	31.0	58.0	21.0	41.0
Non-U.S. Manufacturers										
Captive	.1	31.5	--	45.9	--	54.8	--	58.9	--	60.0
PCM/Distributor	109.4	412.0	228.2	717.3	271.0	871.0	289.0	941.5	307.0	998.0
OEM/Integrator	51.9	117.2	82.2	245.3	93.2	276.7	92.6	309.0	86.0	315.0
TOTAL NON-U.S. SHIPMENTS	161.4	560.7	310.4	1,008.5	364.2	1,202.5	381.6	1,309.4	393.0	1,373.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	236.5	703.3	348.8	1,074.2	398.2	1,266.5	412.6	1,367.4	414.0	1,414.0
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	1,105.7	2,746.5	1,454.5	3,820.7	1,852.7	5,087.2	2,265.3	6,454.6	2,679.3	7,868.6

TABLE 31

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues			Forecast							
				1996		1997		1998		1999	
	5.25"	3.5"	2.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS											
Captive	46.9	48.0	--	8.0	--	--	--	--	--	--	--
PCM/Distributor	59.6	10.1	--	52.9	--	47.6	--	41.9	--	27.3	--
OEM/Integrator	26.8	7.4	--	34.8	--	36.0	--	31.1	--	22.0	--
TOTAL U.S. REVENUES	133.3	65.5	--	95.7	--	83.6	--	73.0	--	49.3	--
NON-U.S. MANUFACTURERS											
Captive	22.9	10.0	--	13.3	20.3	11.0	21.2	9.2	22.0	--	21.6
PCM/Distributor	22.7	158.1	--	31.6	216.5	35.1	219.5	29.4	220.3	24.0	215.1
OEM/Integrator	82.8	19.5	.4	127.4	40.7	108.7	49.8	88.0	55.3	65.0	55.0
TOTAL NON-U.S. REVENUES	128.4	187.6	.4	172.3	277.5	154.8	290.5	126.6	297.6	89.0	291.7
WORLDWIDE RECAP											
Captive	69.8 +11.3%	58.0 +142.7%	-- --	21.3 -69.5%	20.3 -65.0%	11.0 -48.4%	21.2 +4.4%	9.2 -16.4%	22.0 +3.8%	-- --	21.6 -1.8%
PCM/Distributor	82.3 -44.7%	168.2 -31.2%	-- --	84.5 +2.7%	216.5 +28.7%	82.7 -2.1%	219.5 +1.4%	71.3 -13.8%	220.3 +.4%	51.3 -28.1%	215.1 -2.4%
OEM/Integrator	109.6 -11.1%	26.9 -54.0%	.4 -42.9%	162.2 +48.0%	40.7 +51.3%	144.7 -10.8%	49.8 +22.4%	119.1 -17.7%	55.3 +11.0%	87.0 -27.0%	55.0 -.5%
Total Revenues	261.7 -21.8%	253.1 -22.6%	.4 -42.9%	268.0 +2.4%	277.5 +9.6%	238.4 -11.0%	290.5 +4.7%	199.6 -16.3%	297.6 +2.4%	138.3 -30.7%	291.7 -2.0%
ANNUAL SHARE, BY DIAMETER	50.9%	49.1%	--	49.2%	50.8%	45.2%	54.8%	40.2%	59.8%	32.2%	67.8%

TABLE 32

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments			Forecast							
				1996		1997		1998		1999	
	5.25"	3.5"	2.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS											
Captive	20.2	32.0	--	3.8	--	--	--	--	--	--	--
PCM/Distributor	44.1	14.4	--	35.5	--	34.0	--	31.0	--	21.0	--
OEM/Integrator	19.5	12.4	--	26.4	--	30.0	--	27.0	--	20.0	--
TOTAL U.S. SHIPMENTS	83.8	58.8	--	65.7	--	64.0	--	58.0	--	41.0	--
NON-U.S. MANUFACTURERS											
Captive	11.5	20.0	--	5.9	40.0	4.8	50.0	3.9	55.0	--	60.0
PCM/Distributor	16.9	395.1	--	23.5	693.8	27.0	844.0	23.5	918.0	20.0	978.0
OEM/Integrator	72.6	44.0	.6	113.8	131.5	98.7	178.0	88.0	221.0	65.0	250.0
TOTAL NON-U.S. SHIPMENTS	101.0	459.1	.6	143.2	865.3	130.5	1,072.0	115.4	1,194.0	85.0	1,288.0
WORLDWIDE RECAP											
Captive	31.7	52.0	--	9.7	40.0	4.8	50.0	3.9	55.0	--	60.0
	+39.6%	+227.0%	--	-69.4%	-23.1%	-50.5%	+25.0%	-18.7%	+10.0%	--	+9.1%
PCM/Distributor	61.0	409.5	--	59.0	693.8	61.0	844.0	54.5	918.0	41.0	978.0
	-32.1%	+11.8%	--	-3.3%	+69.4%	+3.4%	+21.6%	-10.7%	+8.8%	-24.8%	+6.5%
OEM/Integrator	92.1	56.4	.6	140.2	131.5	128.7	178.0	115.0	221.0	85.0	250.0
	+14.1%	-43.4%	-45.5%	+52.2%	+133.2%	-8.2%	+35.4%	-10.6%	+24.2%	-26.1%	+13.1%
Total Shipments	184.8	517.9	.6	208.9	865.3	194.5	1,072.0	173.4	1,194.0	126.0	1,288.0
	-4.4%	+7.5%	-45.5%	+13.0%	+67.1%	-6.9%	+23.9%	-10.8%	+11.4%	-27.3%	+7.9%
ANNUAL SHARE, BY DIAMETER	26.3%	73.7%	--	19.4%	80.6%	15.4%	84.6%	12.7%	87.3%	8.9%	91.1%

TABLE 33

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	4.2	.6	4.2	.3
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	62.9	8.9	33.9	2.4
PERSONAL COMPUTERS				
Business and professional, single user	508.6	72.3	1,063.3	75.2
WORKSTATIONS				
Engineering and office, single user	105.6	15.0	246.0	17.4
CONSUMER, GAME AND HOBBY COMPUTERS	.4	.1	2.8	.2
OTHER APPLICATIONS	21.6	3.1	63.8	4.5
Total	703.3	100.0	1,414.0	100.0

TABLE 34

READ/WRITE OPTICAL DISK DRIVES, LESS THAN 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
Fujitsu	--	100.0	--	100.0	47.3	.2	342.0	--	342.2	55.2
Olympus Optical	12.6	12.8	--	25.4	12.0	19.6	77.0	--	96.6	15.6
Sony	27.0	4.0	--	31.0	14.7	46.0	20.1	.6	66.7	10.8
IBM	10.4	7.4	--	17.8	8.4	13.9	26.8	--	40.7	6.6
Maxoptix	18.0	--	--	18.0	8.5	27.0	--	--	27.0	4.4
Hewlett-Packard	14.1	--	--	14.1	6.7	22.7	--	--	22.7	3.7
Other U.S.	--	--	--	--	--	--	--	--	--	--
Other Non-U.S.	4.9	--	--	4.9	2.4	23.7	--	--	23.7	3.7
TOTAL	87.0	124.2	--	211.2	100.0	153.1	465.9	.6	619.6	100.0

READ/WRITE OPTICAL DISK DRIVES MORE THAN 2 GIGABYTES

1996 DISK/TREND REPORT

READ/WRITE OPTICAL DISK DRIVES MORE THAN 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

Eastman Kodak	System 2000

12" disk diameter

ATG Cygnet	GD6001, GD9001/S, GD16000
Hitachi	OD 321-1
NEC	N6513-23
Nikon	MO-DD121-1AJ (Rewritable)
Philips LMS	LD 4100, LD 6100
Sony	WDD 600, WDD 930-01, WDD-530

5.25" disk diameter

Pinnacle Micro	Apex (Rewritable)

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

This product group has been redefined to include drives with over 2 gigabytes of on-line capacity, reflecting increases in drive capacity levels, rather than the one gigabyte limit used in last year's report. The writable DVD format drives included in the equivalent section of last year's report have been moved to chapter DT-21, Writable CD Format Drives. High capacity optical disk drives are read/write drives, either write-once or rewritable. Most drives in this capacity range are 12" write-once types, although Nikon started shipments of a 12" rewritable drive in 1992. Eastman Kodak produces high capacity 14" drives as well. 5.25" drives will become participants in this product group in 1996, with the expected shipment of Pinnacle Micro's Apex 2.3 gigabyte per side rewritable drive late in the year. More 5.25" drives in this group are expected to be announced in late 1996.

12" and 14" drives in this product group are used primarily with networked minicomputers and mainframes in imaging, document storage, or archiving applications. They are often used in library devices that provide random access mass storage subsystems having hundreds of gigabytes of storage capacity. All

but two of the listed drives in this group use 12" media, and most access a single side of a disk. Philips LMS offers a drive that accesses both sides of the disk simultaneously. 12" optical libraries holding a single drive and fewer than 15 disks are also being used in departmental systems and small work groups.

Market status

1995 drive shipments in this group grew to 6,400 units, a 12.3% increase. The gain was due largely to improved 12" drive shipments, notably from Philips LMS. 1995 revenues declined slightly to $85.9 million, due to price declines. U.S. manufacturers accounted for 12.4% of worldwide sales revenues. 63.7% of worldwide revenue was generated in the U.S. market. 64.3% of 1995 revenues were produced by sales to OEMs and integrators, while 22.1% were from resale channels.

Almost 94% of 1995 unit shipments were produced by non-U.S. firms, about the same as in 1994. Over 64% of 1995 unit shipments went to the U.S. market, while 36% were sold in other parts of the world. 1995's leading noncaptive producers were Philips LMS, Sony and Hitachi.

Although there are relatively few manufacturers of drives in this product group, with the arrival of high capacity 5.25" drives, the number of producers will increase. Japanese firms were the first to enter this drive group because of early emphasis for use on systems capable of storing documents produced in Asian character sets. Of the Japanese firms, Sony and Hitachi have most aggressively pressed forward with improved designs and have benefited by remaining in the market while several other competitors have dropped out. In later years, Philips LMS was able to start ramping production of its double sided drive and increase its market presence.

Government and financial organizations continue as major markets for high capacity disk drives in this group, and system integrators continue to quote on orders of significant magnitude, usually involving optical libraries plus drives. Eastman Kodak's sales of optical drives to replace microfilm equipment for records management have also helped extend the available market. Lower cost 5.25" and, possibly, 12 centimeter drives will expand the market for this product group into general industry.

Marketing trends

Shipments of 12" and 14" drives are expected to increase gradually throughout the forecast period as a result of higher capacity drives becoming available. The first shipments of 5.25" drives in this group are expected to begin in late 1996 and are forecasted to eclipse shipments of 12" drives in 1997. 5.25" drives won't have the same capacity per media unit as the 12" drives, but their higher performance, much lower price, rewritability, multifunctionality and downward compatibility are expected to make them immediately popular. The competition from 5.25" drives may halt or reverse the tendency of 12" drive prices to climb each year. It is anticipated that the 5.25" drives in this product group will be rewritable or multifunction. Write-once drives are not expected to have a major impact because most customers will prefer the flexibility of multifunction rewritable drives and media. A consortium of drive and media producers is working towards an MO drive, approximately 5" in diameter, with targeted 6 to 7 gigabytes per side capacity that may become available during the forecast period. The drive will probably read CD-ROM and DVD-ROM media, but not existing 3.5" and 5.25" MO media. The potential availability of this drive is currently too uncertain to permit forecasting.

The largest change in this group will be the result of multigigabyte rewritable 2.6 gigabytes per side drives expected to be announced starting in late 1996. These drives will be inexpensive compared to the 12" and 14" drives in the group, causing the average OEM unit price to fall sharply during the forecast period. Of the over 171,000 drives in this product group expected to ship in 1999, 95% will be 5.25" drives.

1999 sales revenues are expected to reach almost $251 million, up from $85.9 million in 1995. The U.S. market is expected to continue to generate the majority of worldwide revenues for this product group, with U.S. firms' share of worldwide revenues improving to over 41% as a result of anticipated shipments of high capacity 5.25" drives by several U.S. producers. Most of the U.S. share will come from sales of 5.25" drives. 12" drive sales should be helped by expanding sales of small optical libraries with a single 12" drive, plus a new generation of higher capacity drives.

Average OEM drive prices for the group are expected to begin a sharp decline in 1996 due to the effect of 5.25" drives on the product mix. Prices for 12"

and 14" drives are expected to climb, however, as new higher capacity models enter the market, although competitive pressure from 5.25" drives may flatten the rate of increase. A major acceleration in the rate of price decline is expected in 1997 as 5.25" drive shipments in this group ramp up.

Applications

In 1995, networks and multiuser systems were the major application for drives in this group, accounting for nearly two thirds of the units shipped. The majority of these drives were installed in optical libraries. Libraries attached to mainframes used enough drives to account for 13.6% of group shipments. With the arrival of 5.25" drives in this group, the pattern will change drastically, with personal computer applications expected to capture over 60% of the 1999 total, with workstations and networks accounting for nearly 16% each.

Currently, major applications for optical disk drives over 2 gigabytes capacity include records management, medical, geophysical, military or industrial imaging, and storage of transaction documents required for future reference. Almost all of these applications are archival in nature and favor the use of write-once optical disk technology. As 5.25" and 12" MO drives increasingly participate in this product group, archival applications may become less dominant, although many of the 5.25" drives may be used for archiving personal files, as will the newly proposed 5" MO drives if they actually materialize on schedule in 1997, as some potential suppliers have suggested.

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

Typical usage includes:

Engineering and manufacturing systems

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

* Document storage and dissemination for construction projects.

Records management

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

Save/restore operations

* Disk backup.
* Archival storage.
* Hierarchical storage.

Office automation

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

Transaction audit trails

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

Data acquisition

* Capture of data from scanners, seismic detectors or other imaging devices.
* Capture of data having military or intelligence significance.

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

In 1995, over 90% of the 12", 14" and 5.25" drives shipped in this group were attached to optical libraries, but library attachment is expected to gradually decline as 5.25" drives (which are less likely to be used with libraries) form a greater part of the total.

Automated library systems using large capacity drives usually have two or more drives to improve overall response time, although the single drive, five cartridge Philips LMS library is a notable exception. The number of drives per large library is expected to increase with time, especially for the 5.25" drives, so that at the end of the forecast period the typical library will average between three and four drives installed, which will help sustain the optical disk drive market.

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

Large capacity optical disk drives will continue to be employed in dedicated departmental systems that store and manipulate engineering drawings, technical specifications and reference materials. These smaller systems will need smaller library units to meet departmental needs.

12" stand-alone drive applications are being attacked by 5.25" diameter drives used with library units of 10-20 disk capacity and, in some cases, by large capacity 5.25" magnetic rigid disk drives with capacities of 9 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 is limiting growth prospects for 12" systems, and this situation will be further aggravated by the expected arrival of 2.6 gigabyte 5.25" drives in 1996 and 1997.

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

Technical trends

Many of the technical issues discussed in the section on optical disk drives under 2 gigabytes capacity also apply to the larger capacity drives in this section. The issues are reviewed here as they pertain specifically to the higher capacity drives.

Performance: Almost all of the 12" products in this group currently use complex optical head assemblies, resulting in excessive head positioning times. This is of less consequence when the drive is used in a library subsystem, because of the time required to locate, mount, and spin-up the disk to operating speed. Considerable work is being done by manufacturers to reduce drive complexity and to improve access time. Although it will probably be another year or two before all head positioning times are below 100 milliseconds, Philips LMS and ATG Cygnet have already broken the 100 millisecond barrier for 12" drives, and 5.25" drives in this group are expected to be largely sub-30 millisecond seek time devices. 5.25" drives will probably offer substantially higher rotation rates as a group than the 12" drives, and already have much shorter average zaccess times.

The 2.6 gigabytes per side 5.25" drives to be introduced will probably use zoned recording with PRML, 630 to 680 nanometer lasers and the CCS track format. Data transfer rates in the 10 megabyte per second range are anticipated.

Standards: Because various manufacturer's 12" product designs are already established and incompatible, standardization for 12" drives has been limited. ECMA 190 and ISO 13403 apply to the 12" CCS format, while ECMA 189 and ISO 13614 apply to the 12" sampled servo format. ISO standard 10885 for 14" media (which affects only the Eastman Kodak drive) has also been completed. In any event, the continuous servo versus sampled servo conflict yet remains, and there is no standard for 12" rewritable media.

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

System design: Many large capacity optical disk storage systems will incorporate an automated library. Several firms, including ATG Cygnet, FileNet, Philips LMS, Hitachi and others have designed libraries, discovering in the process that it is a major project, requiring substantial time and investment. To be a generally applicable product, the library may have to accommodate several brands of disk drives, an awkward consideration given the weak product standardization in the industry. The library unit also has to be interfaced to the computer system with which it is to be used, requiring significant development time. The drives themselves must be designed to withstand thousands of cartridge insertions without failure and must accommodate library control and signaling functions. By virtue of Hewlett-Packard's strong position in the library industry, its library interface definition is becoming a de facto standard.

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

Capacity: Capacity per disk is increasing through the use of zoned recording and data compression techniques. The family of 12" drives that started its introduction cycle in late 1994 offers over 7 to 10 gigabytes per side, much improved from a typical capacity of 1 gigabyte per side in earlier models. Eastman Kodak's 14" drive uses disks with over 7.4 gigabytes per side and is also expected to further upgrade capacity. Several 12" drive models now have dual heads, making the entire capacity of the cartridge available without the need to flip the disk.

Rewritability: In 1992, Nikon started shipments of a rewritable 12" drive and media, but no other firms have yet indicated definite intentions to offer

a production drive. Media yields for large diameter rewritable media are projected to be low by media suppliers, so media is likely to be scarce and expensive. Consequently, shipments are likely to be modest until media is available and the technology has matured to the point that customers and manufacturers feel confident. On the other hand, 5.25" drives in this group will most often be rewritable drives.

Packaging: The 12" optical disk drives typically have a rack mount configuration. Because these drives are often used with library devices, there is a need to adhere to a standardized mechanical interface that will permit any drive to be used with any library load/unload mechanism. The 12" form factor was the most frequently encountered drive size in this product group during 1994, but in 1997 and thereafter 5.25" drives are expected to predominate.

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

Interface: SCSI is the most commonly encountered interface on large capacity 12" and 5.25" optical drives. SCSI is likely to remain the preferred choice because of design commitments, or until drives with higher performance are technically possible. For many drives, proprietary interfaces are used at the device level, but the desire of manufacturers to sell drive/library combinations attachable to a variety of host systems favors the SCSI interface. For drives to be sold to manufacturers of optical disk libraries, the use of the SCSI interface is a necessity.

Lasers: The larger size of 12" optical disk drives favors the use of head assemblies with multiple lasers. The use of multiple lasers can improve drive performance by permitting direct read during write, higher bit densities, use of unusual active layer material, and possibly other benefits. If head designs that separate the laser from the head optics are adopted to reduce mass, it may also be possible to use nonsemiconductor lasers and still achieve reasonable performance.

Because nonsemiconductor lasers can operate at higher frequencies and powers, very high performance may be possible by using them in optical storage systems. However, cost and reliability will have to be traded for performance in such designs. Short wavelength semiconductor lasers

being developed by IBM, Nichia Chemical and others probably have more applicability.

Media: Larger diameter media requires substrates that will not deform at high rotation rates and will maintain consistent optical properties over the usable area of the disk. The latter point is especially significant for magneto-optical media in which distortion caused by locked-in or dynamic stresses in the substrate creates signal degradation. These mechanical problems may be a significant obstacle to improving the performance of high capacity optical drives. The considerations for 5.25" media are much the same as in the low capacity drive group.

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

Substrates: Both plastic and glass are in use for 12" media substrates, and Eastman Kodak is using an aluminum substrate for its 14" drive. Because of the difficulty in molding large diameter plastic substrates with adequately low birefringence, it seems likely that glass will retain a prominent role in the fabrication of readily producible erasable media for large diameter drives. 5.25" media for this product group will also use both glass and plastic, while 12 centimeter media will use only plastic substrates.

Forecasting assumptions

1. 5.25" optical disk drives will be major participants in this product group after 1996.
2. There will continue to be an adequate supply of media for drives and components in this product group.
3. There will be no generally accepted single standard for 12" drives and media through 1999.
4. Rewritable 12" drives and media will have only marginal impact.

TABLE 35

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	3.5	3.5	3.0	6.0	3.3	6.6	2.8	8.4	4.8	9.6
PCM/Distributor	4.8	7.2	4.5	9.0	5.4	10.1	8.8	14.1	17.8	31.6
OEM/Integrator	--	--	.2	.4	2.4	4.0	12.5	20.6	32.4	61.9
TOTAL U.S. REVENUES	8.3	10.7	7.7	15.4	11.1	20.7	24.1	43.1	55.0	103.1
Non-U.S. Manufacturers										
Captive	1.9	8.2	2.0	8.4	2.5	11.3	2.3	13.4	2.2	14.5
PCM/Distributor	7.3	11.8	9.0	15.2	12.4	20.6	16.0	31.8	21.8	43.4
OEM/Integrator	37.2	55.2	38.9	57.6	43.4	64.7	51.8	80.5	56.0	89.9
TOTAL NON-U.S. REVENUES	46.4	75.2	49.9	81.2	58.3	96.6	70.1	125.7	80.0	147.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	54.7	85.9	57.6	96.6	69.4	117.3	94.2	168.8	135.0	250.9
OEM Average Price ($000)		11.500		10.943		5.367		2.101		1.306

TABLE 36

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	.1	.1	.1	.2	.1	.2	.1	.3	.2	.4
PCM/Distributor	.2	.3	.3	.6	1.7	2.7	4.3	6.5	16.3	29.5
OEM/Integrator	--	--	.2	.5	3.0	5.0	16.4	27.0	45.0	86.0
TOTAL U.S. SHIPMENTS	.3	.4	.6	1.3	4.8	7.9	20.8	33.8	61.5	115.9
Non-U.S. Manufacturers										
Captive	.1	.4	.1	.4	.1	1.0	.1	2.6	.1	3.6
PCM/Distributor	.5	.8	.6	1.0	1.2	2.1	3.9	11.5	9.1	21.9
OEM/Integrator	3.2	4.8	3.2	4.8	4.3	7.8	10.9	21.1	13.6	30.2
TOTAL NON-U.S. SHIPMENTS	3.8	6.0	3.9	6.2	5.6	10.9	14.9	35.2	22.8	55.7
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	4.1	6.4	4.5	7.5	10.4	18.8	35.7	69.0	84.3	171.6
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	44.5	92.8	49.0	100.3	59.4	119.1	95.1	188.1	179.4	359.7

TABLE 37

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues	Forecast							
		1996		1997		1998		1999	
	12"-14"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"
U.S. MANUFACTURERS									
Captive	3.5	6.0	--	6.6	--	8.4	--	9.6	--
PCM/Distributor	7.2	8.8	.2	8.0	2.1	9.0	5.1	7.8	23.8
OEM/Integrator	--	--	.4	--	4.0	--	20.6	--	61.9
TOTAL U.S. REVENUES	10.7	14.8	.6	14.6	6.1	17.4	25.7	17.4	85.7
NON-U.S. MANUFACTURERS									
Captive	8.2	8.4	--	10.0	1.3	9.2	4.2	8.7	5.8
PCM/Distributor	11.8	15.2	--	19.6	1.0	21.2	10.6	25.2	18.2
OEM/Integrator	55.2	57.6	--	61.5	3.2	65.3	15.2	68.6	21.3
TOTAL NON-U.S. REVENUES	75.2	81.2	--	91.1	5.5	95.7	30.0	102.5	45.3
WORLDWIDE RECAP									
Captive	11.7 +27.2%	14.4 +23.1%	-- --	16.6 +15.3%	1.3 --	17.6 +6.0%	4.2 +223.1%	18.3 +4.0%	5.8 +38.1%
PCM/Distributor	19.0 +62.4%	24.0 +26.3%	.2 --	27.6 +15.0%	3.1 --	30.2 +9.4%	15.7 +406.5%	33.0 +9.3%	42.0 +167.5%
OEM/Integrator	55.2 -22.0%	57.6 +4.3%	.4 --	61.5 +6.8%	7.2 --	65.3 +6.2%	35.8 +397.2%	68.6 +5.1%	83.2 +132.4%
Total Revenues	85.9 -6.3%	96.0 +11.8%	.6 --	105.7 +10.1%	11.6 --	113.1 +7.0%	55.7 +380.2%	119.9 +6.0%	131.0 +135.2%
ANNUAL SHARE, BY DIAMETER	100.0%	99.5%	.5%	90.2%	9.8%	67.1%	32.9%	47.8%	52.2%

TABLE 38

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments	Forecast							
		1996		1997		1998		1999	
	12"-14"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"	12"-14"	5.25"
U.S. MANUFACTURERS									
Captive	.1	.2	--	.2	--	.3	--	.4	--
PCM/Distributor	.3	.4	.2	.4	2.3	.5	6.0	.5	29.0
OEM/Integrator	--	--	.5	--	5.0	--	27.0	--	86.0
TOTAL U.S. SHIPMENTS	.4	.6	.7	.6	7.3	.8	33.0	.9	115.0
NON-U.S. MANUFACTURERS									
Captive	.4	.4	--	.4	.6	.4	2.2	.4	3.2
PCM/Distributor	.8	1.0	--	1.3	.8	1.5	10.0	1.9	20.0
OEM/Integrator	4.8	4.8	--	4.8	3.0	5.1	16.0	5.2	25.0
TOTAL NON-U.S. SHIPMENTS	6.0	6.2	--	6.5	4.4	7.0	28.2	7.5	48.2
WORLDWIDE RECAP									
Captive	.5 +25.0%	.6 +20.0%	-- --	.6 --	.6 --	.7 +16.7%	2.2 +266.7%	.8 +14.3%	3.2 +45.5%
PCM/Distributor	1.1 +57.1%	1.4 +27.3%	.2 --	1.7 +21.4%	3.1 --	2.0 +17.6%	16.0 +416.1%	2.4 +20.0%	49.0 +206.3%
OEM/Integrator	4.8 +4.3%	4.8 --	.5 --	4.8 --	8.0 --	5.1 +6.3%	43.0 +437.5%	5.2 +2.0%	111.0 +158.1%
Total Shipments	6.4 +12.3%	6.8 +6.3%	.7 --	7.1 +4.4%	11.7 --	7.8 +9.9%	61.2 +423.1%	8.4 +7.7%	163.2 +166.7%
ANNUAL SHARE, BY DIAMETER	100.0%	90.8%	9.2%	37.8%	62.2%	11.3%	88.7%	4.9%	95.1%

TABLE 39

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1995		Forecast									
	--Shipments--		-----1996----		-----1997----		-----1998----		-----1999----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	.1		.2		.2		.3		.4	
Write-Once	.1	100.0%	.2	100.0%	.2	100.0%	.3	100.0%	.4	100.0%
Noncaptive Total	.3		1.1		7.7		33.5		115.5	
Write-Once	.3	100.0%	.4	36.4%	.4	5.2%	.5	1.5%	.5	.4%
Rewritable	--	--	.7	63.6%	7.3	94.8%	33.0	98.5%	115.0	99.6%
Total U.S.	.4		1.3		7.9		33.8		115.9	
Write-Once	.4	100.0%	.6	46.2%	.6	7.6%	.8	2.4%	.9	.8%
Rewritable	--	--	.7	53.8%	7.3	92.4%	33.0	97.6%	115.0	99.2%
NON-U.S. MANUFACTURERS										
Captive Total	.4		.4		1.0		2.6		3.6	
Write-Once	.4	100.0%	.4	100.0%	.4	40.0%	.4	15.4%	.4	11.1%
Rewritable	--	--	--	--	.6	60.0%	2.2	84.6%	3.2	88.9%
Noncaptive Total	5.6		5.8		9.9		32.6		52.1	
Write-Once	5.6	100.0%	5.8	100.0%	6.1	61.6%	6.6	20.2%	7.1	13.6%
Rewritable	--	--	--	--	3.8	38.4%	26.0	79.8%	45.0	86.4%
Total Non-U.S.	6.0		6.2		10.9		35.2		55.7	
Write-Once	6.0	100.0%	6.2	100.0%	6.5	59.6%	7.0	19.9%	7.5	13.5%
Rewritable	--	--	--	--	4.4	40.4%	28.2	80.1%	48.2	86.5%
WORLDWIDE RECAP										
Total Worldwide Shipments	6.4		7.5		18.8		69.0		171.6	
	+12.3%		+17.2%		+150.7%		+267.0%		+148.7%	
Write-Once	6.4	100.0%	6.8	90.7%	7.1	37.8%	7.8	11.3%	8.4	4.9%
	+12.3%		+6.3%		+4.4%		+9.9%		+7.7%	
Rewritable	--	--	.7	9.3%	11.7	62.2%	61.2	88.7%	163.2	95.1%
	--		--		--		+423.1%		+166.7%	

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

TABLE 40

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	.4	6.9	12.2	7.1
MAINFRAME SYSTEMS				
General purpose	.9	13.6	1.9	1.1
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	4.2	65.7	26.8	15.6
PERSONAL COMPUTERS				
Business and professional, single user	--	.5	103.1	60.1
WORKSTATIONS				
Engineering and office, single user	.7	10.7	27.1	15.8
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.2	2.6	.5	.3
Total	6.4	100.0	171.6	100.0

TABLE 41

READ/WRITE OPTICAL DISK DRIVES, MORE THAN 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 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	1.2	--	1.2	30.8	1.9	--	1.9	32.2
Sony	1.3	--	1.3	33.3	1.6	--	1.6	27.1
Hitachi	.9	--	.9	23.1	1.5	--	1.5	25.4
Other U.S.	.2	--	.2	5.1	.3	--	.3	5.1
Other Non-U.S.	.3	--	.3	7.7	.6	--	.6	10.2
TOTAL	3.9	--	3.9	100.0	5.9	--	5.9	100.0

CD FORMAT OPTICAL DISK LIBRARIES

1996 DISK/TREND REPORT

CD FORMAT OPTICAL DISK LIBRARIES

Coverage

Examples of optical disk libraries in this group include:

12 centimeter (4.72") disk diameter

Alps Electric	4x4 Changer
ASM	CDR 40, CDR 1400
Borett Automation Technologies	MMAS (CD)
CD International	CDJ2800, CDJ2801
DISC	D300, D600, D1050-2
DSM	CD60, CD-62, CDR-74
Dynatek Automation	infiniDISC
Eastman Kodak	CD-ADL 150
Hyundai	HAS-550
K&S	CDJ-30, CDJ-M200, MCD-35
Kubik Enterprises	CDR240M, CD Tower
Matsushita Electric Industrial	SQ-TC500N, LF-J50A, LF-J100A
Nakamichi	MJ-4.4, MJ-4.6, MJ-4.8S
NEC	CDR-C302, CDR-4300
Nippon Columbia	DRD-1400
Nistec	ALW-501
NSM	CDR-100, Mercury-40
Optomedia Engineering	Hawk
Pioneer	DRM624X, DRM 1804X, DRM5004X
Regal Electronics	CDC-4X
Sanyo	CDR-C3G
Sony	CDL 2100, CDL 2200
TiltRac	M3C, M6C
Todd Enterprises	TAJ-2000

CD-ROM format optical disk libraries incorporate CD-ROM drives, DVD-ROM drives, CD-E/R 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 that hold from 3 to 6 disks and fit into a half-high slot.

Market status

There are now 24 CD-ROM format library manufacturers, up from 19 last year. Nakamichi, Sanyo and Pioneer were the largest producers, collectively

accounting for over 98% of the units shipped. Other firms shipped libraries that ranged from the 16,000+ disk version of Borett Automation, to the Regal Electronics unit with an integrated drive and up to 5 disks in a half high 5.25" form factor, the design for which is derived from a multidisk CD audio player.

ASM, NSM, DSM, DISC, Todd Enterprises, Pioneer, TiltRac and Dynatek Automation have all announced libraries with 100 disk or greater capacity, with NSM achieving the highest shipment volume in this category in 1995. Matsushita has announced 50 and 100 disk libraries incorporating its PD drive. The most elaborate library in this class is produced by Borett Automation Technologies and uses an industrial robot. It is a variant of a design developed to handle other forms of media, and requires each disk to be in a caddy. Several other companies are using karaoke system libraries to which have been added appropriate controller logic and software support.

Over 337,000 units were shipped in 1995, primarily as a result of Nakamichi's entry into the market with a low cost, 4 disk, internally mounted half-high autochanger. Non-U.S. suppliers had nearly 99% of the market, although more U.S. suppliers may appear in the future. 46.9% of the units were shipped to the U.S., a decline from 64% in 1994, due to shipments of small autochangers to Asian PC manufacturers. The low cost autochangers negatively impacted sales of 10 to 100 disk units, which were displaced by multiple 1 to 5 disk units at lower cost.

1995 worldwide sales revenues nearly doubled to $90 million, largely as a result of large shipments of small autochangers by Nakamichi and Sanyo and continued growth for Pioneer and NSM. The average OEM price in the product group dropped sharply under the stimulus of the added low end shipments.

Over 98% of the 1995 units shipped held fewer than 10 disks, 1.1% had from 10 to 100 disks, and .7% of the units shipped used over 100 disks. However, only 50.3% of the revenues for the group came from the under 10 disk segment, while the 10-100 and over 100 disk segments accounted for 10.3% and 39.4%, respectively. The revenue share of the under 10 disk segment is expected to grow slightly over the next few years to about 60%. Competition from CD-towers is expected to limit growth in the 10 to 100 disk segment.

The smaller CD-ROM libraries compete against server or network attached CD-ROM towers which typically contain 4 to 7 drives, although 14, 21 and 28

drive configurations are frequently encountered. While DISK/TREND has not formally surveyed shipments of CD-ROM towers, 1996 unit shipments are estimated to be about 150,000 systems, half of them direct network attached and half attached to servers via SCSI controllers.

Marketing trends

1999 revenues are expected to increase to $271.5 million in 1999, less than anticipated earlier because of quickly decreasing prices for small autochangers. Over 1.5 million libraries in this product group are expected to be shipped in 1999, with over 99% of them small autochangers for personal computers and small servers. 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 a "mere" annual 25% by the end of the forecast period. The market will continue to favor libraries with fewer than 10 disks or more than 100 disks. In 1999, 59.7% of revenues are expected to come from libraries with fewer than 10 disks, while 89.5% are anticipated from libraries with over 100 disks. Only 7.4% is forecasted for libraries with 10 to 100 disks, and most of that is expected from products at the upper end of the capacity range. DVD drives will help to keep this segment active towards the end of the forecast period.

As a result of the adoption of small autochangers by personal computer manufacturers, sales through distribution will dip in 1996 as add-on units are displaced by factory installations. Sales through distribution are expected to recover somewhat in 1997 and following years as some users replace individual CD-ROM drives with autochangers.

The number of competitors and the complexity of the solutions offered are both expected to increase, in order to serve network users interested in adding CD-ROM capability to their networks. The majority of computer manufacturers now include CD-ROM capability with their file servers, increasing the opportunity for upgrades to a library subsystem.

Applications

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

end CD-ROM format libraries have applications in large institutional libraries and in organizations that must provide network access to large amounts of documentation for many users located at diverse sites. Low-end libraries, such as the Pioneer and Nakamichi units, are used primarily with single-user computers and workstations or with servers in small networks with low transaction rates.

Certain users of CD-ROM data bases that normally span more than one disk find the low-end CD-ROM format libraries particularly convenient. Legal case records, citations and regulatory material often fit this pattern, as do CD-ROM records of archival material such as patent records. Other beneficiaries of low-end libraries could be users of large clip art files or large numbers of maps, and analysts wishing to keep large collections of historical financial data readily available.

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

Technical trends

CD-ROM format disk library technology is derived from other well established product designs. The typical CD-ROM format library is an adaptation of an audio player/changer, but a few models derive from high performance 5.25" library designs, notably from DSM, DISC and Borett Automation. Kubik's rotary carousel design is innovative and provides a relatively high storage density. Interfaces are standard RS-232 or SCSI variants. Library designs derived from audio or karaoke systems usually don't do well as server attached libraries because performance is slow, MSBF is low and the ratio of drives to media units is too low, resulting in undesirably long waiting times after data is requested. Features normally found in read/write optical libraries are starting to migrate into the CD-ROM library arena. Faster exchange times, hard drive buffering, filtered air, and hot swap capability all are anticipated features in newer products.

Typical CD-ROM drives are not engineered to withstand the physical stresses of thousands of disk insertions and ejections in a short period of time. The same deficiency may exist in libraries derived from audio designs, which are typically designed to favor cost considerations over long-term reliability with high exchange rates. Some current CD-ROM disk load/eject mechanism designs require modification so that the drive can be used in a library.

There is some competition for CD-ROM format libraries from configurations of multiple CD-ROM drives (CD towers), usually attached to file servers or directly to networks, that can provide multiple disk availability or offer multiple user access to the same disk with minimal delay. However, multiple copies of an application may be needed to serve all users adequately. Where only one or a few disks need to be used by a work group, this may be a favored approach. Manufacturers include Procom, Logicraft, Microtest, Meridian Data, Micro Design Ornetix, Compact Devices and a number of other producers.

Forecasting assumptions

1. CD-ROM format library unit shipments will continue to be dominated by low cost, low performance devices, but revenues will increasingly reflect shipments of higher capacity designs.
2. Non-U.S. suppliers will continue to dominate the CD-ROM format library market. U.S. firms will concentrate upon lower volume, higher capacity and higher performance designs.
3. There will be no significant changes in library technology impacting CD-ROM libraries over the period of the forecast, but direct network attached CD-ROM towers are expected to become stronger competitors in the 10 to 100 disk segment.
4. Additional competitors will appear in the low-end library market, resulting in price competition that will spur unit shipments.

TABLE 42

CD FORMAT OPTICAL LIBRARIES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	.7	.9	3.1	4.0	4.7	6.0	6.4	8.2	8.2	10.5
OEM/Integrator	8.7	11.2	10.3	13.7	11.6	15.6	13.0	17.7	13.9	19.1
TOTAL U.S. REVENUES	9.4	12.1	13.4	17.7	16.3	21.6	19.4	25.9	22.1	29.6
Non-U.S. Manufacturers										
PCM/Distributor	21.5	30.9	17.8	26.7	22.4	32.1	26.9	38.4	31.2	45.0
OEM/Integrator	25.9	47.0	58.7	85.2	87.8	120.4	118.1	158.5	148.9	196.9
TOTAL NON-U.S. REVENUES	47.4	77.9	76.5	111.9	110.2	152.5	145.0	196.9	180.1	241.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	56.8	90.0	89.9	129.6	126.5	174.1	164.4	222.8	202.2	271.5
OEM Average Price ($000)		.204		.157		.148		.146		.143

TABLE 43

CD FORMAT OPTICAL LIBRARIES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	1,496	1,995	8,550	11,160	12,080	15,694	16,310	21,330	20,540	26,966
OEM/Integrator	446	588	2,070	2,763	2,690	3,630	3,410	4,700	3,930	5,570
TOTAL U.S. SHIPMENTS	1,942	2,583	10,620	13,923	14,770	19,324	19,720	26,030	24,470	32,536
Non-U.S. Manufacturers										
PCM/Distributor	36,450	49,240	7,955	11,935	9,200	13,760	10,350	15,500	11,500	17,310
OEM/Integrator	119,717	285,217	441,305	625,265	691,180	912,950	943,880	1,206,170	1,204,590	1,507,400
TOTAL NON-U.S. SHIPMENTS	156,167	334,457	449,260	637,200	700,380	926,710	954,230	1,221,670	1,216,090	1,524,710
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	158,109	337,040	459,880	651,123	715,150	946,034	973,950	1,247,700	1,240,560	1,557,246
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	226	439	686	1,090	1,401	2,036	2,375	3,284	3,616	4,841

TABLE 44

CD FORMAT OPTICAL LIBRARIES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY LIBRARY SIZE

	1995 Revenues			Forecast											
	1996			1997			1998			1999					
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
PCM/Distributor	.5	--	.4	3.3	--	.7	4.7	--	1.3	6.4	--	1.8	8.0	--	2.5
OEM/Integrator	--	--	11.2	.5	--	13.2	.8	--	14.8	1.1	--	16.6	1.3	--	17.8
TOTAL U.S. REVENUES	.5	--	11.6	3.8	--	13.9	5.5	--	16.1	7.5	--	18.4	9.3	--	20.3
NON-U.S. MANUFACTURERS															
PCM/Distributor	13.2	6.2	11.5	2.2	9.6	14.9	2.5	10.3	19.3	2.6	11.4	24.4	2.6	12.4	30.0
OEM/Integrator	31.5	3.1	12.4	63.2	3.8	18.2	90.8	4.6	25.0	120.0	6.0	32.5	150.0	7.7	39.2
TOTAL NON-U.S. REVENUES	44.7	9.3	23.9	65.4	13.4	33.1	93.3	14.9	44.3	122.6	17.4	56.9	152.6	20.1	69.2
WORLDWIDE RECAP															
PCM/Distributor	13.7	6.2	11.9	5.5	9.6	15.6	7.2	10.3	20.6	9.0	11.4	26.2	10.6	12.4	32.5
	-17.0%	-28.7%	+466.7%	-59.9%	+54.8%	+31.1%	+30.9%	+7.3%	+32.1%	+25.0%	+10.7%	+27.2%	+17.8%	+8.8%	+24.0%
OEM/Integrator	31.5	3.1	23.6	63.7	3.8	31.4	91.6	4.6	39.8	121.1	6.0	49.1	151.3	7.7	57.0
	+668.3%	-32.6%	+214.7%	+102.2%	+22.6%	+33.1%	+43.8%	+21.1%	+26.8%	+32.2%	+30.4%	+23.4%	+24.9%	+28.3%	+16.1%
Total Revenues	45.2	9.3	35.5	69.2	13.4	47.0	98.8	14.9	60.4	130.1	17.4	75.3	161.9	20.1	89.5
	+119.4%	-30.1%	+269.8%	+53.1%	+44.1%	+32.4%	+42.8%	+11.2%	+28.5%	+31.7%	+16.8%	+24.7%	+24.4%	+15.5%	+18.9%
ANNUAL SHARE	50.3%	10.3%	39.4%	53.5%	10.3%	36.2%	56.8%	8.6%	34.6%	58.5%	7.8%	33.7%	59.7%	7.4%	32.9%

Note: Headings define number of disks stored per library.

TABLE 45

CD FORMAT OPTICAL LIBRARIES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY LIBRARY SIZE

	1995 Shipments			Forecast											
				1996			1997			1998			1999		
	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100	<10	10-100	>100
U.S. MANUFACTURERS															
PCM/Distributor	1,968	--	27	11,100	--	60	15,600	--	94	21,200	--	130	26,800	--	166
OEM/Integrator	--	--	588	2,003	--	760	2,700	--	930	3,600	--	1,100	4,300	--	1,270
TOTAL U.S. SHIPMENTS	1,968	--	615	13,103	--	820	18,300	--	1,024	24,800	--	1,230	31,100	--	1,436
NON-U.S. MANUFACTURERS															
PCM/Distributor	46,140	2,030	1,070	8,000	2,260	1,675	9,000	2,500	2,260	9,800	2,730	2,970	10,600	2,960	3,750
OEM/Integrator	282,430	1,625	1,162	621,400	1,720	2,145	908,000	1,830	3,120	1,200,000	2,000	4,170	1,500,000	2,180	5,220
TOTAL NON-U.S. SHIPMENTS	328,570	3,655	2,232	629,400	3,980	3,820	917,000	4,330	5,380	1,209,800	4,730	7,140	1,510,600	5,140	8,970
WORLDWIDE RECAP															
PCM/Distributor	48,108	2,030	1,097	19,100	2,260	1,735	24,600	2,500	2,354	31,000	2,730	3,100	37,400	2,960	3,916
	+47.7%	-49.9%	+345.9%	-60.3%	+11.3%	+58.2%	+28.8%	+10.6%	+35.7%	+26.0%	+9.2%	+31.7%	+20.6%	+8.4%	+26.3%
OEM/Integrator	282,430	1,625	1,750	623,403	1,720	2,905	910,700	1,830	4,050	1,203,600	2,000	5,270	1,504,300	2,180	6,490
	--	-5.2%	+133.6%	+120.7%	+5.8%	+66.0%	+46.1%	+6.4%	+39.4%	+32.2%	+9.3%	+30.1%	+25.0%	+9.0%	+23.1%
Total Shipments	330,538	3,655	2,847	642,503	3,980	4,640	935,300	4,330	6,404	1,234,600	4,730	8,370	1,541,700	5,140	10,406
	+618.7%	-36.6%	+186.1%	+94.4%	+8.9%	+63.0%	+45.6%	+8.8%	+38.0%	+32.0%	+9.2%	+30.7%	+24.9%	+8.7%	+24.3%
ANNUAL SHARE	98.2%	1.1%	.7%	98.8%	.6%	.6%	99.0%	.5%	.5%	99.1%	.4%	.5%	99.1%	.3%	.6%

Note: Headings define number of disks stored per library.

READ/WRITE OPTICAL DISK LIBRARIES 1-20 CARTRIDGES

1996 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
1 - 39 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

3.5" disk diameter

Fujitsu	M2531A, M2532B1
PFU	MC700A, MC700B

5.25" disk diameter

DSM	4000
Fujitsu	M2522/AX
Hewlett-Packard	C1100A/B, C1713T, 40fx, 80fx
IBM	3995-043, 3995-063
K&S	Megastore 1000
Matsushita Electric Industrial	LF-J7322, LF-J7330
NEC	N1137-06, N1137-58, OL5120
Nikkyo	NOL-102, NOL-161, NOL-322
Plasmon Data Systems	RF26J-695, RF20J-695
Sony	OSL 2001

12" disk diameter

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

5.25" optical libraries remain predominant in this product group. The first 3.5" optical libraries in the group were announced by IBM and IDE (now Plasmon Data Systems), but only mechanisms from Fujitsu (PFU uses the Fujitsu mechanism) are available as of mid-1996. The libraries in this group include both tabletop and deskside types, as well as conventional rack mounted units. They are used with workstations, high end personal computers and in local area networks.

Also included is the Philips LMS library, which incorporates a dual head optical drive, enabling 16% of its 72 gigabyte capacity to be on-line at all times. Drives included in libraries of this group are either write-once or rewritable for 5.25" types, but 12" types are still limited to write-once drives. Although the first 12" rewritable drive (from Nikon) has gone into production, it is currently available only in larger optical libraries.

Market status

Unit shipments made a minimal gain of .4% in 1995, to 12,799 units, as manufacturers in this product group struggled against competition from high capacity 5.25" magnetic rigid disk drives capable of storing up to 9 gigabytes at selling prices only a fraction of optical library prices. Sales revenues for the product group were even more severely impacted in 1995, falling 17.3% to $83.7 million. 51.9% of 1995 revenues and 59.4% of 1995 shipments were generated by U.S. manufacturers, notably Hewlett-Packard, whose unit share of the market exceeded 57% in this product group's total. Philips LMS was again the dominant 12" library supplier. 62.8% of unit shipments were made to U.S. destinations, an increase from 1994, as a result of generally lower prices in the U.S. market.

Hewlett-Packard retained its commanding lead in unit shipments within the product group, again followed by Plasmon Data Systems and Philips LMS.

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 are expected to become more attractive after 1996 as more 640+ megabyte 3.5" drives become available.

Marketing trends

Unit shipments are forecasted to grow to 17,642 units in 1999, and total revenues will increase to $111.7 million, a significant reduction from previous forecasts. Shipments at the low capacity end of this product group will be increasingly impacted in the future by magnetic disk drives such as 5.25" drives capable of storing as much as 23 gigabytes per spindle, and 3.5" drives whose capacities are expected to move above the 10 gigabyte per spindle range within the forecast period. This product group will also see future competition from libraries employing the PD drive and DVD-RAM drives.

OEMs and system integrators are expected to account for 48% of 1999 unit shipments, while 39% will be through PCM/Resellers. 5.25" shipments, which were 69.3% of the 1995 total shipments, are expected to decline moderately over the forecast period under pressure from 3.5" libraries using higher capacity drives. 12" autochangers in this product group held a 26.6% share in 1995, and

this share, driven by anticipated higher capacity products from Philips LMS, is expected to increase moderately to about 38% in 1999. Manufacturers with facilities in Japan and Europe are expected to suffer the consequences of a continuing weak U.S. dollar, and are not expected to make significant inroads on U.S.-based manufacturers. Of 1999's total worldwide sales revenues, nearly 46% are expected to be generated by U.S. manufacturers. About 60% of the worldwide library revenues in this group are expected to be generated in the U.S. market in 1999.

As a result of competition from high capacity rigid disk drives, such as the Seagate 23 gigabyte Elite model, future libraries in this group will move to the upper end of the cartridge capacity spectrum. Libraries with fewer than 10 cartridges are gone, and the arrival of the Elite 23 will only accelerate this trend. Another consequence is the reversal of a declining average price trend in this product group. OEM prices will tend to decline slightly with time despite increasing capability in order to compete with high capacity magnetic disk drives. A second consequence is that the sales channel will become increasingly OEM dominated, as the PCM/Distributor channel handled most of the now discontinued low end libraries.

Applications

Optical libraries with single drives, regardless of diameter, are being used in stand-alone applications where their relatively low price and limited storage capacities are appropriate. Multidrive libraries are more likely to be used in multiuser or networked systems where response time to an inquiry is a critical parameter and the cost is shared among a number of system users.

The Philips LMS, Sony and ATG Cygnet 12" libraries occupy the middle ground: While moderately priced, they provide on-line capacity so large (especially the dual head Philips design) that throughput may frequently be better than that of multidrive 5.25" units. In cases where rewritable media is not required, the small 12" library may displace some 5.25" libraries in both single user and multiuser systems. The small 12" libraries, the only write-once libraries in this product group, are expected to sustain moderate growth throughout the forecast period.

Technical trends

For the time being, most libraries in this product group will continue to use 5.25" or 12" drives and media. Eventual introduction of libraries using the 12 centimeter PD drive is a possibility. 3.5" libraries will use the 600+ megabyte drives expected to be in production starting in late 1995, but 3.5" libraries, offering much less capacity than 5.25" libraries, and limited further by single sided recording, will be viewed as relatively unattractive. They may have some appeal as automated disk writers for software duplication where production requirements are nominal, but specialized equipment for this purpose is already in the market. The major competition to this product group comes from high capacity rigid magnetic disk drives such as the Seagate Elite 23, which offer the capacity of a small optical library at a lower price and with better performance, and from libraries based upon PD drives and DVD-RAM drives when they become available in 1998.

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

The use of advanced components such as optical position sensors, optical position encoders and nonvolatile semiconductor memory for controller functions is improving reliability. Some libraries will perform several hundred thousand cartridge exchanges between failures. It is not unusual for library manufacturers to require drive suppliers to make drives specified to withstand over 300,000 cartridge insertions, in order to achieve adequate system reliability.

Forecasting assumptions

1. A relatively strong yen will continue to favor U.S.-based manufacturers.
2. The 5.25" format will remain the most commonly used, but it will receive increasing competition from 12" and 3.5" libraries.
3. There are no significant changes in anticipated technology affecting libraries over the period of the forecast, but drive capacity improvements will favor the growth of 5.25" libraries over 12" libraries.
4. Significant competition for the 5.25" and 3.5" libraries in this group will come from libraries incorporating PD drives and DVD-RAM drives.
5. The availability of higher capacity optical drives will tend to increase the growth rate of the upper end of this product group.

TABLE 46

OPTICAL LIBRARIES, 1-39 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	6.1	8.7	7.3	10.4	7.9	11.2	8.0	11.3	8.0	11.2
PCM/Distributor	13.3	19.0	13.8	19.7	14.0	20.1	13.7	20.1	13.5	20.3
OEM/Integrator	11.0	15.7	11.6	16.6	13.0	18.5	12.9	19.3	13.3	19.5
TOTAL U.S. REVENUES	30.4	43.4	32.7	46.7	34.9	49.8	34.6	50.7	34.8	51.0
Non-U.S. Manufacturers										
Captive	.2	6.2	.2	3.9	.2	2.9	.2	2.6	.3	2.8
PCM/Distributor	6.9	13.1	7.4	14.3	9.0	15.9	10.5	18.8	11.9	21.1
OEM/Integrator	13.1	21.0	14.9	24.9	16.1	29.2	18.4	32.6	20.5	36.8
TOTAL NON-U.S. REVENUES	20.2	40.3	22.5	43.1	25.3	48.0	29.1	54.0	32.7	60.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	50.6	83.7	55.2	89.8	60.2	97.8	63.7	104.7	67.5	111.7
OEM Average Price ($000)		7.017		6.771		6.722		6.624		6.560

TABLE 47

OPTICAL LIBRARIES, 1-39 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	784	1,120	878	1,254	982	1,399	1,030	1,450	1,060	1,485
PCM/Distributor	2,289	3,270	2,564	3,664	2,802	4,023	2,920	4,290	2,990	4,500
OEM/Integrator	2,246	3,209	2,515	3,595	2,820	4,000	2,832	4,250	3,018	4,432
TOTAL U.S. SHIPMENTS	5,319	7,599	5,957	8,513	6,604	9,422	6,782	9,990	7,068	10,417
Non-U.S. Manufacturers										
Captive	7	371	7	271	8	214	10	192	12	184
PCM/Distributor	1,752	2,808	1,738	2,837	1,730	2,715	1,730	2,854	1,736	2,891
OEM/Integrator	956	2,021	1,171	2,534	1,251	3,096	1,712	3,585	1,946	4,150
TOTAL NON-U.S. SHIPMENTS	2,715	5,200	2,916	5,642	2,989	6,025	3,452	6,631	3,694	7,225
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	8,034	12,799	8,873	14,155	9,593	15,447	10,234	16,621	10,762	17,642
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	30	50	39	64	49	79	59	96	70	114

TABLE 48

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues			Forecast											
	1996			1997			1998			1999					
	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"
U.S. MANUFACTURERS															
Captive	--	8.7	--	--	10.4	--	--	11.2	--	--	11.3	--	--	11.2	--
PCM/Distributor	--	19.0	--	--	19.7	--	--	20.1	--	--	20.1	--	--	20.3	--
OEM/Integrator	--	15.7	--	--	16.6	--	--	18.5	--	--	19.3	--	--	19.5	--
TOTAL U.S. REVENUES	--	43.4	--	--	46.7	--	--	49.8	--	--	50.7	--	--	51.0	--
NON-U.S. MANUFACTURERS															
Captive	.4	5.8	--	.4	3.5	--	.4	2.5	--	.4	2.2	--	.6	2.2	--
PCM/Distributor	4.7	5.9	2.5	6.6	5.0	2.7	8.1	5.0	2.8	10.1	5.7	3.0	12.0	6.0	3.1
OEM/Integrator	17.2	2.8	1.0	20.1	3.2	1.6	23.5	3.1	2.6	26.2	3.1	3.3	29.6	3.5	3.7
TOTAL NON-U.S. REVENUES	22.3	14.5	3.5	27.1	11.7	4.3	32.0	10.6	5.4	36.7	11.0	6.3	42.2	11.7	6.8
WORLDWIDE RECAP															
Captive	.4	14.5	--	.4	13.9	--	.4	13.7	--	.4	13.5	--	.6	13.4	--
	-71.4%	-24.9%	--	--	-4.1%	--	--	-1.4%	--	--	-1.5%	--	+50.0%	-.7%	--
PCM/Distributor	4.7	24.9	2.5	6.6	24.7	2.7	8.1	25.1	2.8	10.1	25.8	3.0	12.0	26.3	3.1
	-62.1%	+31.1%	--	+40.4%	-.8%	+8.0%	+22.7%	+1.6%	+3.7%	+24.7%	+2.8%	+7.1%	+18.8%	+1.9%	+3.3%
OEM/Integrator	17.2	18.5	1.0	20.1	19.8	1.6	23.5	21.6	2.6	26.2	22.4	3.3	29.6	23.0	3.7
	-25.9%	-28.8%	--	+16.9%	+7.0%	+60.0%	+16.9%	+9.1%	+62.5%	+11.5%	+3.7%	+26.9%	+13.0%	+2.7%	+12.1%
Total Revenues	22.3	57.9	3.5	27.1	58.4	4.3	32.0	60.4	5.4	36.7	61.7	6.3	42.2	62.7	6.8
	-39.7%	-10.0%	--	+21.5%	+.9%	+22.9%	+18.1%	+3.4%	+25.6%	+14.7%	+2.2%	+16.7%	+15.0%	+1.6%	+7.9%
ANNUAL SHARE, BY DIAMETER	26.6%	69.3%	4.1%	30.2%	65.1%	4.7%	32.7%	61.9%	5.4%	35.2%	58.9%	5.9%	37.9%	56.1%	6.0%

TABLE 49

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments			Forecast											
	1996			1997			1998			1999					
	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"	12-14"	5.25"	3.5"
U.S. MANUFACTURERS															
Captive	--	1,120	--	--	1,254	--	--	1,399	--	--	1,450	--	--	1,485	--
PCM/Distributor	--	3,270	--	--	3,664	--	--	4,023	--	--	4,290	--	--	4,500	--
OEM/Integrator	--	3,209	--	--	3,595	--	--	4,000	--	--	4,250	--	--	4,432	--
TOTAL U.S. SHIPMENTS	--	7,599	--	--	8,513	--	--	9,422	--	--	9,990	--	--	10,417	--
NON-U.S. MANUFACTURERS															
Captive	11	360	--	11	260	--	13	201	--	15	177	--	17	167	--
PCM/Distributor	218	2,300	290	311	2,216	310	385	2,000	330	464	2,040	350	521	2,000	370
OEM/Integrator	770	925	326	913	1,041	580	1,070	1,161	865	1,235	1,195	1,155	1,410	1,400	1,340
TOTAL NON-U.S. SHIPMENTS	999	3,585	616	1,235	3,517	890	1,468	3,362	1,195	1,714	3,412	1,505	1,948	3,567	1,710
WORLDWIDE RECAP															
Captive	11	1,480	--	11	1,514	--	13	1,600	--	15	1,627	--	17	1,652	--
	-69.4%	-.8%	--	--	+2.3%	--	+18.2%	+5.7%	--	+15.4%	+1.7%	--	+13.3%	+1.5%	--
PCM/Distributor	218	5,570	290	311	5,880	310	385	6,023	330	464	6,330	350	521	6,500	370
	-65.7%	+34.5%	--	+42.7%	+5.6%	+6.9%	+23.8%	+2.4%	+6.5%	+20.5%	+5.1%	+6.1%	+12.3%	+2.7%	+5.7%
OEM/Integrator	770	4,134	326	913	4,636	580	1,070	5,161	865	1,235	5,445	1,155	1,410	5,832	1,340
	-42.6%	-18.8%	--	+18.6%	+12.1%	+77.9%	+17.2%	+11.3%	+49.1%	+15.4%	+5.5%	+33.5%	+14.2%	+7.1%	+16.0%
Total Shipments	999	11,184	616	1,235	12,030	890	1,468	12,784	1,195	1,714	13,402	1,505	1,948	13,984	1,710
	-50.4%	+4.3%	--	+23.6%	+7.6%	+44.5%	+18.9%	+6.3%	+34.3%	+16.8%	+4.8%	+25.9%	+13.7%	+4.3%	+13.6%
ANNUAL SHARE, BY DIAMETER	7.8%	87.5%	4.7%	8.7%	85.1%	6.2%	9.5%	82.9%	7.6%	10.3%	80.7%	9.0%	11.0%	79.4%	9.6%

TABLE 50

OPTICAL LIBRARIES, 1-39 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1995 --Shipments--		Forecast 1996		1997		1998		1999	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	1,120.0		1,254.0		1,399.0		1,450.0		1,485.0	
Rewritable	1,120.0	100.0%	1,254.0	100.0%	1,399.0	100.0%	1,450.0	100.0%	1,485.0	100.0%
Noncaptive Total	6,479.0		7,259.0		8,023.0		8,540.0		8,932.0	
Rewritable	6,479.0	100.0%	7,259.0	100.0%	8,023.0	100.0%	8,540.0	100.0%	8,932.0	100.0%
Total U.S.	7,599.0		8,513.0		9,422.0		9,990.0		10,417.0	
Rewritable	7,599.0	100.0%	8,513.0	100.0%	9,422.0	100.0%	9,990.0	100.0%	10,417.0	100.0%
NON-U.S. MANUFACTURERS										
Captive Total	371.0		271.0		214.0		192.0		184.0	
Write-Once	11.0	3.0%	11.0	4.1%	13.0	6.1%	15.0	7.8%	17.0	9.2%
Rewritable	360.0	97.0%	260.0	95.9%	201.0	93.9%	177.0	92.2%	167.0	90.8%
Noncaptive Total	4,829.0		5,371.0		5,811.0		6,439.0		7,041.0	
Write-Once	988.0	20.5%	1,224.0	22.8%	1,455.0	25.0%	1,699.0	26.4%	1,931.0	27.4%
Rewritable	3,841.0	79.5%	4,147.0	77.2%	4,356.0	75.0%	4,740.0	73.6%	5,110.0	72.6%
Total Non-U.S.	5,200.0		5,642.0		6,025.0		6,631.0		7,225.0	
Write-Once	999.0	19.2%	1,235.0	21.9%	1,468.0	24.4%	1,714.0	25.8%	1,948.0	27.0%
Rewritable	4,201.0	80.8%	4,407.0	78.1%	4,557.0	75.6%	4,917.0	74.2%	5,277.0	73.0%
WORLDWIDE RECAP										
Total Worldwide Shipments	12,799.0		14,155.0		15,447.0		16,621.0		17,642.0	
	+.5%		+10.6%		+9.1%		+7.6%		+6.1%	
Write-Once	999.0	7.8%	1,235.0	8.7%	1,468.0	9.5%	1,714.0	10.3%	1,948.0	11.0%
	-60.1%		+23.6%		+18.9%		+16.8%		+13.7%	
Rewritable	11,800.0	92.2%	12,920.0	91.3%	13,979.0	90.5%	14,907.0	89.7%	15,694.0	89.0%
	+15.4%		+9.5%		+8.2%		+6.6%		+5.3%	

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

READ/WRITE OPTICAL DISK LIBRARIES, 40-69 CARTRIDGES

1996 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
40 - 69 CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Hewlett-Packard	160fx, C1162C
Hitachi	OL152-48, OL172-48
Matsushita Electric Industrial	LF-J7360A, LF-J7350A
NEC	N7925-83, N7925-84, N5817-31/32
Nikkyo	NOL-642, NOL-604
Plasmon Data Systems	M52J-695
Sony	OSL 6000-21, OSL 6000-41

12" disk diameter

DSM	48
FileNet	OSAR 50 GTL
Hitachi	OL321-22/32

The libraries in this group are mainstream products for classical library uses in imaging and archiving systems, frequently attached to network platforms. The 12" models are frequently used in multiuser and networked systems because of their ability to keep large amounts of data accessible in minimal time. The 5.25" libraries are often found in networked systems also, but many are being used in freestanding document image filing systems used for general office purposes and for technical documentation.

Market status

1995 optical library shipments in this product group were 1,632 units worldwide, a 9.1% drop. Shipments again declined relative to the previous year because of customer preferences for either larger or smaller 5.25" libraries. However, capacity increases in 12" drives caused 12" libraries shipments in this group to expand, diverting shipments from the "Greater than 70 cartridge group", because fewer cartridges are needed to hold the required amount of data. Sales revenues declined only 3.2%, to $27.3 million, reflecting declining shipments but a higher proportion of higher priced 12" libraries in the mix.

Shipments of 5.25" units still greatly exceeded shipments of 12" units, capturing 91.9% of the worldwide total. The U.S. market accounted for 49.6% of unit shipments and 38.1% of revenues, as a result of U.S. preferences for 5.25" libraries, a factor heavily influenced by the strong position of 5.25" library producers Plasmon Data Systems and Hewlett-Packard in the U.S. market. 12" libraries, only 8.1% of unit shipments in 1995, generated over 25% of product group revenues as a result of their higher price tags.

Plasmon Data Systems was 1995's leading supplier in the product group, followed by Hewlett-Packard and Hitachi. Hewlett-Packard, which began shipping a 64 disk library in 1995, is expected to challenge Plasmon for leadership in this group in future periods.

Marketing trends

Moderate growth is projected for this product group, resulting in unit shipments of 2,914 in 1999. Shipments of 12" libraries are expected to grow faster than shipments of 5.25" libraries, although from a much smaller base, capturing 11.1% of shipments in 1999. While it is possible that higher capacity 5.25" drives will eventually shift preferences to this product group from the "Greater than 70 cartridge group", as was the case for 12" libraries, no significant evidence for this has yet developed. Still, it is a possibility worth watching, as 5.2 gigabytes per cartridge drives appear in 1997.

1999 unit shipments to the U.S. are expected to represent 54.4% of total worldwide unit shipments, reflecting an increasing degree of interest in hierarchical storage management in the U.S., which typically makes use of 5.25" libraries of various sizes. The U.S. market is forecasted to produce 49.5% of revenues in 1999.

Applications

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

companies, large construction firms and geophysical exploration and production firms.

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

A considerable percentage of the 5.25" optical disk libraries in this product group are used in technical design environments where they serve an engineering design team. Few libraries in this category will be used with personal computers, because they are too expensive for most installations and the amount of data stored is more than a single user could reasonably use. Single-site video-on-demand library systems may become a future market for some of the larger libraries in this product group, serving as an adjunct to magnetic disk based video servers.

Technical trends

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

There may be some competition for conventional optical disk 5.25" libraries in this group from libraries incorporating PD drives. Because PD drive performance is relatively slow, such competition would be most effective where small servers and small workgroups are involved. Because the PD price is low relative to 5.25" MO drives, an equivalently priced PD based library could have more drives, hence more data actively available at any given time, and could compete in performance effectively in a limited number of situations that did not require much disk swapping.

Specialized internal controllers will be increasingly replaced by personal computer processors packaged for the application. The basic electronic modules of a personal computer are fast enough and powerful enough to perform the necessary functions, costs are low, and excellent software tools are available. Computer based controllers permitting the direct attachment of an optical library to a local area network are a result of the shift to computer based controllers.

Forecasting assumptions

1. Archival applications will continue to favor 12" write-once drives and media. Other applications will favor 5.25" rewritable or multifunction drive based optical libraries.
2. There are no immediate expectations in this product group for libraries using formats other than 12" and 5.25" formats.
3. There will be no fundamental changes in technology affecting this group of libraries over the period of the forecast, although pickers capable of handling several types of media within one library are anticipated.
4. The higher capacity drives entering the market in 1996 and 1997 may restimulate customer interest for products in this group, resulting in new growth after a period of flat sales.
5. Competition from PD or DVD-RAM based libraries will have only minor impact on shipments of libraries in this group.

TABLE 51

OPTICAL LIBRARIES, 40-69 CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	2.4	3.5	7.1	10.0	8.6	12.9	9.9	14.8	11.1	16.9
PCM/Distributor	1.6	2.3	1.7	2.4	1.8	2.6	1.8	2.6	1.9	2.8
OEM/Integrator	1.4	2.0	1.5	2.2	1.6	2.4	1.7	2.7	1.8	2.9
TOTAL U.S. REVENUES	5.4	7.8	10.3	14.6	12.0	17.9	13.4	20.1	14.8	22.6
Non-U.S. Manufacturers										
Captive	--	5.6	--	5.7	--	6.7	--	7.9	--	9.1
PCM/Distributor	2.0	4.1	2.3	4.1	3.7	5.7	4.2	6.2	4.7	6.7
OEM/Integrator	3.0	9.8	3.5	10.8	5.6	12.2	6.4	13.9	7.0	15.1
TOTAL NON-U.S. REVENUES	5.0	19.5	5.8	20.6	9.3	24.6	10.6	28.0	11.7	30.9
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	10.4	27.3	16.1	35.2	21.3	42.5	24.0	48.1	26.5	53.5
OEM Average Price ($000)		16.905		15.588		14.792		14.225		13.423

TABLE 52

OPTICAL LIBRARIES, 40-69 CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	51	74	95	135	112	166	128	190	141	211
PCM/Distributor	110	157	120	172	131	188	138	202	150	218
OEM/Integrator	108	154	115	168	125	188	136	212	148	236
TOTAL U.S. SHIPMENTS	269	385	330	475	368	542	402	604	439	665
Non-U.S. Manufacturers										
Captive	--	167	--	175	--	199	--	226	--	253
PCM/Distributor	302	536	380	620	460	707	544	801	623	891
OEM/Integrator	238	544	305	666	373	799	448	955	524	1,105
TOTAL NON-U.S. SHIPMENTS	540	1,247	685	1,461	833	1,705	992	1,982	1,147	2,249
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	809	1,632	1,015	1,936	1,201	2,247	1,394	2,586	1,586	2,914
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	6	13	7	15	8	17	10	19	11	22

TABLE 53

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues		Forecast							
			1996		1997		1998		1999	
	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS										
Captive	2.5	1.0	8.8	1.2	11.6	1.3	13.4	1.4	15.4	1.5
PCM/Distributor	--	2.3	--	2.4	--	2.6	--	2.6	--	2.8
OEM/Integrator	--	2.0	--	2.2	--	2.4	--	2.7	--	2.9
TOTAL U.S. REVENUES	2.5	5.3	8.8	5.8	11.6	6.3	13.4	6.7	15.4	7.2
NON-U.S. MANUFACTURERS										
Captive	1.9	3.7	1.7	4.0	2.0	4.7	2.4	5.5	3.0	6.1
PCM/Distributor	--	4.1	--	4.1	--	5.7	--	6.2	--	6.7
OEM/Integrator	2.5	7.3	2.6	8.2	3.2	9.0	3.9	10.0	4.6	10.5
TOTAL NON-U.S. REVENUES	4.4	15.1	4.3	16.3	5.2	19.4	6.3	21.7	7.6	23.3
WORLDWIDE RECAP										
Captive	4.4 +51.7%	4.7 +56.7%	10.5 +138.6%	5.2 +10.6%	13.6 +29.5%	6.0 +15.4%	15.8 +16.2%	6.9 +15.0%	18.4 +16.5%	7.6 +10.1%
PCM/Distributor	-- --	6.4 -22.0%	-- --	6.5 +1.6%	-- --	8.3 +27.7%	-- --	8.8 +6.0%	-- --	9.5 +8.0%
OEM/Integrator	2.5 +108.3%	9.3 -27.9%	2.6 +4.0%	10.4 +11.8%	3.2 +23.1%	11.4 +9.6%	3.9 +21.9%	12.7 +11.4%	4.6 +17.9%	13.4 +5.5%
Total Revenues	6.9 +68.3%	20.4 -15.4%	13.1 +89.9%	22.1 +8.3%	16.8 +28.2%	25.7 +16.3%	19.7 +17.3%	28.4 +10.5%	23.0 +16.8%	30.5 +7.4%
ANNUAL SHARE, BY DIAMETER	25.3%	74.7%	37.3%	62.7%	39.6%	60.4%	41.1%	58.9%	43.1%	56.9%

TABLE 54

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"	12-14"	5.25"
U.S. MANUFACTURERS										
Captive	21	53	70	65	89	77	101	89	110	101
PCM/Distributor	--	157	--	172	--	188	--	202	--	218
OEM/Integrator	--	154	--	168	--	188	--	212	--	236
TOTAL U.S. SHIPMENTS	21	364	70	405	89	453	101	503	110	555
NON-U.S. MANUFACTURERS										
Captive	37	130	35	140	41	158	50	176	62	191
PCM/Distributor	--	536	--	620	--	707	--	801	--	891
OEM/Integrator	74	470	86	580	106	693	127	828	150	955
TOTAL NON-U.S. SHIPMENTS	111	1,136	121	1,340	147	1,558	177	1,805	212	2,037
WORLDWIDE RECAP										
Captive	58	183	105	205	130	235	151	265	172	292
	+11.5%	+36.6%	+81.0%	+12.0%	+23.8%	+14.6%	+16.2%	+12.8%	+13.9%	+10.2%
PCM/Distributor	--	693	--	792	--	895	--	1,003	--	1,109
	--	-6.9%	--	+14.3%	--	+13.0%	--	+12.1%	--	+10.6%
OEM/Integrator	74	624	86	748	106	881	127	1,040	150	1,191
	+146.7%	-28.4%	+16.2%	+19.9%	+23.3%	+17.8%	+19.8%	+18.0%	+18.1%	+14.5%
Total Shipments	132	1,500	191	1,745	236	2,011	278	2,308	322	2,592
	+61.0%	-14.3%	+44.7%	+16.3%	+23.6%	+15.2%	+17.8%	+14.8%	+15.8%	+12.3%
ANNUAL SHARE, BY DIAMETER	8.1%	91.9%	9.9%	90.1%	10.5%	89.5%	10.8%	89.2%	11.1%	88.9%

TABLE 55

OPTICAL LIBRARIES, 40-69 CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1995		Forecast							
	--Shipments--		-----1996----		-----1997----		-----1998----		-----1999----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	74.0		135.0		166.0		190.0		211.0	
Write-Once	21.0	28.4%	70.0	51.9%	89.0	53.6%	101.0	53.2%	110.0	52.1%
Rewritable	53.0	71.6%	65.0	48.1%	77.0	46.4%	89.0	46.8%	101.0	47.9%
Noncaptive Total	311.0		340.0		376.0		414.0		454.0	
Rewritable	311.0	100.0%	340.0	100.0%	376.0	100.0%	414.0	100.0%	454.0	100.0%
Total U.S.	385.0		475.0		542.0		604.0		665.0	
Write-Once	21.0	5.5%	70.0	14.7%	89.0	16.4%	101.0	16.7%	110.0	16.5%
Rewritable	364.0	94.5%	405.0	85.3%	453.0	83.6%	503.0	83.3%	555.0	83.5%
NON-U.S. MANUFACTURERS										
Captive Total	167.0		175.0		199.0		226.0		253.0	
Write-Once	37.0	22.2%	35.0	20.0%	41.0	20.6%	50.0	22.1%	62.0	24.5%
Rewritable	130.0	77.8%	140.0	80.0%	158.0	79.4%	176.0	77.9%	191.0	75.5%
Noncaptive Total	1,080.0		1,286.0		1,506.0		1,756.0		1,996.0	
Write-Once	74.0	6.9%	86.0	6.7%	106.0	7.0%	127.0	7.2%	150.0	7.5%
Rewritable	1,006.0	93.1%	1,200.0	93.3%	1,400.0	93.0%	1,629.0	92.8%	1,846.0	92.5%
Total Non-U.S.	1,247.0		1,461.0		1,705.0		1,982.0		2,249.0	
Write-Once	111.0	8.9%	121.0	8.3%	147.0	8.6%	177.0	8.9%	212.0	9.4%
Rewritable	1,136.0	91.1%	1,340.0	91.7%	1,558.0	91.4%	1,805.0	91.1%	2,037.0	90.6%
WORLDWIDE RECAP										
Total Worldwide Shipments	1,632.0		1,936.0		2,247.0		2,586.0		2,914.0	
	-10.8%		+18.6%		+16.1%		+15.1%		+12.7%	
Write-Once	132.0	8.1%	191.0	9.9%	236.0	10.5%	278.0	10.8%	322.0	11.1%
	+1.5%		+44.7%		+23.6%		+17.8%		+15.8%	
Rewritable	1,500.0	91.9%	1,745.0	90.1%	2,011.0	89.5%	2,308.0	89.3%	2,592.0	89.0%
	-11.8%		+16.3%		+15.2%		+14.8%		+12.3%	

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

READ/WRITE OPTICAL DISK LIBRARIES. 70 OR MORE CARTRIDGES

1996 DISK/TREND REPORT

READ/WRITE OPTICAL DISK LIBRARIES
70 OR MORE CARTRIDGES

Coverage

Examples of optical disk libraries in this group include:

5.25" disk diameter

Asaca	ADL-450
Borett Automation Technology	MMAS (5.25")
DISC	D255U, D510-2, D1050-2
DSM	5300, 7100
EMASS	AML/J
Fujitsu	F6445/A1, F6445/A2, F6445/A2X2
Hewlett-Packard	C1705T, 300st, 600fx
IBM	3995-143, 3995-163
K&S	Megastore
Kubik Enterprises	MO-120
Matsushita Electric	LF-J73120, LF-J73330
Plasmon Data Systems	M104J-695, M156J-695, M285J-695E

12" and 14" disk diameter

ATG Cygnet	1800
Borett Automation Technology	MMAS (12")
DSM	100-2000
Eastman Kodak	2000 ADL+, 2000E
FileNet	Model 0150, Model 0140
Sony	WDA-E930, WDA-E550

This group was pioneered by manufacturers of 12" libraries, which are typically used in large systems that manage image files for a complete business or major government department. FileNet started the 12" activity in this product group in 1985, but 5.25" libraries are now the majority component of this group, with over 10 manufacturers in production.

Market status

Unit shipments again grew strongly in 1995, jumping 48.2% to 4,069 optical libraries. Shipments of 5.25" libraries rose 68.3% to 3,522 units, while shipments in the 12" to 14" segment fell 16.6% to 547 units. The reasons for the decline include a shift in momentum to the 40 to 69 cartridge group, as increasing capacity of the disk drives allows users to store their data with fewer cartridges, percep-

tion that the 5.25" segment has stronger standards and that interchange is more universal, and favorable economics for 5.25" libraries relative to 12" libraries. Worldwide sales revenues for 1995 advanced 10.8% to $146.1 million, with gains registered for 5.25" libraries and declines for the 12" to 14" segment. 54.3% of this product group's revenues were generated from sales in the United States, and 59.6% of worldwide revenues were generated by U.S. manufacturers, down significantly from 1994 as a result of the mix shift in the product group. Hewlett-Packard repeated as the shipment leader for the group in 1995, followed by Fujitsu and, distantly, by Plasmon Data.

OEM/Integrator channel shipments were 53.8% of the total, again down from the previous year. Captive shipments declined to 10.9%, while PCM/Distributor activity for the libraries in this group rose to 35.3% of shipments. Distribution activity tends to concentrate in Europe, where the typical reseller is more likely to be technically sophisticated, and in the 5.25" subsystem area, regardless of location, where complexity is less and carrying costs are lower. The higher proportion of 5.25" libraries in the group product mix tends to increase the share of sales through distribution.

Non-U.S. manufacturers have increased their participation in this product group, but gaining share against the aggressive U.S. competitors remains difficult, especially in light of the weaker dollar. The strongest challenge from non-U.S. firms in the 5.25" optical library segment is from Fujitsu, whose strong non-U.S. shipments in 1995 produced almost a 30% share of the unit market.

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

Marketing trends

1999 unit shipments are forecasted to grow to 7,375 units, over 92% of which will be 5.25" libraries. Only minor growth is expected for the 12" to 14" segment.

About 54% of the libraries will be shipped to U.S. markets, reflecting growing interest in Europe and Asia. While U.S. suppliers are expected to remain strong because of their very strong system support capabilities for larger computing systems and the price advantage afforded by the current weak dollar, the growing non-U.S. markets are expected to result in shipments from non-U.S. firms to exceed those of U.S. firms later in the forecast period. No 3.5" libraries in this group are anticipated through 1999, but competition from inexpensive 12 centimeter libraries with PD drives and DVD-RAM drives may have moderate impact on sales for this product group.

Sales revenues for this group are expected to exceed $179 million in 1999, a reduction from previous forecasts, because of the shifting product mix in the group to 5.25" libraries with lower average prices. 58.4% of revenues are expected to be generated in the U.S. System size, in terms of the number of stored cartridges, is expected to increase, but the average price per system will fluctuate, reflecting the presence of new models in the product group and an expected weak dollar. The appearance of higher capacity optical drives over the next several years will tend to keep library subsystem prices from declining rapidly, but is likely to be a brake on the tendency for library size to increase, since fewer drives will be needed for a given on-line capacity at any time.

12" to 14" libraries are expected to retain only 7.9% of 1999 unit shipments, but will account for 31.1% of 1999 revenue. The lower prices of the 5.25" libraries will produce a much stronger growth rate for 5.25" libraries than for 12" libraries throughout the forecast period.

Most 12" libraries will use write-once media. The 5.25" libraries are strongly oriented toward erasable or multifunction drives. The emphasis on archival storage applications on large systems in this product group, the desire to retain compatibility with the installed base, and the desire of the archivist to minimize the number of media units all tend to favor the continued use of 12" write-once drives. European customers also tend to favor the use of write-once media, which will help maintain the market for 12" systems.

Libraries using rewritable disk drives are expected to increase their share of the market. Most of the rewritable drives will be 5.25" diameter drives, but Nikon's rewritable 12" drives are also available for libraries in this product group.

Applications

Financial and government institutions are, and will remain, the major users of optical disk drive libraries in this product group, although data warehousing applications in corporate environments are expected to grow as well. Systems employing hierarchical storage management also represent an opportunity for libraries in this group, but interest is strongly oriented to the rewritable 5.25" libraries rather than write-once configurations because of the desire to reuse the rather expensive media.

The IBM 3995 optical library introduced in 1991 (based on the Hewlett-Packard library) represented a response to customer pressures for a library and the competitive pressure of Storage Technology's model 4400 tape-based library system. Many 3995 library models have been introduced for use with various systems, and IBM's support for the 3995 as a virtual 3390 disk subsystem under System Managed Storage further increased the appeal of the 3995 optical library. IBM has steadily increased the number of models available within the 3995 family and now offers them with interfaces to its mainframes as well as the AS/400, RS/6000 and local area networks. About four fifths of the model 3995 libraries in this product group are attached to mainframes.

Technical trends

The large libraries that have appeared so far have used X-Y positioners accessing multiple bays of disk cartridge storage cells. Some 5.25" models offer the buyer the ability to configure the library with almost any combination of drives and storage cells. These same systems also offer multiple independently actuated positioner mechanisms. Some library designers are attempting a silo design similar in concept to the tape cartridge library developed by Storage Technology. In Borett's unusual design, the use of an industrial robot permits mixing of various types of media within the library. The robotic mechanism serves a mix of optical and tape drives, and is capable of exchanging its picking mechanism on the fly, as necessary, to handle the selected type of cartridge. Libraries capable of handling multiple types of media units represent an emerging trend, with Borett, EMASS and probably others offering high-end systems able to handle tape, optical cartridges and CD-ROM disks in caddies simultaneously.

5.25" drives with capacities of 2.6 gigabytes (1.3 gigabytes per side) appeared in quantity in 1996 and 5.2 gigabyte (2.6 gigabytes per side) drives are anticipated in 1997. As they appear, they will help 5.25" based optical libraries to compete more strongly against 12" drives, because fewer disk swaps will be required to support a given amount of stored data. 12" to 14" drive storage capabilities have increased to the 10-25 gigabyte per cartridge range, advantageous in archival applications and in systems where frequent accesses to the same mounted data volume are likely to occur.

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

Modular systems are becoming increasingly prominent in this product class. Manufacturers including DISC, DSM and others offer a semicustom configuration permitting a mix of drives and media that balance the need for capacity and library performance. Customers can specify the number and location of drives and cartridge storage modules to optimize performance for their application.

Most of the libraries in this group use a linear elevator mechanism, but Kubik has introduced a library in this product group using a rotary mechanism. It is based on the firm's CD-ROM library designs. Rotary designs have not yet met with widespread user acceptance.

Forecasting assumptions

1. The appearance of higher capacity 5.25" drives and the lower prices of 5.25" drives and libraries will continue to drive the movement to 5.25" drive usage in this product group. 12" is the only other format expected to be significant in the forecast period.
2. U.S. suppliers will continue their strength in this segment of the library market due to their experience and system integration skills, but non-U.S. manufacturers will become more powerful in their local markets.
3. There will be no significant changes in basic technology affecting these libraries over the period of the forecast.
4. Governments, financial institutions and other large users will continue to be the primary market for libraries in this product group.

TABLE 56

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

REVENUE SUMMARY

	LIBRARY REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	19.5	29.5	15.2	21.9	15.3	21.0	15.2	20.7	15.3	21.1
PCM/Distributor	12.5	17.9	13.4	19.2	14.2	20.3	14.6	21.1	15.0	21.7
OEM/Integrator	31.1	39.8	33.1	43.9	34.3	46.3	34.5	51.2	36.0	54.9
TOTAL U.S. REVENUES	63.1	87.2	61.7	85.0	63.8	87.6	64.3	93.0	66.3	97.7
Non-U.S. Manufacturers										
Captive	--	3.6	--	3.9	--	4.0	--	4.1	--	4.2
PCM/Distributor	3.2	17.6	3.3	12.4	4.1	11.4	4.3	11.2	4.5	11.2
OEM/Integrator	13.1	37.7	19.5	49.3	28.6	59.4	32.4	63.8	33.9	66.2
TOTAL NON-U.S. REVENUES	16.3	58.9	22.8	65.6	32.7	74.8	36.7	79.1	38.4	81.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	79.4	146.1	84.5	150.6	96.5	162.4	101.0	172.1	104.7	179.3
OEM Average Price ($000)		35.340		30.240		26.759		25.392		24.298

TABLE 57

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

UNIT SHIPMENT SUMMARY (SINGLE UNITS)

	LIBRARY UNIT SHIPMENTS, BY SHIPMENT DESTINATION									
	1995		Forecast							
	Shipments		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
Captive	295	425	292	412	304	430	323	451	334	478
PCM/Distributor	555	793	610	875	674	965	730	1,054	790	1,144
OEM/Integrator	754	1,020	835	1,138	916	1,251	953	1,468	1,038	1,647
TOTAL U.S. SHIPMENTS	1,604	2,238	1,737	2,425	1,894	2,646	2,006	2,973	2,162	3,269
Non-U.S. Manufacturers										
Captive	--	20	--	22	--	23	--	24	--	25
PCM/Distributor	198	638	219	662	231	680	258	710	285	744
OEM/Integrator	239	1,173	699	1,944	1,114	2,699	1,392	3,061	1,550	3,337
TOTAL NON-U.S. SHIPMENTS	437	1,831	918	2,628	1,345	3,402	1,650	3,795	1,835	4,106
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,041	4,069	2,655	5,053	3,239	6,048	3,656	6,768	3,997	7,375
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	7	11	9	16	13	22	16	28	20	36

TABLE 58

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues		Forecast							
			1996		1997		1998		1999	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	21.8	7.7	13.5	8.4	12.1	8.9	11.3	9.4	11.3	9.8
PCM/Distributor	--	17.9	--	19.2	--	20.3	--	21.1	--	21.7
OEM/Integrator	16.5	23.3	17.7	26.2	18.0	28.3	18.7	32.5	19.7	35.2
TOTAL U.S. REVENUES	38.3	48.9	31.2	53.8	30.1	57.5	30.0	63.0	31.0	66.7
NON-U.S. MANUFACTURERS										
Captive	--	3.6	--	3.9	--	4.0	--	4.1	--	4.2
PCM/Distributor	.5	17.1	.6	11.8	.7	10.7	.7	10.5	.9	10.3
OEM/Integrator	17.1	20.6	20.0	29.3	20.8	38.6	22.3	41.5	23.8	42.4
TOTAL NON-U.S. REVENUES	17.6	41.3	20.6	45.0	21.5	53.3	23.0	56.1	24.7	56.9
WORLDWIDE RECAP										
Captive	21.8 -12.4%	11.3 -54.4%	13.5 -38.1%	12.3 +8.8%	12.1 -10.4%	12.9 +4.9%	11.3 -6.6%	13.5 +4.7%	11.3 --	14.0 +3.7%
PCM/Distributor	.5 -83.9%	35.0 +173.4%	.6 +20.0%	31.0 -11.4%	.7 +16.7%	31.0 --	.7 --	31.6 +1.9%	.9 +28.6%	32.0 +1.3%
OEM/Integrator	33.6 -6.4%	43.9 +44.9%	37.7 +12.2%	55.5 +26.4%	38.8 +2.9%	66.9 +20.5%	41.0 +5.7%	74.0 +10.6%	43.5 +6.1%	77.6 +4.9%
Total Revenues	55.9 -12.5%	90.2 +32.8%	51.8 -7.3%	98.8 +9.5%	51.6 -.4%	110.8 +12.1%	53.0 +2.7%	119.1 +7.5%	55.7 +5.1%	123.6 +3.8%
ANNUAL SHARE, BY DIAMETER	38.4%	61.6%	34.5%	65.5%	31.8%	68.2%	30.8%	69.2%	31.1%	68.9%

Note: 12" libraries include 14" libraries.

TABLE 59

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (UNITS)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"	12"	5.25"
U.S. MANUFACTURERS										
Captive	153	272	112	300	101	329	92	359	87	391
PCM/Distributor	--	793	--	875	--	965	--	1,054	--	1,144
OEM/Integrator	143	877	157	981	162	1,089	172	1,296	180	1,467
TOTAL U.S. SHIPMENTS	296	1,942	269	2,156	263	2,383	264	2,709	267	3,002
NON-U.S. MANUFACTURERS										
Captive	--	20	--	22	--	23	--	24	--	25
PCM/Distributor	8	630	9	653	10	670	11	699	12	732
OEM/Integrator	243	930	276	1,668	288	2,411	295	2,766	303	3,034
TOTAL NON-U.S. SHIPMENTS	251	1,580	285	2,343	298	3,104	306	3,489	315	3,791
WORLDWIDE RECAP										
Captive	153 +11.7%	292 -30.6%	112 -26.8%	322 +10.3%	101 -9.8%	352 +9.3%	92 -8.9%	383 +8.8%	87 -5.4%	416 +8.6%
PCM/Distributor	8 -81.4%	1,423 +222.7%	9 +12.5%	1,528 +7.4%	10 +11.1%	1,635 +7.0%	11 +10.0%	1,753 +7.2%	12 +9.1%	1,876 +7.0%
OEM/Integrator	386 -18.9%	1,807 +46.8%	433 +12.2%	2,649 +46.6%	450 +3.9%	3,500 +32.1%	467 +3.8%	4,062 +16.1%	483 +3.4%	4,501 +10.8%
Total Shipments	547 -16.6%	3,522 +68.3%	554 +1.3%	4,499 +27.7%	561 +1.3%	5,487 +22.0%	570 +1.6%	6,198 +13.0%	582 +2.1%	6,793 +9.6%
ANNUAL SHARE, BY DIAMETER	13.4%	86.6%	11.0%	89.0%	9.3%	90.7%	8.4%	91.6%	7.9%	92.1%

Note: 12" libraries include 14" libraries.

TABLE 60

OPTICAL LIBRARIES, 70 OR MORE CARTRIDGES

WORLDWIDE SHIPMENTS (SINGLE UNITS)

REWRITABLE/WRITE-ONCE DRIVE ANALYSIS

	1995		Forecast							
	--Shipments--		-----1996----		-----1997----		-----1998----		-----1999----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Captive Total	425.0		412.0		430.0		451.0		478.0	
Write-Once	153.0	36.0%	112.0	27.2%	101.0	23.5%	92.0	20.4%	87.0	18.2%
Rewritable	272.0	64.0%	300.0	72.8%	329.0	76.5%	359.0	79.6%	391.0	81.8%
Noncaptive Total	1,813.0		2,013.0		2,216.0		2,522.0		2,791.0	
Write-Once	143.0	7.9%	157.0	7.8%	162.0	7.3%	172.0	6.8%	180.0	6.4%
Rewritable	1,670.0	92.1%	1,856.0	92.2%	2,054.0	92.7%	2,350.0	93.2%	2,611.0	93.6%
Total U.S.	2,238.0		2,425.0		2,646.0		2,973.0		3,269.0	
Write-Once	296.0	13.2%	269.0	11.1%	263.0	9.9%	264.0	8.9%	267.0	8.2%
Rewritable	1,942.0	86.8%	2,156.0	88.9%	2,383.0	90.1%	2,709.0	91.1%	3,002.0	91.8%
NON-U.S. MANUFACTURERS										
Captive Total	20.0		22.0		23.0		24.0		25.0	
Rewritable	20.0	100.0%	22.0	100.0%	23.0	100.0%	24.0	100.0%	25.0	100.0%
Noncaptive Total	1,811.0		2,606.0		3,379.0		3,771.0		4,081.0	
Write-Once	246.0	13.6%	272.0	10.4%	278.0	8.2%	282.0	7.5%	287.0	7.0%
Rewritable	1,565.0	86.4%	2,334.0	89.6%	3,101.0	91.8%	3,489.0	92.5%	3,794.0	93.0%
Total Non-U.S.	1,831.0		2,628.0		3,402.0		3,795.0		4,106.0	
Write-Once	246.0	13.4%	272.0	10.4%	278.0	8.2%	282.0	7.4%	287.0	7.0%
Rewritable	1,585.0	86.6%	2,356.0	89.7%	3,124.0	91.8%	3,513.0	92.6%	3,819.0	93.0%
WORLDWIDE RECAP										
Total Worldwide Shipments	4,069.0		5,053.0		6,048.0		6,768.0		7,375.0	
	+48.0%		+24.2%		+19.7%		+11.9%		+9.0%	
Write-Once	542.0	13.3%	541.0	10.7%	541.0	8.9%	546.0	8.1%	554.0	7.5%
	-16.9%		-.1%		--		+.9%		+1.5%	
Rewritable	3,527.0	86.7%	4,512.0	89.3%	5,507.0	91.1%	6,222.0	91.9%	6,821.0	92.5%
	+68.3%		+27.9%		+22.1%		+13.0%		+9.6%	

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

CD FORMAT DISK DRIVE SPECIFICATIONS

1996 DISK/TREND REPORT

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-E, 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".

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

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

Compatibility: Indicates compatibility with major formats. The following abbreviations are used:

MS = Multisession (implies Photo CD compatibility as well)
XA = Conforms to XA ready requirements
CD-I = Reads CD-I media

Speed control: The following abbreviations are used:

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

Capacities: Capacities are listed as "U" for unformatted and "F" for formatted. For optical drives that can access only one side of the media, 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.

Positioner type: Optical disk drives have compound head positioning systems. A coarse movement positions the head near the track to be located. A fine, or vernier, actuator then positions the head on the desired track and also maintains correct focus. Unless otherwise indicated, a vernier actuator is always present.

Average access time: The average access time is the sum of average positioning time plus rotational latency. Optical drive manufacturers, and especially CD-

ROM manufacturers, are inconsistent in the use of this definition, so while the values given for these specifications are believed to be accurate, they should be accepted with caution and individual drive manufacturers contacted for details.

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

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

If separated by a slash, the figures represent the rates obtained when the drive (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.

1996 DISK/TREND optical disk product groups

For the 1996 report, products are classified in eight groups.

Optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.
Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 51: Optical disk libraries with 1 to 39 cartridge capacity.
Group 52: Optical disk libraries with 40 to 69 cartridge capacity.
Group 53: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER	ACER	ACER	ACER	ACER	ACER PERIPHERALS
DRIVE	CD-767E	CD-787E	CD-910E	CD-1420C	CD-610A
DISK/TREND GROUP	20	20	20	21	20
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Dye Polymer	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-R	CD-ROM
Relative speed	6X	8X	10X	2X WR/4X RD	10X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI
Compatibility	MS, XA, CD-I	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY Total capacity (Mbytes)	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750		20750
Track density (TPI)	15875	15875	15875		15875
Maximum linear density (BPI)	27600	27600	27600		27600
Rotational speed (RPM)	3180-1200	2160-800	2160-800	2120-400	5300-2000
PERFORMANCE Positioner type	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear	Linear, DC Motor & Gear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)				--/363	150
Average rotational delay (msec)				27	11
Average access time (msec)				--/390	161
Data transfer rate (MBytes/sec) . Internal	.914	1.2	1.5	.307/.614	1.53
External				5.0	11.6 PIO Mode 3
Buffer/cache size (Kbytes)	128	256	512	512	128
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	41.3 x 146 x 203	42 x 146 x 211
FIRST CUSTOMER SHIPMENT		1996	1996	1996	7/96
COMMENTS	Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Caddy. Ricoh mechanism	Philips mechanism. Tray loading.

MANUFACTURER		ACER PERIPHERALS	ACER PERIPHERALS	ADI	AZTECH SYSTEMS	AZTECH SYSTEMS
DRIVE		CD-665A	CD-685A	CDP-6000	CDA 1068-011	CDA 468-011
DISK/TREND GROUP		20	20	20	20	20
MARKET		OEM, PCM	OEM, PCM	PCM	OEM, PCM	OEM, PCM
MEDIA:	Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
	Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE:	Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
	Relative speed	6X	8X	6X	10X	4X
	Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
	Compatibility	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I*	MS, CD-I, MPC-2
	Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY						
Total capacity (Mbytes)		748 Mode 2 F: 656 Mode 1	748 Mode 2 F: 656 Mode 1	635 Mode 2 F: 553 Mode 1	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)		N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle		1	1	1	1	1
Tracks per surface		20750	20750	20750	20750	20750
Track density (TPI)		15875	15875	15875	15875	15875
Maximum linear density (BPI)		27600	27600	27600	27600	27600
Rotational speed (RPM)		3180-1200	4240-1600	3180-1200	5000-2174	2120-800
PERFORMANCE						
Positioner type		Linear, DC Motor & Gear	Linear, DC Motor & Gear	Linear	Linear	Linear
Servo type		Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		182	150		130	235
Average rotational delay (msec)		18	14		12	27
Average access time (msec)		200	164		142	262
Data transfer rate (MBytes/sec)						
	Internal	.914	1.24	.9	1.5	.614
	External	8.3 PIO Mode 3	8.3 PIO Mode 3			
Buffer/cache size (Kbytes)		128	128	128	128	256
SIZE (mm: H x W x D)		42 x 146 x 211	42 x 146 x 211	42.6 x 149 x 211	41.5 x 146 x 208	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT		4Q95	2/96	3/96	3/96	4Q94
COMMENTS		Philips mechanism. Tray loading.	Philips mechanism. Tray loading.	Tray loading.	*MPC-3 compliant. Tray loading. Supports DMA Mode 2.	Tray loading.

MANUFACTURER	AZTECH SYSTEMS	AZTECH SYSTEMS	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER	BEHAVIOR TECH COMPUTER
DRIVE	CDA 668-01I	CDA 868-01I Zeta	BCD-10X	BCD-639	BCD-739
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	8X	8X	6X	8X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	630 Mode 2 F: 540 Mode 1	630 Mode 2 F: 540 Mode 1	742 Mode 2 F: 650 Mode 1	635 Mode 2 F: 553 Mode 1	742 Mode 2 F: 650 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	4240-1600	4900-2000	3180-1200	3093-1600
PERFORMANCE					
Positioner type	Linear	Linear	Linear, DC Motor	Linear	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	190	175	140	250	180
Average rotational delay (msec)	18	14	40	18	70
Average access time (msec)	218	189	180	268	250
Data transfer rate (MBytes/sec) Internal External	.921	1.23	1.5 11.1 PIO Mode 3	.900	1.2 11.1 PIO Mode 3
Buffer/cache size (Kbytes)	256	128		128	
SIZE (mm: H x W x D)	41.5 x 146 x 208	41.5 x 146 x 208	42 x 146 x 201.8	42 x 146 x 201	42 x 146 x 201.8
FIRST CUSTOMER SHIPMENT	1995	1/96	1996		1996
COMMENTS	*MPC-2 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-2 compliant. Tray loading.	Tray loading.	*MPC-2 compliant. Tray loading.

MANUFACTURER	CD-ROM, INC.	CD-ROM, INC.	CHINON	CHINON	DELTA ELECTRONICS
DRIVE	CRI 1600	CRI 1800	CDS-545 CDS-545i	CDS-585	ODC-8101
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	8X	4X	8X	8X
Interface	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2	IDE/ATAPI
Compatibility	MS, XA, MPC-2	MS, XA, MPC-2	MS, XA, MPC-2	MS, XA, MPC-3	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 650	F: 650	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	4240-1600	2120-200	4240-200	4240-1600
PERFORMANCE					
Positioner type	Linear	Linear	Linear, Voice Coil	Linear, Voice Coil	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	140	175	185	185	177
Average rotational delay (msec)	18	14	45	45	13
Average access time (msec)	158	189	230	230	190
Data transfer rate (MBytes/sec)					
Internal	.914	1.20	.600	1.2	1.22
External	10.0 synch.	10.0 synch.			
Buffer/cache size (Kbytes)	128	128	128	256	128/256 option
SIZE (mm: H x W x D)	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	41.4 x 146 x 203	41.4 x 146 x 208	41 x 146 x 203
FIRST CUSTOMER SHIPMENT	6/96	10/96	4Q94	1Q96	1996
COMMENTS	Tray loading.	Tray loading.	Tray loading.	Tray loading.	*MPC-3 compliant. Tray loading. Purchased mechanism.

MANUFACTURER	DELTA ELECTRONICS	DELTA ELECTRONICS	DIAMOND FLOWER (DFI)	DIAMOND FLOWER (DFI)	EASTMAN KODAK
DRIVE	ODC-D101	ODR-4121	CR-600	CR-800	PCD Writer 600
DISK/TREND GROUP	20	21	20	20	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm
Recording technology	Replication	Dye Polymer	Replication	Replication	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-R	CD-ROM	CD-ROM	CD-R
Relative speed	10X	2X WR/4X RD	6X	8X	6X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	F: 580/682
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	5300-2000	2120-400	3180-1200	4240-1600	3646-1165
PERFORMANCE					
Positioner type	Linear	Linear	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	140	350	230	230	1271
Average rotational delay (msec)	10	27/55	18	14	17
Average access time (msec)	150	377/405	248	244	1288
Data transfer rate (MBytes/sec)					
Internal	1.53	.614/.307	.914	1.2 11.1 PIO Mode 3	.921
External					4.0 synch.
Buffer/cache size (Kbytes)	128		128	128	1000-8000
SIZE (mm: H x W x D)	41 x 146 x 203	41 x 146 x 203	41.5 x 146 x 203	41.5 x 146 x 203	145 x 430 x 380
FIRST CUSTOMER SHIPMENT	1996	1996	1996	8/96	2Q94
COMMENTS	*MPC-3 compliant. Tray loading. Purchased mechanism.	*MPC-3 compliant. Tray loading. Purchased mechanism.	*MPC-2 compliant. Tray loading.	*MPC-3 compliant. Tray loading. Prelim. spec.	75 disk loader option. Tray loading.

MANUFACTURER	EASTMAN KODAK	ELITEGROUP COMPUTER SYSTEMS	ELITEGROUP COMPUTER SYSTEMS	ELITEGROUP COMPUTER SYSTEMS	FUNAI ELECTRIC
DRIVE	PCD Writer 200 PCD Writer 200+ PCD Writer 225	VERTOS 600ESD	VERTOS 800ETD	VERTOS 800ESS	E2650
DISK/TREND GROUP	21	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X	6X	8X	8X	6X
Interface	SCSI	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI
Compatibility	MS, XA, CD-I	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 660	F: 660	F: 660	F: 540
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1000-428	3180-1200	4240-1600	4240-1600	3180-1200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	945	177	177	177	--
Average rotational delay (msec)	55	13	13	13	--
Average access time (msec)	1000	190	190	190	200
Data transfer rate (MBytes/sec)					
Internal	.307	.900	1.229	1.229	.921
External	1.5 asynch.			10	PIO Mode 2
Buffer/cache size (Kbytes)	256	256	256	256	256
SIZE (mm: H x W x D)	118 x 420 x 334	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 198
FIRST CUSTOMER SHIPMENT	3Q92				11/95
COMMENTS	Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	Spin up: 2.5 seconds. Video CD ready.

MANUFACTURER	FUNAI ELECTRIC	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI
DRIVE	E2850	4020i CD-Writer	CDR-7730	CDR-7830	CDR-7930
DISK/TREND GROUP	20	21	20	20	20
MARKET	OEM	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Dye Polymer	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-R	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	2X WR/4X RD	4X	7X	8X
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, MPC-3	MS, XA, CD-I	MS, XA, MPC-3	MS, XA, MPC-3	MS, XA, MPC-3
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 682 581	F: 742	F: 742	F: 742
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-1600	2120-400*	2120-800	3710-1400	4240-1600
PERFORMANCE					
Positioner type	Linear	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	--	400	213	159	136
Average rotational delay (msec)	--	27 RD/55 WR	27	16	14
Average access time (msec)	150	427 RD/455 WR*	240	175	150
Data transfer rate (MBytes/sec)					
Internal	1.23	.600 RD/.30 WR*	.614	1.050	1.2
External	PIO Mode 3		8.3 PIO Mode	11.1 PIO Mode 3	11.1 PIO Mode 3
Buffer/cache size (Kbytes)	256	1000	128	128	128
SIZE (mm: H x W x D)	42.5 x 148 x 198	1.625 x 5.75 x 8	41.3 x 146 x 190	41.3 x 146 x 190	41.3 x 146 x 190
FIRST CUSTOMER SHIPMENT	4/96	4Q95	2Q95	1Q96	2Q96
COMMENTS	Spin up: 2.5 seconds. Video CD ready.	Philips mech. *2X recording, 4X playback. Tray loading.	Tray loading.	Tray loading.	Tray loading.

MANUFACTURER	HITACHI	HOPAX INDUSTRIES	HOPAX INDUSTRIES	HOPAX INDUSTRIES	HOPAX INDUSTRIES
DRIVE	GD-1000	HO-760	HO-806P	HO-808	HO-968
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	DVD/CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	6X	6X	8X	8X
Interface		IDE/ATAPI	PCMCIA 2.1	IDE/ATAPI	IDE/ATAPI
Compatibility		MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	4700 F: 8500 2 surf.	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1, 2	1	1	1	1
Tracks per surface	45946	20750	20750	20750	20750
Track density (TPI)	34324	15875	15875	15875	15875
Maximum linear density (BPI)	96000	27600	27600	27600	27600
Rotational speed (RPM)	1700-590	3180-1200	3180-1200	4240-1600	4240-1600
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		160			160
Average rotational delay (msec)		18			15
Average access time (msec)	190	178	200	150	175
Data transfer rate (MBytes/sec) Internal	1.38/1.2	1.2	.9	1.2	1.2
External					
Buffer/cache size (Kbytes)		256	128*	128	256
SIZE (mm: H x W x D)		41.5 x 146 x 208	32.2 x 130 x 189.5	41.5 x 146 x 208	41.5 x 146 x 208
FIRST CUSTOMER SHIPMENT	3Q96	1995	1995	1996	1996
COMMENTS	Preliminary specification.	Tray loading. Hitachi mechanism.	*256K option. Portable model. Top loading.	Tray loading. Toshiba mechanism.	Tray loading. Hitachi, Sony mechanisms.

MANUFACTURER	IPC PERIPHERALS	IPC PERIPHERALS	IPC PERIPHERALS	JVC	JVC
DRIVE	MCD-268	MCD-268e	MCD-288	XR-S202	XR-W2010
DISK/TREND GROUP	20	20	20	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Organic Dye	Organic Dye
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-R	CD-R
Relative speed	6X	7X	8X	2X WR/4X RD	2X WR/4X RD
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540 Mode 1	F: 540 Mode 1	F: 540 Mode 1	F: 580/680	F: 580/680
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	3710-1400	4240-1600	1060-400	1060-400
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	230	230	230	335	335
Average rotational delay (msec)	18	16	14	55	55
Average access time (msec)	248	246	244	390	390
Data transfer rate (MBytes/sec) Internal	.900	1.05	1.2	.307/.614	.307/.614
External					
Buffer/cache size (Kbytes)	256	256	256	1000	1000
SIZE (mm: H x W x D)	42 x 147 x 215	42 x 147 x 215	42 x 147 x 215	71 x 265 x 294	43 x 149 x 215
FIRST CUSTOMER SHIPMENT	2/96	2/96	7/96	3/96	1/96
COMMENTS	*MPC-3 compliant. Tray loading. Philips mechanism.	*MPC-3 compliant. Tray loading. Philips mechanism.	*MPC-3 compliant. Tray loading. Philips mechanism.	Tray loading. External mount.	Tray loading.

MANUFACTURER	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS	LG ELECTRONICS
DRIVE	GCD-R540B	GCD-R560B	GCD-R580B Goldstar	GDI-750 GDI-1000	GPI-1200
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X	6X	8X		
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	Audio/Video	--
Compatibility	MS, XA, CD-I*	MS, XA, CD-I	MS, XA, CD-I*	CD-I	XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 535 Mode 1	690 Mode 2 F: 540 Mode 1	690 Mode 2 F: 540 Mode 1	F: 680	F: 540
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2120-800	3180-1200	4240-1600		
PERFORMANCE					
Positioner type	Linear	Linear	Linear, Voice Coil	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	163	160	150		
Average rotational delay (msec)	27	15	14		
Average access time (msec)	190	175	164		
Data transfer rate (MBytes/sec) Internal External	.600	.900 11.1 PIO	1.229 11.1 PIO Mode 3		
Buffer/cache size (Kbytes)	128/256	256	256		
SIZE (mm: H x W x D)	41.5 x 146 x 189	41.3 x 146 x 189	41.3 x 146 x 189	67 x 299 x 190	70 x 172 x 160
FIRST CUSTOMER SHIPMENT				5/95	7/95
COMMENTS	*MPC-2 compliant. Motorized tray loading.		*MPC-3 compliant. Tray loading.	Tray loading.	CD-I player.

MANUFACTURER	LION OPTICS	LION OPTICS	LION OPTICS	LITE-ON TECHNOLOGY	LITE-ON TECHNOLOGY
DRIVE	XC-800EI	XC-800SI	XE-800EE	LTN-10XI	LTN-12EI
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	8X	8X	10X	12X
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	650 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-1600	4240-1600	4240-1600	5300-2000	6360-2400
PERFORMANCE					
Positioner type	Linear, DC Motor & Gear	Linear, DC Motor & Gear	Linear, DC Motor & Gear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	175	175	175	150	125
Average rotational delay (msec)	14	14	14	11	10
Average access time (msec)	189	189	189	161	135
Data transfer rate (MBytes/sec)					
Internal	1.200	1.200	1.200	1.53	1.84
External	11.1 PIO	11.1 PIO	11.1 PIO		
Buffer/cache size (Kbytes)	256	256	256	128/256 option	128/256 option
SIZE (mm: H x W x D)	41.5 x 146 x 208	41.5 x 146 x 208	60 x 160 x 290	41.5 x 146 x 210	41.5 x 146 x 210
FIRST CUSTOMER SHIPMENT	1Q96	1996	1996	3Q96	4Q96
COMMENTS	Tray loading.	Tray loading.	Tray loading.	JVC mechanism.	JVC mechanism.

MANUFACTURER	LITE-ON TECHNOLOGY	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LTN-12XI	4720	4730	CR-505	CR-506
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	12X	4X	4X	8X	8X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2
Compatibility	MS, XA, CD-I	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	650 Mode 2 F: 553 Mode 1	F: 540	F: 540	F: 682 Mode 2	F: 682 Mode 2
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	6360-2400	2120-800	2120-800	3180-1200	4240-1600
PERFORMANCE					
Positioner type	Linear	Linear, DC Motor & Gear	Linear, DC Motor & Gear	DC Motor, Lead Screw	DC Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	150	223	223	175	150
Average rotational delay (msec)	10	27	27	18	14
Average access time (msec)	160	250	250	193	164
Data transfer rate (MBytes/sec) Internal External	1.84	.614	.614	.914	1.2
Buffer/cache size (Kbytes)	128/256 option			128	256
SIZE (mm: H x W x D)	41.5 x 146 x 210	15 x 128 x 141	15 x 128 x 141	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q96	9/95	9/95	2Q96	2Q96
COMMENTS	JVC mechanism.	*MPC-3 compliant. Flat cable. Tray loading.	*MPC-3 compliant. Tray loading. Pin connector.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	CR-582	CR-583	KXL-D740 KXL-D745	LK-MC608BP	LK-MC608S
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM	PCM	PCM	PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	8X	4X	8X	8X
Interface	IDE/ATAPI	IDE/ATAPI	PCMCIA, SCSI-2	SCSI-2	SCSI-2
Compatibility	MS, XA, MPC-3	MS, XA, CD-I*	MS, MPC-2	MS, XA, MPC-3	MS, XA, MPC-3
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682 Mode 2	F: 656	F: 540	F: 682	F: 682
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27900	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	4240-1600	2120-800	4240-200	4240-200
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	DC Motor, Lead Screw	DC Motor, Lead Screw	DC Motor, Lead Screw	DC Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	175	150	295	136	136
Average rotational delay (msec)	18	14	27	14	14
Average access time (msec)	193	164	322	150	150
Data transfer rate (MBytes/sec)					
Internal	.914	1.2	.614	1.2	1.2
External	13.3 PIO Mode 3	13.3 PIO Mode 3		10.0 synch.	10.0 synch.
Buffer/cache size (Kbytes)	128	128	128	256	256
SIZE (mm: H x W x D)	41.3 x 146 x 190	41.3 x 146 x 190	41 x 147 x 196	41.3 x 146 x 203	57 x 158 x 314
FIRST CUSTOMER SHIPMENT	2Q96	2Q96	1/96	3Q96	3Q96
COMMENTS	Tray loading.	*MPC-3 compliant. Tray loading.	KXL-D745 includes sound card support.	Tray loading.	Tray loading. External mount.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LK-MC688BP	UJDCD6710	UJDCD6720	UJDCD6730	CW-7501
DISK/TREND GROUP	20	20	20	20	21
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-R
Relative speed	8X	6X	6X	6X	2X/4X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Compatibility	MS, XA, MPC-3	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, CD-Plus
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 682	F: 540	F: 540	F: 540	F: 682
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-200	3180-1200	3180-1200	3180-1200	2120-200
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	Linear, DC Motor & Gear	Linear, DC Motor & Gear	Linear, DC Motor & Gear	DC Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	136	182	182	182	222
Average rotational delay (msec)	14	18	18	18	50/28*
Average access time (msec)	150	200	200	200	272/250
Data transfer rate (MBytes/sec)					
Internal	1.2	.921	.921	.921	.3/.6
External	13.3 PIO Mode 3				
Buffer/cache size (Kbytes)	128				
SIZE (mm: H x W x D)	41.3 x 146 x 190	12.7 x 128 x 130	15 x 128 x 141	15 x 128 x 141	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	3Q96	6/96	1/96	1/96	1Q96
COMMENTS	Tray loading.	*MPC-3 compliant. Tray loading. Pin connector.	*MPC-3 compliant. Tray loading. Flat cable.	*MPC-3 compliant. Tray loading. Pin connector.	*4X read. Tray loading.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LF-1000AB	LF-1001JAN	LF-1001JB	LF-1001JDN	LF-1004AB LF-1004ABK LF-1004JD* LF-1094 PD Drive
DISK/TREND GROUP	21	21	21	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Ph.Chg.,Replic.
DRIVE: Operating mode	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only	Rewrit.,Rd.Only
Relative speed	--/4X*	6X*	6X*	6X*	--/4X**
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	PD, CD-ROM	PD, CD-ROM	PD, CD-ROM	PD, CD-ROM	PD, CD-ROM
Speed control & zones	ZCAV/CLV*	ZCAV/CLV*	ZCAV/CLV*	ZCAV/CLV*	ZCAV/CLV**
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	27200/20750*	27200/20750*	27200/20750*	27200/20750*	27200/20750**
Track density (TPI)	21166/15875*	21166/15875*	21166/15875*	21166/15875*	21166/15875**
Maximum linear density (BPI)	29195/27600*	29195/27600*	29195/27600*	29195/27600*	29195/27600**
Rotational speed (RPM)	2026/2120-800*	2026/3180-1200*	2026/3180-1200*	2026/3180-1200*	2026/2120-800**
PERFORMANCE					
Positioner type	DC Motor, Lead Screw	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	165/195*	109/130*	109/130*	109/130*	165/195**
Average rotational delay (msec)	12.5/27*	12.5/18*	12.5/18*	12.5/18*	12.5/27**
Average access time (msec)	177/222*	131.5/148*	131.5/148*	131.5/148*	177/222**
Data transfer rate (MBytes/sec) Internal External	.518-1.141 (PC) .600 (CD-ROM)	.518-1.41 (PC) .900*	.518-1.41 (PC) .900*	.518-1.41 (PC) .900*	1.14 max. (PC) 600 (CD-ROM)
Buffer/cache size (Kbytes)	256	256	256	256	512
SIZE (mm: H x W x D)	58 x 158 x 318				41.3 x 146.1 x 196
FIRST CUSTOMER SHIPMENT	1Q95	3Q96	3Q96	3Q96	1Q95
COMMENTS	*For CD-ROM mode. Tray loading. For Macintosh. External mount.	*For CD-ROM mode. For Macintosh.	*For CD-ROM mode. Tray loading. External mount.	*For CD-ROM mode. For DOS V and PC9800.	**For CD-ROM mode. *For Macintosh. -ABK includes controller. Tray loading.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MITSUBISHI ELECTRIC	MITSUMI ELECTRIC
DRIVE	LF-1005JD	LF-1195	LK-MW602B LK-MW602BP LK-RW602	MDV-010	CRMC-FX600
DISK/TREND GROUP	21	21	21	20	20
MARKET	OEM, PCM	OEM, PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm/80 mm
Recording technology	Ph.Chg.,Replic.	Ph.Chg.,Replic.	Dye Polymer	Replication	Replication
DRIVE: Operating mode	Rewrit.,Rd.Only	Rewrit.,Rd.Only	CD-R	DVD-ROM/CD-ROM	CD-ROM
Relative speed	6X*	--/6X	2X/4X	8X/9X	6X
Interface	SCSI-2	ATAPI	SCSI-2		IDE/ATAPI
Compatibility	PD, CD-ROM	PD, CD-ROM	MS, XA, CD-I	CD-ROM, CD-R	MS, XA, CD-I*
Speed control & zones	ZCAV/CLV*	ZCAV/CLV*	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	668 PD F: 540 CD-ROM	668 PD F: 540 CD-ROM	682 Mode 2 F: 540 Mode 1	F: 680/4700	650 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	27200/20750*	27200/20750*	20750		20750
Track density (TPI)	21166/15875*	21166/15875*	15875	34000	15875
Maximum linear density (BPI)	29195/27600*	29195/27600*	27600	96000	27600
Rotational speed (RPM)	2026/3180-1200*	2026/3180-1200*	2120-200		3180-1200
PERFORMANCE					
Positioner type	Linear	Linear, Voice Coil	DC Motor, Lead Screw	Linear	Motor, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	109/130*		222		180
Average rotational delay (msec)	12.5/18*	12.5/18*	56/28*		18
Average access time (msec)	131.5/148*		270/250*	150	198
Data transfer rate (MBytes/sec)					
Internal	.518-1.41 (PC)	.518-1.41 (PC)	.300/.600*	1.2/1.38	.900
External	.900*	.900* (CD-ROM)	5.0		
Buffer/cache size (Kbytes)	256		1000/256*		128
SIZE (mm: H x W x D)		41.3 x 146 x 203	41.3 x 146 x 203		1.625 x 146 x 200
FIRST CUSTOMER SHIPMENT	3Q96	6/96	1995	4Q96	2/96
COMMENTS	*For CD-ROM mode. For DOS V PC.	*For CD-ROM mode. Tray loading. 6X read.	*4X read mode. Tray loading. LK-RW602 sold only in Japan.	Preliminary specification. Dual laser pickup.	*MPC-3 compliant. Tray loading.

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MOUNTAIN OPTECH	NEC	NEC
DRIVE	CRMC-FX800	CR-2600TE	SC-680 SI-680 ST-680	ODX-651	ODX-652
DISK/TREND GROUP	20	21	20	21	21
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Dye Polymer	Replication	Phase Change	Phase Change
DRIVE: Operating mode	CD-ROM	CD-R	CD-ROM	Rewrit.,Rd.Only	Rewrit.,Rd.Only
Relative speed	8X	2X WR/6X RD	4X	--/4X*	--/4X*
Interface	IDE/ATAPI	IDE/ATAPI	SCSI	SCSI-2	IDE-ATAPI
Compatibility	MS, XA, CD-I*	MS, XA	MS, XA, MPC-2	PD, CD-ROM	PD, CD-ROM
Speed control & zones	CLV	CLV	CLV	CAV/CLV*	CAV/CLV*
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	640 Mode 2 F: 540 Mode 1	664 PD F: 650 CD-ROM	664 PD F: 650 CD-ROM
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	27200/20750*	27200/20750*
Track density (TPI)	15875	15875	15875	21167/15875*	21167/15875*
Maximum linear density (BPI)	27600	27600	27600	28400/27600*	28400/27600*
Rotational speed (RPM)	4240-1600	3180-1200	2120-800	2026 (PD)	2026 (PD)
PERFORMANCE					
Positioner type	Motor, Lead Screw		Linear	Linear, Gear Drive	Linear, Gear Drive
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	150	220		165/195*	150/180*
Average rotational delay (msec)	13	18	27	15/27*	15/27*
Average access time (msec)	163	238		180/222*	165/207*
Data transfer rate (MBytes/sec)					
Internal	1.229	.900	.614	1.14 RD/.300 WR	1.14 RD/.300 WR
External				5.0 synch.	5.0 synch.
Buffer/cache size (Kbytes)	256	1000	256	256	512
SIZE (mm: H x W x D)	41.3 x 146 x 200	41.3 x 146 x 210		41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4/96	4Q96	4Q95	4Q95	4Q95
COMMENTS	*MPC-3 compliant. Tray loading.	Preliminary specification. Tray loading.	Ruggedized CD-ROM.	*CD-ROM mode. Tray loading.	*CD-ROM mode. Tray loading.

MANUFACTURER	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS
DRIVE	CDR-1300A	CDR-1350A MultiSpin 6V	CDR-1400	CDR-1410	CDR-1450
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	OEM, PCM	OEM	OEM	PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	6X	8X	8X	8X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	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
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	3180-1200	4240-1840	4240-1840	4240-1840
PERFORMANCE					
Positioner type	Linear, Rack & Pinion	Linear, Voice Coil	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Rack & Pinion
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	145	145	125	125	125
Average rotational delay (msec)	17	18	15	15	15
Average access time (msec)	162	163	140	140	140
Data transfer rate (MBytes/sec)					
Internal	.900	.900	1.2	1.2	1.2
External		11.1			
Buffer/cache size (Kbytes)	128		128	128	128
SIZE (mm: H x W x D)	42.8 x 149 x 210	42.8 x 149 x 211	42.8 x 149 x 208	42.8 x 149 x 208	42.8 x 149 x 210.8
FIRST CUSTOMER SHIPMENT	1Q96	1Q96	2Q96	2Q96	2Q96
COMMENTS	*MPC-3 compliant. Tray loading.	Tray loading.	Tray loading.	Tray loading.	Tray loading.

MANUFACTURER	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS
DRIVE	CDR-1460	CDR-3460	CDR-401 MultiSpin 3XP+	CDR-502 MultiSpin 6Xi	CDR-602 PC-CD600 MultiSpin 6Xe
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	PCM	PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	8X		6X	6X
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS, XA, CD-I	MS, XA, CD-I		MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1	F: 540/680	680 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-1840	4240-1840	2000-800	3180-1200	3180-1200
PERFORMANCE					
Positioner type	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	125	125	200	130	127
Average rotational delay (msec)	15	15	40	15	18
Average access time (msec)	140	140	240	145	145
Data transfer rate (MBytes/sec) Internal External	1.2	1.2	.500	.900	.900
Buffer/cache size (Kbytes)	128	128	256	256	256
SIZE (mm: H x W x D)	42.8 x 149 x 208	42.8 x 149 x 213.5	55.9 x 154 x 257	42.8 x 149 x 219.7	76.2 x 175 x 331
FIRST CUSTOMER SHIPMENT	2Q96	3Q96	1994	2Q95	2Q95
COMMENTS	Tray loading.	Tray loading.			Caddy.

MANUFACTURER	OCEAN OFFICE AUTOMATION	OCEAN OFFICE AUTOMATION	OPTICS STORAGE	OPTICS STORAGE	OPTICS STORAGE
DRIVE	CDR 688	CDR 810	8622 Maverick 12X	Stingray 8422	Stingray 8522
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	10X	12X	8X	10X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680	F: 680	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-1600	5300-2000	6360-2400	4240-1600	5300-2000
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear, DC Motor	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	180	170	140	196	188
Average rotational delay (msec)	13	11	10	14	12
Average access time (msec)	193	181	150	210	200
Data transfer rate (MBytes/sec) Internal	1.229	1.53	1.8	1.200	1.500
External					
Buffer/cache size (Kbytes)	256	256	256	256	256
SIZE (mm: H x W x D)	41.5 x 146 x 205	41.5 x 146 x 205	41 x 146 x 210	41.3 x 146 x 210	41 x 146 x 210
FIRST CUSTOMER SHIPMENT	1995	6/96	1996	3Q95	1Q96
COMMENTS	*MPC-2 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	Purchased mechanism. Tray loading.	Purchased mechanism. Tray loading.

MANUFACTURER	PHILIPS	PHILIPS	PHILIPS	PHILIPS	PHILIPS
DRIVE	CDI 370DV	CDI 470	CDI 615	PCA 62CR	PCA 80SC
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	OEM, PCM	OEM, PCM	PCM	PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X	1X	1X	6X	8X
Interface	Serial	Serial	Serial	IDE/ATAPI	SCSI-2
Compatibility	CD-I	CD-I	CD-I	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-200	500-200	500-200	3180-1200	4240-1600
PERFORMANCE					
Positioner type	Rotary Galvanometer	Rotary Galvonometer	Rotary Galvonometer	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	790	790	790	210	195
Average rotational delay (msec)	110	110	110	18	14
Average access time (msec)	900	900	900	228	209
Data transfer rate (MBytes/sec) Internal External	.153/.175	.153/.175	.153/.175	.921	1.224 11.1 PIO Mode 3
Buffer/cache size (Kbytes)				256	256
SIZE (mm: H x W x D)	70 x 190 x 172	85 x 200 x 220	105 x 435 x 280		
FIRST CUSTOMER SHIPMENT	1/96	7/95	1/96		2Q96
COMMENTS	Portable CD-I player with LCD screen. Opt. battery pk Digital Video capability.	Tray loading. Thumbpad remote control. Digital Video capability.	Tray loading. Thumbpad remote control. Digital Video capability.		Tray loading.

MANUFACTURER	PHILIPS	PHILIPS	PINNACLE MICRO	PINNACLE MICRO	PINNACLE MICRO
DRIVE	CDD 2000 CDD 2010	CDD 2600	10Xtreme	Explorer	RCD 5040
DISK/TREND GROUP	21	21	20	21	21
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
MEDIA: Disk diameter	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm
Recording technology	Dye Polymer	Dye Polymer	Replication	Dye Polymer	Dye Polymer
DRIVE: Operating mode	CD-R	CD-R	CD-ROM	CD-R	CD-R
Relative speed	2X WR/4X RD	2X WR/6X RD	10X	2X WR/4X RD	2X WR/4X RD
Interface	SCSI-2	SCSI-2	IDE/ATAPI	SCSI-2	SCSI-2
Compatibility	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I*	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	630 Mode 2 F: 550 Mode 1	630 Mode 2 F: 550 Mode 1	635 Mode 2 F: 540 Mode 1	681 Mode 2 F: 580 Mode 1	681 Mode 2 F: 580 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2160-400	3180-1200	5300-2000	2120-400	2120-400
PERFORMANCE					
Positioner type	Linear, Worm Gear/Lead Screw	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	350		130	300	300
Average rotational delay (msec)	55 WR/27 RD	55 WR/18 RD	11	55/27	55/27
Average access time (msec)	405 WR/377 RD		141	355/327	355/327
Data transfer rate (MBytes/sec)					
Internal	.300 WR/.600 RD	.921/.307	1.5	.300/.600	.300/.600
External				5.0 synch.	5.0 synch.
Buffer/cache size (Kbytes)	1000	1000	256	1000	1000
SIZE (mm: H x W x D)	41.5 x 146 x 206	41.5 x 146 x 206	41.3 x 146 x 211.3	41.3 x 146 x 211	60 x 200 x 255
FIRST CUSTOMER SHIPMENT	2Q95	4Q96	2Q96	1996	1996
COMMENTS	Tray loading. CDD 2010 is external mount.	Preliminary specification.	*MPC-3 compliant. Tray loading. Purchased mechanism.	Tray loading. Purchased mechanism.	Purchased mechanism. Tray loading.

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
DRIVE	DR-411	DR-A10X	DR-S104X DR-U104X	DR-U124X	DR-UA124X
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM	PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	10X	10X	4X	4.4X	4X
Interface	IDE/ATAPI	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, MPC-2	MS, XA, MPC-2
Speed control & zones	CAV/CLV	CAV/CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	F: 540	F: 540	F: 540
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	5300-2000	5300-2000	2120-800	2332-880	2120-800
PERFORMANCE					
Positioner type	Linear, Stepping Motor	Linear, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	74/139	74/139	190	110	110
Average rotational delay (msec)	6/11	6/11	55	24.5	27
Average access time (msec)	80/150	80/150	245	134.5	137
Data transfer rate (MBytes/sec) Internal External	.66-1.55	.66-1.55	.614	.676	.614
Buffer/cache size (Kbytes)	128	128		128	128
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 202	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q96	2Q96	3Q94	1Q95	2Q95
COMMENTS	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. DR-S104X is external model.		

MANUFACTURER	PIONEER	PIONEER	PIONEER	PIONEER	PIONEER
DRIVE	DRD-504X	DRM-1804X	DRM-624X	DR-504X	DW-S114X
DISK/TREND GROUP	20	20	20	21	21
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Replication	Dye Polymer	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-R	CD-R
Relative speed	4X	4X	4X	4X	4X
Interface		SCSI	SCSI-2		SCSI-2
Compatibility	MS, XA	MS	MS, XA, MPC-2	MS, XA	MS, XA
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 550	F: 540	F: 540	F: 550	F: 550
Capacity per track (Bytes)	NA	N/A	N/A	NA	NA
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2120-800	2120-200	2332-880	2120-800	2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	280	300	110	110	603
Average rotational delay (msec)	27	28	18.7	27	27
Average access time (msec)	307	328	128.7	137	630
Data transfer rate (MBytes/sec)					
Internal	.614	.614	.614	.614	.614
External					
Buffer/cache size (Kbytes)	1000	256	128	1000	1000
SIZE (mm: H x W x D)	41.3 x 146 x 203	198 x 262 x 422	88.3 x 210 x 370	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	1Q95	1994	2Q95	1Q95	3Q95
COMMENTS	For use with CD library.	Integral with 18 disk changer		For use with CD library.	

MANUFACTURER	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)	PLEXTOR (SHINANO KENSHI)
DRIVE	PX 43CE PX 45CE	PX 43CS 4PleX	PX 63CS 6PleX	PX 65CS 6PleX	PX 83CS 8PleX
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4.5X	4X	6X	6X	8X
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Compatibility	MS, XA, CD-I	MS, CD-I	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2060-800	2120-800	3180-1200	3180-1200	4240-1600
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	100	133	127	127	95
Average rotational delay (msec)	30	27	18	18	20
Average access time (msec)	130	160	145	145	115
Data transfer rate (MBytes/sec) Internal External	.675 5.7	.600 2.5 asynch.	.922 5.0 synch.	.922 5.0 synch.	1.2
Buffer/cache size (Kbytes)	256	256	256	256	256
SIZE (mm: H x W x D)	41 x 146 x 202	41.3 x 146.1 x 202	41.3 x 146.1 x 202	56.9 x 177.8 x 305.6	41.7 x 147 x 202
FIRST CUSTOMER SHIPMENT			2Q95	6/95	
COMMENTS	Caddy loading.			External mount.	Caddy loading.

MANUFACTURER	RICOH	RICOH	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	RO-1060C RS-1060C	RO-1420C RS-1420C	SCDR-530	SCR-630	SCR-631
DISK/TREND GROUP	21	21	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Dye Polymer	Dye Polymer	Replication	Replication	Replication
DRIVE: Operating mode	CD-R	CD-R	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X	2X WR/4X RD	2X	4X	4X
Interface	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS	MS, XA, CD-I	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 780/660	650 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	680 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1060-400	2120-400	1060-400	3120-800	2120-800
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	300		495	190	190
Average rotational delay (msec)	35	55/27	55	27	27
Average access time (msec)	335	--/390	550	227	217
Data transfer rate (MBytes/sec) Internal External	.300	.300/.600 5.0	.300	.600	.600 11.1 PIO
Buffer/cache size (Kbytes)	512	512, 1000	256	256	128/256**
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	42.5 x 148.5 x 203	42 x 148 x 215	
FIRST CUSTOMER SHIPMENT	1Q95	1Q96	1994	3Q95	1995
COMMENTS	Caddy loading. RS-1060C is external version.	Caddy loading. Position: horizontally or vertically. RS-1420C is external vers.	*MPC-2 compliant. Tray loading.	*MPC-2 compliant. Tray loading.	*MPC-2 compliant. **Option. Tray loading.

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SANYO ELECTRIC	SANYO ELECTRIC	SANYO ELECTRIC
DRIVE	SCR-730	SCR-830	CRD-168P	CRD-256P	CRD-S54P
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	OEM, PCM	OEM	OEM, PCM	
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	6X	8X	8X	6X	4X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	3180-1200	4240-1600	4240-1600	3180-1200	2120-800
PERFORMANCE					
Positioner type	Linear	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	190	136	150	180	323
Average rotational delay (msec)	17	14	14	18	27
Average access time (msec)	207	160	164	198	350
Data transfer rate (MBytes/sec) Internal External	.9	1.2	1.2	.900	.600
Buffer/cache size (Kbytes)	128(256 option)	128(256 option)		128	128
SIZE (mm: H x W x D)	42 x 148 x 216	42 x 148 x 202	41.3 x 146 x 203	41.5 x 146 x 203	19 x 131 x 147
FIRST CUSTOMER SHIPMENT	1996	1996	3Q96	4Q95	4Q95
COMMENTS	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading.	Tray loading.	Tray loading.	Tray loading.

MANUFACTURER	SANYO ELECTRIC	SEIKO EPSON	SONY	SONY	SONY
DRIVE	CRD-R24S CRD-RS2000	CMD-2260	CDU111	CDU311	CDU50E
DISK/TREND GROUP	21	20	20	20	20
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Dye Polymer	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-R	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X WR/4X RD	6X	6X	8X	2X
Interface	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA	MS, XA, CD-I			MS, XA, MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 640	F: 540	F: 540	F: 540	F: 540
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2120-800	3180-1200	3480-1200	4640-1600	1160-400
PERFORMANCE					
Positioner type	Linear	Linear	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	300	195	162	146	135
Average rotational delay (msec)	27	18	18	14	55
Average access time (msec)	327	213	180	160	190
Data transfer rate (MBytes/sec)					
Internal	.600	.900	.900	1.2	.300
External					
Buffer/cache size (Kbytes)			128	256	256
SIZE (mm: H x W x D)	41.3 x 146 x 188.5	43 x 146 x 208	41.4 x 146 x 203	41.4 x 146 x 203	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT			2Q96	3Q96	1994
COMMENTS	Tray loading. CRD-RS2000 is external mount.	Philips mechanism. Tray loading.	Tray loading.	Tray loading.	Tray loading.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	CDU76E CSD760E	CDU76S CSD76S CSD760S	CSD-880E	CSD-7611M	DD-20 DD-22 Data Discman
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	PCM
MEDIA: Disk diameter	120 mm	120 mm	120 mm/80 mm	120 mm	80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	4X	4X	8X	4X	1X
Interface	IDE/ATAPI	SCSI-2	IDE/ATAPI	SCSI-2	--
Compatibility	MS, XA, MPC-2	MS, XA, MPC-2	MS, XA, CD-I	MS, XA, CD-I	
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 540	F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	F: 184
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	9062
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2320-800	2320-800	4240-1600	2120-800	500-300
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, DC Motor	Linear	Linear	DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	223	163	160	163	NS
Average rotational delay (msec)	27	27	14	27	
Average access time (msec)	250	190	174	190	NS
Data transfer rate (MBytes/sec) Internal External	.600	.600	1.2	.600	NS
Buffer/cache size (Kbytes)	256	256	256	1000	
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 210 x 293	41 x 166 x 113
FIRST CUSTOMER SHIPMENT	1995	1995	7/96	2Q95	1993
COMMENTS	Tray loading.	Tray loading.		Tray loading. External mount. For Macintosh.	

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	DD-2001 Data Discman	DD-25 Data Discman	DD-30 DD-30DBZ Data Discman	DD-55 Data Discman	DD-66 Data Discman
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Disk diameter	80 mm	80 mm	80 mm	80 mm	80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X	1X	1X	1X	1X
Interface			RS232C		
Compatibility					
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 184	F: 184	F: 184	F: 184	F: 184
Capacity per track (Bytes)	NA	NA	N/A	NA	NA
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	9062	9062	9062	9062	9062
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-300	500-300	500-300	500-300	500-300
PERFORMANCE					
Positioner type	DC Motor	DC Motor	DC Motor	DC Motor	DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	NS	NS	NS	NS
Average rotational delay (msec)					
Average access time (msec)	NS	NS	NS	NS	NS
Data transfer rate (MBytes/sec)					
Internal	NS	NS	NS	NS	NS
External					
Buffer/cache size (Kbytes)					
SIZE (mm: H x W x D)	39 x 160 x 110	41 x 166 x 113	34 x 160 x 111	34 x 160 x 110	34 x 160 x 110
FIRST CUSTOMER SHIPMENT	1996	1994	1993	1994	1995
COMMENTS					

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	DD-75 Data Discman	DD-DR1 Data Discman	PRD-100 PRD-105SC	PRD-150	PRD-155SB
DISK/TREND GROUP	20	20	20	20	20
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Disk diameter	80 mm	80 mm	120 mm/80 mm	120 mm/80 mm	120 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	1X	1X	2X	2X	2X
Interface		RS232C	Parallel Port	PCMCIA	PCMCIA
Compatibility			MS, MPC-2	MS, XA, MPC-2	MS, XA
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 184	F: 184	F: 540	F: 540	F: 540
Capacity per track (Bytes)	NA	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	9062	9062	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	500-300	500-300	1060-400	1060-400	1060-400
PERFORMANCE					
Positioner type	DC Motor	DC Motor	Linear	Linear	Linear, DC Motor
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	NS			
Average rotational delay (msec)					55
Average access time (msec)	NS	NS			
Data transfer rate (MBytes/sec) Internal External	NS		.300	.300	.300
Buffer/cache size (Kbytes)					128
SIZE (mm: H x W x D)	39 x 160 x 110	35 x 110 x 173		26.5 x 132.5 x 167.9	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	1996	1991	3/95	7/95	7/95
COMMENTS			Preliminary specification.	Preliminary specification.	

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	PRD-250WN	SCPH1000 Playstation	CDU920S CSP-920S CSP-9211S Spressa 920	CDU921S	CDU924S
DISK/TREND GROUP	20	20	21	21	21
MARKET	PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	120 mm
Recording technology	Replication	Replication	Dye Polymer	Dye Polymer	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-R	CD-R	CD-R
Relative speed	4X	--	2X	2X	2X WR/4X RD
Interface	PCMCIA	Proprietary	SCSI-2	SCSI-2	SCSI-2
Compatibility	MPC-2	--	MS, XA, MPC-2	MS, XA, MPC-2	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1	650 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	--	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	2120-800	NS	1060-400	1060-400	1160-400 WR
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear, DC Motor	Linear	Linear	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	250	NS	245	245	223 RD/245 WR
Average rotational delay (msec)	27	NS	55	55	27 RD/55 WR
Average access time (msec)	277	NS	300	300	250 RD/300 WR
Data transfer rate (MBytes/sec) Internal External	.600	.300	.300	.300	.600 4.0 synch.
Buffer/cache size (Kbytes)			1000	1000	1000
SIZE (mm: H x W x D)	27 x 132 x 172	60 x 270 x 188	41.4 x 146.1 x 203.2	70 x 210 x 293	41.4 x 146 x 203
FIRST CUSTOMER SHIPMENT	1996	4Q94	1Q95	1Q95	2Q96
COMMENTS			Caddy required. CSP-9211S is external mount.	External mount. Caddy required.	

MANUFACTURER	SONY	SONY	TAE-IL MEDIA	TAE-IL MEDIA	TATUNG
DRIVE	CDW-900E	Spressa 940 Spressa 9411	CDD-6001	CDD-6801	CD-650E
DISK/TREND GROUP	21	21	20	20	20
MARKET	Captive	OEM, PCM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	120 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Dye Polymer	Dye Polymer	Replication	Replication	Replication
DRIVE: Operating mode	CD-R	CD-R	CD-ROM	CD-ROM	CD-ROM
Relative speed	2X	2X WR/4X RD	6X	8X	6X
Interface	SCSI	SCSI-2	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility		CD-ROM, CDRFS	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 680	650 Mode 2 F: 553 Mode 1	F: 540 Mode 1	F: 540 Mode 1	742 Mode 2 F: 650 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	1000-200	2120-400	3180-1200	4240-1600	3180-1200
PERFORMANCE					
Positioner type	Linear, DC Motor	Linear	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	NS	--/230	160	160	180
Average rotational delay (msec)	NS	27	18	18	40
Average access time (msec)	NS	--/257	220	220	220
Data transfer rate (MBytes/sec) Internal External	.150-.300	.307/.614	.900	1.200	.9
Buffer/cache size (Kbytes)		1000	256	256	256
SIZE (mm: H x W x D)	88 x 424 x 411	41.3 x 146 x 203	41.5 x 146 x 203	41.5 x 146 x 203	41.5 x 146 x 203
FIRST CUSTOMER SHIPMENT	1992	6/96	4Q95	2Q96	1995
COMMENTS	Sold only with mastering system.	9411 is external model.			*MPC-2 compliant. Tray loading.

MANUFACTURER	TATUNG	TEAC	TEAC	TEAC	TEAC
DRIVE	CD-652E	CD-36E	CD-44E	CD-46E	CD-56E
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Dye Polymer	Replication	Dye Polymer	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	6X	4X	6X	6X
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, MPC-2	MS, XA, MPC-2	MS, MPC-2	MS, XA, MPC-2
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	742 Mode 2 F: 650 Mode 1	650 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1	650 Mode 2 F: 540 Mode 1	635 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-1600	1200-3180	2120-800	1200-3180	3180-1200
PERFORMANCE					
Positioner type	Linear	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	180	230	350	190	110
Average rotational delay (msec)	40	18	27	18	18
Average access time (msec)	220	248	377	208	128
Data transfer rate (MBytes/sec) Internal External	1.2	.900	.600	.900	.900
Buffer/cache size (Kbytes)	256	128	128	128	256
SIZE (mm: H x W x D)	41.5 x 146 x 203	13.7 x 131 x 140.5	17 x 131 x 140.5	17 x 131 x 140.5	41.3 x 146 x 192
FIRST CUSTOMER SHIPMENT	1996	2Q96	3Q95	2Q96	3Q95
COMMENTS	*MPC-2 compliant. Tray loading.	For Notebook computer.	For Notebook computer.	For Notebook computer.	Tray loading.

MANUFACTURER	TEAC	TEAC	TEAC	TOSHIBA	TOSHIBA
DRIVE	CD-56S	CD-58E	CD-R50S	DVD	XM-1302B
DISK/TREND GROUP	20	20	21	20	20
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm	120 mm/80 mm	120 mm	120 mm
Recording technology	Replication	Replication	Dye Polymer	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-R	DVD-ROM	CD-ROM
Relative speed	6X	8X	4X WR/4X RD	9X	4X
Interface	SCSI-2	IDE/ATAPI	SCSI-2	IDE/ATAPI*	IDE/ATAPI
Compatibility	MS, XA, MPC-2	MS, XA, CD-I	PC, XA, CD-I	CD-ROM, MPC-3	MS, XA, CD-I
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 540	F: 635 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1	F: 4700/surface	635 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1, 2	1
Tracks per surface	20750	20750	20750		21250
Track density (TPI)	15875	15875	15875	34324	15875
Maximum linear density (BPI)	27600	27600	27600	96000	25400
Rotational speed (RPM)	3180-1200	4240-1600	2400-800		2120-800
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear	Linear, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	110	110	193		170
Average rotational delay (msec)	18	30	27		30
Average access time (msec)	128	140	220		200
Data transfer rate (MBytes/sec)					
Internal	.900	1.200	.600	1.350	.600
External				11.1/5.0*	8.3
Buffer/cache size (Kbytes)	256	128	1000		
SIZE (mm: H x W x D)	41.3 x 146 x 192	41.3 x 146 x 192	41.3 x 146 x 192	41.5 x 146 x 203	17 x 128 x 136.4
FIRST CUSTOMER SHIPMENT	3Q95	1996	7/96	4Q96	4Q95
COMMENTS	Tray loading.	Tray loading.	Tray loading.	Preliminary specification. *SCSI-2 version will be avail.	Tray loading.

MANUFACTURER		TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE		XM-1402B	XM-3701B XM-3701D	XM-5401B	XM-5402B XM-5422B	XM-5522B
DISK/TREND GROUP		20	20	20	20	20
MARKET		OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
	Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE:	Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
	Relative speed	6X	6-7X	4X	4X	6X
	Interface	IDE/ATAPI	SCSI-2	SCSI-2	IDE/ATAPI	IDE/ATAPI
	Compatibility	MS, XA, MPC-3	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*
	Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY						
Total capacity (Mbytes)		635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	650 Mode 2 F: 540 Mode 1
Capacity per track (Bytes)		N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle		1	1	1	1	1
Tracks per surface		21250	21250	21250	21250	21250
Track density (TPI)		15875	15875	15875	15875	15875
Maximum linear density (BPI)		25400	25400	25400	25400	25400
Rotational speed (RPM)		3180-1200	3550-1340	2120-800	2120-800	3180-1200
PERFORMANCE						
Positioner type		Linear, Lead Screw	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear, Rack & Pinion
Servo type		Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		160	120	150	150	150
Average rotational delay (msec)		30	15	40	40	20
Average access time (msec)		190	135	190	190	170
Data transfer rate (MBytes/sec)	Internal	.900	1.000	.600	.600	.900
	External	11.1	5.0 synch.	4.2 synch.	8.3 synch.	11.1
Buffer/cache size (Kbytes)			256	256	128**/256	128
SIZE (mm: H x W x D)		17 x 128 x 136.4	41.5 x 146 x 196	41.5 x 146 x 190	41.5 x 146 x 190	41.5 x 146 x 190
FIRST CUSTOMER SHIPMENT		1Q96	3Q95	4Q95	4Q95	
COMMENTS		Tray loading.	*MPC-3 compliant. Tray loading. XM-3701D is external mount.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading. **XM-5422B has 128K buffer.	*MPC-3 compliant. Tray loading.

MANUFACTURER	TOSHIBA	TOSHIBA	UMAX DATA SYSTEMS	UMAX DATA SYSTEMS	UMAX DATA SYSTEMS
DRIVE	XM-5601B XM-5601D	XM-5602B	CD-12X	CD-IS602	CD-IS801
DISK/TREND GROUP	20	20	20	20	20
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Replication
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-ROM
Relative speed	8X	8X	12X	6X	8X
Interface	SCSI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 540 Mode 1	635 Mode 2 F: 540 Mode 1	660 Mode 2 F: 553 Mode 1	660 Mode 2 F: 553 Mode 1	660 Mode 2 F: 553 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	21250	21250	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	25400	25400	27600	27600	27600
Rotational speed (RPM)	4240-1600	4240-1600	6360-2400	3180-1200	4240-1600
PERFORMANCE					
Positioner type	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear	Linear	Linear
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	130	130	190	200	190
Average rotational delay (msec)	15	15	10	18	10
Average access time (msec)	145	145	200	218	200
Data transfer rate (MBytes/sec)					
Internal	1.2	1.2	1.8	.9	1.2
External	5.0	11.1 PIO Mode 3			
Buffer/cache size (Kbytes)	256	256	256	128	256
SIZE (mm: H x W x D)	41.5 x 146 x 190	41.5 x 146 x 190	41.3 x 146 x 203	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT			1996	1995	1996
COMMENTS	*MPC-3 compliant. Tray loading. XM-5601D is external mount.	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading. Hitachi mechanism. Prelimary spec.	*MPC-3 compliant. Tray loading. Philips mechanism.	*MPC-3 compliant. Tray loading. Hitachi mechanism.

MANUFACTURER	UNITRON	UNITRON	WEARNES PERIPHERALS	WEARNES PERIPHERALS	WEARNES PERIPHERALS
DRIVE	UCD08D	UCD08N	CDD-620	CDD-820	WPI CDR-230
DISK/TREND GROUP	20	20	20	20	21
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm	120 mm/80 mm
Recording technology	Replication	Replication	Replication	Replication	Dye Polymer
DRIVE: Operating mode	CD-ROM	CD-ROM	CD-ROM	CD-ROM	CD-R
Relative speed	8X	8X	6X	8X	2X WR/4X RD
Interface	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	IDE/ATAPI	SCSI-2
Compatibility	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*	MS, XA, CD-I*
Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	635 Mode 2 F: 553 Mode 1	740 Mode 2 F: 550 Mode 1
Capacity per track (Bytes)	N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	20750	20750	20750	20750	20750
Track density (TPI)	15875	15875	15875	15875	15875
Maximum linear density (BPI)	27600	27600	27600	27600	27600
Rotational speed (RPM)	4240-1600	4240-1600	3180-1200	4240-1600	2160-400
PERFORMANCE					
Positioner type	Linear, Rack & Pinion	Linear, Rack & Pinion	Linear	Linear	Linear, WORM, Gear, Lead Screw
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	195	195	185	185	350
Average rotational delay (msec)	13	13	18	14	55 WR/27 RD
Average access time (msec)	208	208	203	199	405 WR/377 RD
Data transfer rate (MBytes/sec) Internal External	1.22	1.22	.900	1.2	.300 WR/.600 RD
Buffer/cache size (Kbytes)	256	128	256	256	1000
SIZE (mm: H x W x D)	41 x 146 x 208	17 x 130 x 140	42 x 149 x 210.5	42 x 149 x 210.5	42 x 149 x 210.5
FIRST CUSTOMER SHIPMENT	6/96	6/96	3Q95	1Q96	2Q96
COMMENTS	*MPC-3 compliant. Tray loading.	*MPC-3 compliant. Tray loading. For Notebook computer.	*MPC-2 compliant. Tray loading.	*MPC-2 compliant. Tray loading.	*MPC-2 compliant. Tray loading.

MANUFACTURER		WEARNES PERIPHERALS	YAMAHA	YAMAHA	YAMAHA	YAMAHA
DRIVE		WPI CDR-432	CDE-100II	CDE-102	CDR-100	CDR-102
DISK/TREND GROUP		21	21	21	21	21
MARKET		OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA:	Disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	120 mm
	Recording technology	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer	Dye Polymer
DRIVE:	Operating mode	CD-R	CD-R	CD-R	CD-R	CD-R
	Relative speed	2X WR/4X RD	4X	2X WR/4X RD	4X	2X WR/4X RD
	Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
	Compatibility	MS, XA, CD-I*	MS, XA, CD-A	MS, XA, CD-I	MS, XA, CD-I	MS, XA, CD-I
	Speed control & zones	CLV	CLV	CLV	CLV	CLV
CAPACITY/RECORDING DENSITY						
Total capacity (Mbytes)		740 Mode 2 F: 550 Mode 1	661 Mode 2 F: 580 Mode 1	681 Mode 2 F: 581 Mode 1	661 Mode 2 F: 580 Mode 1	681 Mode 2 F: 581 Mode 1
Capacity per track (Bytes)		N/A	N/A	N/A	N/A	N/A
Data surfaces per spindle		1	1	1	1	1
Tracks per surface		20750	20750	20750	20750	20750
Track density (TPI)		15875	15875	15875	15875	15875
Maximum linear density (BPI)		27600	29870	29870	29870	29870
Rotational speed (RPM)		2160-400	2000-800	2120-400	2000-800	2120-400
PERFORMANCE						
Positioner type		Linear, WORM, Gear,Lead Screw	Linear, Voice Coil	Linear	Linear, Voice Coil	Linear
Servo type		Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)		350	NS	NS	NS	NS
Average rotational delay (msec)		55 WR/27 RD	NS	NS	NS	NS
Average access time (msec)		405 WR/377 RD	500	500	500	500
Data transfer rate (MBytes/sec)	Internal	.300 WR/.600 RD	.614/.307/.153	.600 RD/.30 WR	.614/.307/.153	.600 RD/.30 WR
	External		2.0 asynch.	2.0 asynch.	2.0 asynch.	2.0 asynch.
Buffer/cache size (Kbytes)		1000	512	512	512	512
SIZE (mm: H x W x D)		42 x 149 x 210.5	61.7 x 170 x 315	62 x 170 x 315	41.3 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT		3Q96	3Q95	4Q95	1Q94	4Q95
COMMENTS		*MPC-2 compliant. Tray loading.	External mount. Caddy loading.	Caddy loading.	Caddy loading.	Caddy loading.

MANUFACTURER	YUNG FU (LXYCON)	YUNG FU (LXYCON)			
DRIVE	CDX-600	CDX-800			
DISK/TREND GROUP	20	20			
MARKET	OEM, PCM	OEM, PCM			
MEDIA: Disk diameter	120 mm/80 mm	120 mm/80 mm			
Recording technology	Replication	Replication			
DRIVE: Operating mode	CD-ROM	CD-ROM			
Relative speed	6X	8X			
Interface	IDE/ATAPI	IDE/ATAPI			
Compatibility	MS, XA, CD-I	MS, XA, CD-I			
Speed control & zones	CLV	CLV			
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 635	F: 635			
Capacity per track (Bytes)	N/A	N/A			
Data surfaces per spindle	1	1			
Tracks per surface	20750	20750			
Track density (TPI)	15875	15875			
Maximum linear density (BPI)	27600	27600			
Rotational speed (RPM)	3180-1200	4240-1600			
PERFORMANCE					
Positioner type	Linear	Linear			
Servo type	Continuous	Continuous			
Average positioning time (msec)	200	187			
Average rotational delay (msec)	17	13			
Average access time (msec)	217	200			
Data transfer rate (MBytes/sec) Internal	.914	1.22			
External					
Buffer/cache size (Kbytes)	128	128			
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203			
FIRST CUSTOMER SHIPMENT	1995	1Q96			
COMMENTS	Tray loading. Philips mechanism.	Tray loading. Philips mechanism.			

READ/WRITE OPTICAL DISK DRIVE SPECIFICATIONS

1996 DISK/TREND REPORT

OPTICAL DISK DRIVE SPECIFICATIONS

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

Recording technology: The type of recording layer is indicated (magneto-optic, phase change, dye-polymer, etc.).

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

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

Speed control: The following abbreviations are used:

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

Capacities: Capacities are listed as "U" for unformatted and "F" for formatted. For optical drives that can access only one side of the media, 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.

Positioner type: Optical disk drives have compound head positioning systems. A coarse movement positions the head near the track to be located. A fine, or vernier, actuator then positions the head on the desired track and also maintains correct focus. Unless otherwise indicated, a vernier actuator is always present.

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

the use of this definition, so while the values given for these specifications are believed to be accurate, they should be accepted with caution and individual drive manufacturers contacted for details.

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

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

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

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.

1996 DISK/TREND optical disk product groups

For the 1996 report, products are classified in eight groups.

Optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.
Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 51: Optical disk libraries with 1 to 39 cartridge capacity.
Group 52: Optical disk libraries with 40 to 69 cartridge capacity.
Group 53: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER	ASACA	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
DRIVE	AMD-1341NS	GD 16000	GD 6000	GD 6001	GD 9001
DISK/TREND GROUP	22	23	23	23	23
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	300 mm	300 mm	300 mm	300 mm
Recording technology	Magneto-Optic	Ablative	Ablative	Ablative	Ablative
DRIVE: Operating mode	Rewritable	Write Once	Write Once	Write Once	Write Once
Interface	SCSI-2	SCSI-2	SCSI	SCSI	SCSI, SCSI-2
Speed control & zones	CAV	ZCAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 598	F: 16000 F: 16000	F: 3200	F: 3200	F: 4500
Capacity per track (Bytes)	N/A	N/A	F: 52428	F: 52428	N/A
Data surfaces per spindle	1	2	1	1	1
Tracks per surface	20800	86667	62500	62500	82000
Track density (TPI)	16933	28200	25400	25400	25400
Maximum linear density (BPI)	34795		28200	28200	25400
Rotational speed (RPM)	3000	1042	1143	1143	914
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear Motor	Linear Motor	Linear Motor
Servo type	Continuous	Sampled	Sampled	Sampled	Sampled
Average positioning time (msec)	160	90	90	90	90
Average rotational delay (msec)	10	29	26.2	26.2	33
Average access time (msec)	170	119	116.2	116.2	123
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	12.24/10.0*	3.3	1.0	1.0	1.0
Buffer/cache size (Kbytes)					
SIZE (mm: H x W x D)	430 x 312 x 600	178 x 430 x 580	174 x 440 x 530	174 x 440 x 530	177 x 482 x 532.5
FIRST CUSTOMER SHIPMENT	3/93	3Q96	3Q89	4Q90	1991
COMMENTS	Proprietary format. *Maximum SCSI rate.	Read compatibility for GD 6001.		Differs from GD 6000 in the cartridge (single operation loading).	Can read GD 6000 disks.

MANUFACTURER	ATG CYGNET	CANON	CANON	EASTMAN KODAK	EASTMAN KODAK
DRIVE	GD 9001/S GD 9001S/E	MO-5001S	OM-500D	ODW25	System 2000
DISK/TREND GROUP	23	22	22	23	23
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Disk diameter	300 mm	130 mm	130 mm	356 mm	356 mm
Recording technology	Ablative	Magneto-Optic	Magneto-Optic	Phase Change	Phase Change
DRIVE: Operating mode	Write Once	Rewritable	Rewritable	Write Once	Write Once
Interface	SCSI, SCSI-2	SCSI	Modified ESDI	SCSI-2	SCSI-2
Speed control & zones	ZCAV	CAV	CAV	MCAV-S	MCAV-S
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 5100	F: 256	F: 256	F: 25000 F: 25000	F: 7412 F: 14824
Capacity per track (Bytes)	N/A	F: 16384	F: 16384	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	82000	15728	15728	104824	104824
Track density (TPI)	25400	15875	15875	25399	25399
Maximum linear density (BPI)	25400	21082	21082	39687	25200
Rotational speed (RPM)	914	3000	3000	2232-948	1362-654
PERFORMANCE Positioner type	Linear Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Sampled	Continuous	Continuous	Sampled	Sampled
Average positioning time (msec)	90	80	80	170	137
Average rotational delay (msec)	33	10	10	17	33
Average access time (msec)	123	90	90	187	170
Spin-up/Spin-down times (sec)				2.5/1.5	2.4/1.4
Data transfer rate (MBytes/sec) Internal External	1.0	1.138	1.138	2.4 5/10/20	1.0 5/10/20
Buffer/cache size (Kbytes)				128	128
SIZE (mm: H x W x D)	177 x 482 x 532.5	137 x 185 x 365	82.6 x 146.1 x 203	241 x 445 x 678	800 x 455 x 714*
FIRST CUSTOMER SHIPMENT	2Q92	3/90	4Q88	4Q96	3Q94
COMMENTS	Can read GD 6000 disks and read/write GD 9001.	SCSI controller available. Exchange coupled MO media. External mount.	SCSI controller available. Exchange coupled MO media.		*Includes controller.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	2512A MOcity	F6445A11	IFD1300A	M2511A DynaMO 128	M2512A DynaMO 230
DISK/TREND GROUP	22	22	22	22	22
MARKET	PCM	Captive	PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	86 mm	130 mm	130 mm	86 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Multifunct-(MO)	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	CAV/ZCAV	CAV	CAV/ZCAV	CAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 128/230	F: 326.4	F: 595/652*	F: 128	F: 128/230
Capacity per track (Bytes)	F: 12800/N/A	F: 17408	F: 17408	F: 12800	F: 12800/12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	18751	21600	10000	10000/17940
Track density (TPI)	15875/18273	15875	18273	15875	15875/18275
Maximum linear density (BPI)	24400/29296	24923	29540	24400	24400/29300
Rotational speed (RPM)	3600	5400	3000	3600	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	30	35	39	30	30
Average rotational delay (msec)	8.3	5.6	10	8.3	8.3
Average access time (msec)	38.3	40.6	49	38.3	38.3
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	1.3-2.1 5.0 synch.	2.08 4.1 synch.	2.0 max.	1.09 4.0 synch.	1.3-2.1 5.0 synch.
Buffer/cache size (Kbytes)	256		1000	256	256
SIZE (mm: H x W x D)	25.4 x 101.6 x 146	82 x 146.1 x 208		25.4 x 101.6 x 146.1	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1995	6/92	1995	1992	3/94
COMMENTS	Sold in Europe.	Direct overwrite, 3 beam head. Sold in Japan.	*512/1024 bytes per sector. Purchased mechanism. Sold in Europe.	DynaMO is external subsystem.	DynaMO is external subsystem.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2513A Cat-4	M2541B DynaMO 230 Portable	M2541BD MicroCat-3	M2541BF Pismo	M2541BS PCMCIA
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	IDE	IDE	Power Book	PCMCIA
Speed control & zones	CAV	CAV/ZCAV	CAV	CAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 640/540	F: 128/230	F: 128/230	F: 128/230	F: 128/230
Capacity per track (Bytes)	F: 34816/12800	F: 12800/N/A	F: 12800	F: 12800	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	18480/42042	10000/17940	10000/17940	10000/17940	10000/17940
Track density (TPI)	23090	15875/18275	15875/18275	15875/18275	15875/18275
Maximum linear density (BPI)	52900	24400/29300	24400/29300	24400/29300	24400/29300
Rotational speed (RPM)	3600	2700	2700	2700	2700
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	30	70	70	65	70
Average rotational delay (msec)	8.3	11	11.1	11.1	11.1
Average access time (msec)	38.3	81	81.1	76.1	81.1
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	2.3-3.9 5.0/10.0 synch.	.975-1.575	1.0-1.6	1.0-1.6	1.0-1.6
Buffer/cache size (Kbytes)	2000/512	128	128	128	128
SIZE (mm: H x W x D)	25.4 x 101.6 x 146	17 x 101.6 x 140	17.2 x 101.6 x 140	17.2 x 101.6 x 140	25.3 x 113.5 x 164.8
FIRST CUSTOMER SHIPMENT	4/96	10/95	1996	1996	1996
COMMENTS	DynaMO is external subsystem.	DynaMO is external subsystem. Direct overwrite.			

MANUFACTURER	FUJITSU	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI
DRIVE	M2541S MicroMO	C1113F 2600fx	OD101-1	OD112-1	OD152 OL-F152 OU152
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	Captive, OEM	Captive, OEM	OEM, PCM
MEDIA: Disk diameter	86 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Ablative	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Multifunct-(MO)	Write Once	Rewritable	Multifunct-(MO)
Interface	PCMCIA	SCSI-2	SCSI	SCSI	SCSI-2
Speed control & zones	CAV/ZCAV	MCAV	CAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 128/230	F: 1300	F: 300	F: 322	F: 1012
Capacity per disk (Mbytes)	F: 128/230	F: 2600		F: 644	F: 2024
Capacity per track (Bytes)	F: 12800/N/A	N/A	F: 16400	F:. 17408	Varies by zone
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	75732*	18624	18751	22440
Track density (TPI)	15875/18273		16000	16000	18947
Maximum linear density (BPI)	24400/29296*		24000	24000	45340*
Rotational speed (RPM)	2700	3000/3600**	1800	2400	3000
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	65	25	93	62.5	40
Average rotational delay (msec)	11	10	16.7	12.5	10
Average access time (msec)	76	35	109.7	75	50
Spin-up/Spin-down times (sec)	7/6	5.5/3.0			
Data transfer rate (MBytes/sec)					
Internal	1.0-1.6	3.4	.690	.925	1.54-3.02
External	8.0				
Buffer/cache size (Kbytes)	128(512 option)	1000			
SIZE (mm: H x W x D)	25.3 x 113.5 x 164.8		83 x 146.1 x 213	107 x 146.1 x 220	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q96	2/96	2Q87	7/89	4Q93
COMMENTS	*2,7 RLL Code. Battery pack available.	2600fx is external mount. *Logical tracks **With lower capacity media. 1,7 RLL Code.		ISO standard.	*1,7 RLL Code. OL-F152 for libraries. OU152 is external mount.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	KONICA
DRIVE	OD172 OU172	OD172-11 OD172 DOW	OL-F172	OD321-1 OD321-2	OMD-7060
DISK/TREND GROUP	22	22	22	23	22
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	300 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Ablative	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Write Once	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI	
Speed control & zones	MCAV	MCAV	MCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 1300	F:322/1012/1303	F: 1300	F: 3500	F: 128/230/640
Capacity per disk (Mbytes)	F: 2607	F:644/2024/2607	F: 2607		F: 128/230/640
Capacity per track (Bytes)	F: 17400	Varies by zone	F: 17400	N/A	F:
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	74883 (logical)	74883 (logical)	74883 (logical)	48035	
Track density (TPI)	23000	23000	23000	17000	
Maximum linear density (BPI)	50000*	50000*	50000*	33200	
Rotational speed (RPM)	3000	3000	3000	1000	
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	39	39	39	120	
Average rotational delay (msec)	10	10	10	30	
Average access time (msec)	49	49	49	150	
Spin-up/Spin-down times (sec)	7.5/4.5: 5/2.5	7.5/4.5	7.5/4.5: 5/2.5		
Data transfer rate (MBytes/sec)					
Internal	2.3-4.6	2.3-4.6	2.3-4.6	1.16-2.22	
External	10.0 synch.	10.0 synch.	10.0 synch.		
Buffer/cache size (Kbytes)	1000	1000	1000		
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203	82.8 x 146 x 203	160 x 430 x 660	25 x 101.6 x 150
FIRST CUSTOMER SHIPMENT	1Q96	3Q96	1Q96	1Q91	3Q96
COMMENTS	*1,7 RLL Code. Mark-edge recording. OU is external mount.	*1,7 RLL Code. LIM Direct Overwrite: will replace OD172.	*1,7 RLL Code. Mark-edge recording.	Pit-edge recording. Glass substrate 321-2 used in libraries.	Preliminary specification.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
DRIVE	LF-3100 LF-3104	LF-3200JA	LF-3200JD	LF-3294	LF-5300A
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Ablative
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Write Once
Interface	SCSI-2	SCSI	SCSI	SCSI	SCSI-2
Speed control & zones	CAV	ZCAV	ZCAV	ZCAV	MCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 128	F: 229.1	F: 229.1	F: 229.1	F: 700
Capacity per track (Bytes)	F: 12800	F: 12800*	F: 12800*	F: 12800*	F:
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000	11510/17853*	11510/17853*	11510/17853*	25920
Track density (TPI)	15875	18273	18273	18273	21770
Maximum linear density (BPI)	24440	29540	29540	29540	--
Rotational speed (RPM)	3000	3600	3600	3600	2400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Voice Coil	Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	40	35	35	35	45
Average rotational delay (msec)	10	8.3	8.3	8.3	12.5
Average access time (msec)	50	43.3	43.3	43.3	57.5
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	.906 1.5 avg.	2.1 5.0 synch.	2.1 5.0 synch.	2.1 5.0 synch.	.74-1.44 5.0 synch.
Buffer/cache size (Kbytes)		256	256	256	
SIZE (mm: H x W x D)	41.3 x 101.6 x 146	56 x 168 x 240	56 x 168 x 240	41.3 x 101.6 x 151.5	74 x 220 x 323
FIRST CUSTOMER SHIPMENT	3Q91	3Q94	3Q94	2Q94	4Q93
COMMENTS	LF-3100 is external mount. Sold in Japan.	*Logical tracks External mount. For use with Macintosh.	*Logical tracks External mount. For use w/DOS, PC-9800 and Panacom systems	*Logical tracks	External mount.

1996 DISK/TREND REPORT

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MAXOPTIX	MAXOPTIX
DRIVE	LF-7300A LF-7300J1	LF-7304	LF-7394	T3-1300	T4-1300
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Phase Change	Phase Change	Phase Change	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(PC)	Multifunct-(PC)	Multifunct-(PC)	Multifunct-(MO)	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	ZCAV	ZCAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 750	F: 750	F: 750/700*	F: 650/512/326 F:1300/1024/654	F: 650/512/322 F:1300/1024/654
Capacity per track (Bytes)	N/A	N/A	N/A	F:	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	25920	25920	25920	37600/25000	37600/25000
Track density (TPI)	21770	21770	21700	18273/16933	18273/16933
Maximum linear density (BPI)				29540*	29540*
Rotational speed (RPM)	2400	2400	2400	3375/4000/4800	3000
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	45	45	45	19	39
Average rotational delay (msec)	12.5	12.5	12.5	6.25/7.5/8.9	10
Average access time (msec)	57.5	57.5	57.5	25.25	49
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	.78-1.56 5.0 synch.	.78-1.56 5.0 synch.	.78-1.56 .740-1.44*	2.2/1.1	2.0 4.0 synch.
Buffer/cache size (Kbytes)				1000-4000	1024
SIZE (mm: H x W x D)	74 x 220 x 323	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	82.6 x 146 x 203	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	4Q93	4Q93	4Q93	5/93	1/95
COMMENTS	External mount. J1 version sold in Japan.		*With WORM media.	*2,7 RLL Code.	*2,7 RLL Code.

MANUFACTURER	MAXOPTIX	MOST	MOST	MOUNTAIN OPTECH	MOUNTAIN OPTECH
DRIVE	T4-2600	Jupiter 1 RMD 525	Jupiter 2 RMD 626	CS-250 R/W SE-250 R/W SI-250 R/W ST-250 R/W	CS-1000 M/F SE-1000 M/F SS-1000 M/F ST-1000 M/F SEL-1000 M/F
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	86 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	MO (LIM-DOW)	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Rewritable	Rewritable
Interface	SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI	SCSI
Speed control & zones	CAV	CAV/ZCAV	CAV/ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 1300/652/322 F:2607/1304/644	F: 325/650/1300 F:650/1300/2600	F: 325/650/1300 F:650/1300/2600	F: 230	F: 512/326.4 F: 1024/652.8
Capacity per track (Bytes)	N/A	N/A	N/A	F: 12800	F: 25000/17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface		26086*	26086	11510/17853*	25000
Track density (TPI)		22087	22087	18273	16933
Maximum linear density (BPI)		50160	50160	29540	25000
Rotational speed (RPM)	3000	3600/2432/1900	3600	3600	2200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	39	24	24	40	35
Average rotational delay (msec)	10	15.8	8.3	8.3	13.6
Average access time (msec)	49	39.8	32.3	48.3	48.6
Spin-up/Spin-down times (sec)	7.6/4.5	3.7/2.5	3.7/2.5		
Data transfer rate (MBytes/sec) Internal External	3.37 10.0 synch.	2.1 5.0 synch.	4.055 5.0 synch.	1.475 max.	1.25/.880
Buffer/cache size (Kbytes)	1024	1000	1000/4000	64	4000
SIZE (mm: H x W x D)	41.3 x 146 x 203	41.3 x 146 x 203.2	41.3 x 146 x 203.2	44.5 x 117.5 x 206.4	
FIRST CUSTOMER SHIPMENT	4Q95	12/95	6/96	1Q95	2Q91
COMMENTS		*75721 logical tracks. Updatable microcode.	Direct over-write (LIM-DOW) compatible. Updatable microcode. Diff. SCSI opt.	Ruggedized. *Logical tracks CS-250 is commercial version.	Ruggedized version of Maxtor Tahiti. SE-1000 is for military use.

MANUFACTURER	MOUNTAIN OPTECH	MOUNTAIN OPTECH	NEC	NEC	NEC
DRIVE	RM-2000 M/F	ST-2600	N1137-04 N7915-11 N7915-84 PC-0D102	N1137-57 N7915-85 0DD-155 PC-0D502	0D-1301
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM	Captive	Captive	PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Multifunct-(MO)
Interface	SCSI	SCSI	SCSI	SCSI	SCSI-2
Speed control & zones	ZCAV	ZCAV	CAV	ZCAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 512/326.4 F: 1024/652.8	F: 325/650/1300 F:650/1300/2600	F: 305	F: 680/325	F: 600/300
Capacity per track (Bytes)	F: 25000/17408	F:	F: 17408	N/A	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	25000	74883 (logical)	18751	21600*	21600*
Track density (TPI)	16933	23000	15375	18273	18273
Maximum linear density (BPI)	25000	50000	25000	29540	29540
Rotational speed (RPM)	2200	3375-4800	3000	4200/3000	4200/3000
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35	39	60	32	29
Average rotational delay (msec)	13.6	10	10	10/7	10/7
Average access time (msec)	48.6	49	70	42/39	39/36
Spin-up/Spin-down times (sec)		7.5/4.5			
Data transfer rate (MBytes/sec) Internal External	1.25/.880	5.0 synch.	1.5	1.94	
Buffer/cache size (Kbytes)	4000	1024			1000
SIZE (mm: H x W x D)		41.9 x 146.1 x 203.2	130 x 170 x 280	41.3 x 146.1 x 203.2	75 x 170 x 310
FIRST CUSTOMER SHIPMENT	3Q95	1996	1Q91	3Q93	
COMMENTS	2 ruggedized drives in 19" rack.			*37600 logical tracks. 0DD-155 is external package.	*37600 logical tracks. Externally packaged 0DD-155.

MANUFACTURER	NEC	NEC	NIKON	NIKON	OLYMPUS
DRIVE	ODD-160	N6513-23 N7913	DD53-B1 DD53-S1	DD121-1AJ DD121-1AS	230MO Plus* 230MO Turbo
DISK/TREND GROUP	22	23	22	23	22
MARKET	OEM	Captive	OEM, PCM	OEM	OEM, PCM
MEDIA: Disk diameter	130 mm	300 mm	130 mm	300 mm	86 mm
Recording technology	Magneto-Optic	Ablative	Magneto-Optic*	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Write Once	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	Prop., SCSI	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	ZCAV	MCAV	ZCAV	CAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 1300	F: 2500	F: 325/650/1300 F:650/1300/2600	F: 4000*	F: 230/128
Capacity per track (Bytes)	N/A	F: NS	F:	F:102442/108222	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	2600	49000	37441**	41881/41196	11500
Track density (TPI)	21200	16940	23000	15875	18273
Maximum linear density (BPI)	51000	25000	50000	30600	29300
Rotational speed (RPM)	3000	600	3600	1000	4200
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35	150	24	73	28
Average rotational delay (msec)	10	50	8.3	30	7.1
Average access time (msec)	45	200	32.3	103	35.1
Spin-up/Spin-down times (sec)	2.5		5.5/3.1		
Data transfer rate (MBytes/sec) Internal External	1.69-3.38	.900	4.0 10.0	1.77/2.01	1.075-1.72/.896
Buffer/cache size (Kbytes)	4000		1000, 4000 opt.	256	1000*
SIZE (mm: H x W x D)	42 x 148 x 295.2		41.3 x 146 x 208.3	400 x 630 x 170	
FIRST CUSTOMER SHIPMENT	1Q96	6/90	3Q96	1Q94	10/94
COMMENTS	Direct overwrite, 2 beam head.		*LIM-DOW. **Logical tracks.	*Sector size 512B/1024B. AJ model is for optical library	*Includes cache

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS	OLYMPUS
DRIVE	MOS320E MOS320S MOS321E* MOS321S*	MOS330E MOS330S MOS331E* MOS331S*	MOS520E MOS520S	MOS525E	MOS540E
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	86 mm	86 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV	ZCAV	ZCAV/CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 230/128	F: 230/128	F: 650/325	F: 595/650*	F: 327/654/1300 F:654/1308/2600
Capacity per track (Bytes)	F: 12800	F: 12800	F: 17408	F: 17408	F: 17836
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11500**	11500**	18750*	21600**	26040*
Track density (TPI)	18273	18273	18273/15875	18273	22030
Maximum linear density (BPI)	29300	29300	31005/27597	29540	31500
Rotational speed (RPM)	4500	4200	3000/4500	3500	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	26	27	56/54	29	26
Average rotational delay (msec)	7.1	7.1	10/6.67	8.57	8.3
Average access time (msec)	33.1	34.1	66/60.67	37.57	34.3
Spin-up/Spin-down times (sec)					2.5/2.2
Data transfer rate (MBytes/sec) Internal External	1.075-1.84/.896	1.075-1.72/.896	1.2-2.3/1.0	1.750	1.78-4.06 5.0
Buffer/cache size (Kbytes)	256, 1000*	256, 1000*	1000**	1000***	4000
SIZE (mm: H x W x D)	41.3 x 101.6 x 160	25.4 x 101.6 x 153.5	82.6 x 146.1 X 205	41.3 x 146.1 x 205	41.3 x 146 x 203
FIRST CUSTOMER SHIPMENT	2Q94	2Q96	11/93	5/94	1Q96
COMMENTS	*1 MB optional. **17900 logical tracks.	*1 MB optional. **37600 logical tracks.	*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.

MANUFACTURER	OLYMPUS	PHILIPS LMS	PHILIPS LMS	PINNACLE MICRO	PINNACLE MICRO
DRIVE	SYS-230	LD 4100	LD 6100	Vertex	Apex
DISK/TREND GROUP	22	23	23	22	23
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	86 mm	300 mm	300 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Ablative	Ablative	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Write Once	Write Once	Multifunct-(MO)	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2/HPAC
Speed control & zones	CAV/ZCAV	CAV	CAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 128/230	F: 5600	F: 12000	F: 1300	F: 2301
Capacity per disk (Mbytes)	F: 128/230			F: 2600	F: 4602
Capacity per track (Bytes)	F: 12800	F: 49808	F: NS	F:	F: 38912/88064
Data surfaces per spindle	1	2	2	1	1
Tracks per surface	11500*	57301	63000		36300 (user)
Track density (TPI)	18273	16925-23132	NS	22087	25400
Maximum linear density (BPI)	29300	NS	NS		63342*
Rotational speed (RPM)	4200	858	858	3755	3755
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Sampled	Sampled	Continuous	Continuous
Average positioning time (msec)	27	90	65	19	17
Average rotational delay (msec)	7.1	35	35	8	8
Average access time (msec)	34.1	125*	100	27	25
Spin-up/Spin-down times (sec)				3/2	3/2
Data transfer rate (MBytes/sec)					
Internal	2.4	.800	2.7		2.498-5.967
External			10.0 synch.	6.0	
Buffer/cache size (Kbytes)	256*		2000	1000	1000
SIZE (mm: H x W x D)	25.4 x 101.6 x 153.5	118 x 475 x 653	178 x 475 x 683	41.3 x 146 x 211.3	41.3 x 146 x 211.3
FIRST CUSTOMER SHIPMENT	3Q96	2Q90	2Q95	6/96	4Q95
COMMENTS	*37600 logical tracks.	*Includes command latency Dual head drive	Dual head drive		*1,7 RLL Code. Direct overwrite.

MANUFACTURER	PINNACLE MICRO	PIONEER	PIONEER	PIONEER	RICOH
DRIVE	Apex (A/V)	DE-SH2200 DE-UH2200	DE-SH7101 DE-UH7101	DE-SH9101 DE-UH9101	RO-5060E RS-5060E
DISK/TREND GROUP	23	22	22	22	22
MARKET	OEM	OEM, PCM	OEM	OEM, PCM	Captive, OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Multifunct-(MO)	Rewritable	Multifunct-(MO)	Multifunction	Multifunct-(MO)
Interface	SCSI-2/HPAC	SCSI	SCSI	SCSI	SCSI-2
Speed control & zones	CLV	CAV	CAV	CAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 2697 F: 5394	F: 1100 F: 2200	F: 327 F: 654	F: 850/327 F: 1700/654	F: 326.2/652.3
Capacity per track (Bytes)	F: 45600/103300	F:	F: 16384	F: 26624/48128*	F: 17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	36300 (user)		19958		18751/21600*
Track density (TPI)	25400		15875		15900/18273
Maximum linear density (BPI)	63342*		15875		24900/29540
Rotational speed (RPM)	3755-5000	3000	1800	2700	4500/3000
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Sampled	Sampled	Sampled	Continuous
Average positioning time (msec)	17	42	53.3	43	29
Average rotational delay (msec)	7	10	16.7	11.1	6.7/10
Average access time (msec)	24	52	70	54.1	35.4/39
Spin-up/Spin-down times (sec)	3/2				
Data transfer rate (MBytes/sec) Internal External	3.8-5.121	5.3 1.4-2.6	.635	5.3 1.2-2.2	5.0 synch. 3.3 asynch.
Buffer/cache size (Kbytes)	1000				512
SIZE (mm: H x W x D)	41.3 x 146 x 211.3	41.3 x 147 x 203	41.3 x 146 x 203.2	41.3 x 147 x 203	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	--	1Q95	2Q93	2Q96	1Q94
COMMENTS	*1,7 RLL Code. Direct overwrite. Prelim. spec.	DE-SH2200 is external mount.		Also reads and writes WORM media. *16384 for 654 MB media.	*37600 logical tracks.

MANUFACTURER	SEIKO EPSON	SHARP	SHARP	SIERRA TECHNOLOGIES	SONY
DRIVE	OMD 6020	JY-750 JY-7500	JY-800 JY-8000***	525 GB+ 525 GBX2+	HS-1
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM, PCM	OEM	OEM, PCM	PCM
MEDIA: Disk diameter	86 mm	130 mm	130 mm	130 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Ablative	Magneto-Optic
DRIVE: Operating mode	Rewritable	Multifunct-(MO)	Multifunct-(MO)	Write Once	Rewritable
Interface	SCSI-2	SCSI, SCSI-2	SCSI, SCSI-2	SCSI-2	SCSI-2
Speed control & zones	ZCAV	CAV	CAV/ZCAV	CAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 230	F: 297/326*	F: 595/652*	F: 640	F: 650 F: 650
Capacity per track (Bytes)	F: 12800*	F: 17408	F: 17408	F: 20000	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	17853*	18751	21600**	32000	17665
Track density (TPI)	18273	15875	18273	35000	21200
Maximum linear density (BPI)	29540**	24944	29540	32000	60500
Rotational speed (RPM)	3600	3000	3000	1800	2400
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Stepping Motor	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Sector	Sampled
Average positioning time (msec)	28	40	39	90	33
Average rotational delay (msec)	8.3	10	10	16.7	12.5
Average access time (msec)	36.3	50	49	106.7	45.5
Spin-up/Spin-down times (sec)		7/4	5.5/4		8/5*
Data transfer rate (MBytes/sec) Internal External	.900-1.44	.870 4.0 synch.	2.0 max. 5.0 synch.	.812	1-2 10
Buffer/cache size (Kbytes)	500	256	1000		512
SIZE (mm: H x W x D)	25.4 x 101.6 x 146	41.3 x 146 x 203	41.3 x 146 x 203	82.6 x 146.1 x 208.2	177 x 60 x 250
FIRST CUSTOMER SHIPMENT	4Q94	10/92	1Q94	4/88	2/96
COMMENTS	*Logical tracks **2,7 RLL Code. Split optics.	*CCW compatible *512/1024 bytes per sector. JY-7500 is external mount.	*512/1024 bytes per sector. **37600 logical tracks. ***External mnt Write cache.	525 GBX2+ is external mount; dual drive available.	External subsystem of HS-D650. *Loading/eject time included.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	HS-D650	MDH-10	RMO-S330	RMO-S570 SMO-S521	RMO-S580
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	PCM	PCM	Captive,OEM,PCM	PCM
MEDIA: Disk diameter	86 mm	64 mm	86 mm	130 mm	130 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rd.Only,Rewrit.	Rewritable	Multifunct-(MO)	Multifunct-(MO)
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI, SCSI-2	SCSI-2
Speed control & zones	ZCAV	CLV	CAV	ZCAV	CAV/ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 650	F: 140	F: 128	F: 650	F: 650
Capacity per disk (Mbytes)	F: 650	F: 140	F: 128	F: 1300	F: 1300
Capacity per track (Bytes)	N/A	NA	F: 12800	F: N/A	F: 17408
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	17665	10000	10000	21600*	21600*
Track density (TPI)	21200	15875	15875	18273	18273
Maximum linear density (BPI)	60500	39827	24420	29540	29540
Rotational speed (RPM)	2400	940-422	1800	3000	3600
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, DC Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Sampled	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	33	455	120	40	39
Average rotational delay (msec)	12.5	45	16.6	10	8.3
Average access time (msec)	45.5	500	136.6	50	47.3
Spin-up/Spin-down times (sec)	8/5*				
Data transfer rate (MBytes/sec)					
Internal	1-2	.150	.375	1.0-2.0	1.2-2.4
External	5	2.5 asynch.	4.0 synch.		5.0 synch.
Buffer/cache size (Kbytes)	512		128	1000	4000
SIZE (mm: H x W x D)	24.5 x 101.6 x 149	30 x 80 x 131	52.4 x 160 x 240	70 x 211 x 293	70 x 211 x 293
FIRST CUSTOMER SHIPMENT	11/95	3Q94	7/94	2Q94	4/95
COMMENTS	*Loading/eject time included.		External mount.	*37600 logical tracks.	*37600 logical tracks. External mount.

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
DRIVE	RMO-S591 RMO-S594	SMO-531/81 SMO-F531	SMO-F541 SMO-F544	WDD-530	WDD-531
DISK/TREND GROUP	22	22	22	23	23
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	Captive, OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	300 mm	300 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Phase Change	Phase Change
DRIVE: Operating mode	Rewritable	Multifunct-(MO)	Rewritable	Write Once	Write Once
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	ZCAV	CAV/ZCAV	ZCAV	CAV/CLV	CAV/CLV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 1300 F: 2600	F: 650 F: 1300	F: 1300 F: 2600	F: 15000 F: 15000	F: 15000 F: 15000
Capacity per track (Bytes)	N/A	F: 17408	N/A	N/A	N/A
Data surfaces per spindle	1	1	1	2	2
Tracks per surface	26010*	21600*	26010*		
Track density (TPI)	22100	18273	22100		
Maximum linear density (BPI)	51000	29540	51000		
Rotational speed (RPM)	3600	3600	3600	920/920-440	920/920-440
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	25	39	25	157.4/755.9	157.4/755.9
Average rotational delay (msec)	8.3	8.3	8.3	32.6/44.1	32.6/44.1
Average access time (msec)	33.3	47.3	33.3	190/800	190/800
Spin-up/Spin-down times (sec)	2.5/2.2	2.5/2.2	2.5/2.2		
Data transfer rate (MBytes/sec) Internal External	2.0-4.2 5.0 synch.	1.2-2.4 5.0 synch.	2.0-4.2 5.0 synch.	1.3-2.7 10.0 synch.	1.3-2.7 10.0 synch.
Buffer/cache size (Kbytes)	1000, 4000	4000	1000, 4000	512*	512*
SIZE (mm: H x W x D)	70 x 211 x 293	41.4 x 146 x 203.2	41.4 x 146 x 203	181 x 412 x 515	181 x 375 x 528
FIRST CUSTOMER SHIPMENT	1Q96	3/95	1Q96	3Q95	3Q95
COMMENTS	*75735 logical tracks.	*37600 logical tracks. 531/81 used for optical library	*75735 logical tracks.	2 optical heads *Option to 16MB Includes read cache.	2 optical heads *Option to 16MB Includes read cache.

MANUFACTURER	SONY	SONY			
DRIVE	WDD-600	WDD-930-01 WDD-931			
DISK/TREND GROUP	23	23			
MARKET	Captive, OEM	Captive, OEM			
MEDIA: Disk diameter	300 mm	300 mm			
Recording technology	Phase Change	Phase Change			
DRIVE: Operating mode	Write Once	Write Once			
Interface	SCSI	SCSI-2			
Speed control & zones	CAV/CLV	CAV/CLV			
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 2182/3276	F: 2182/3276			
Capacity per track (Bytes)	N/A	N/A			
Data surfaces per spindle	1	1			
Tracks per surface	43750	43750			
Track density (TPI)	15875	15875			
Maximum linear density (BPI)	49874	49874			
Rotational speed (RPM)	360-1440	540-2160			
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, Voice Coil			
Servo type	Continuous	Continuous			
Average positioning time (msec)	180/600	180/600			
Average rotational delay (msec)	41/55	27/36.7			
Average access time (msec)	221/455	207/636.7			
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	.600	.900			
Buffer/cache size (Kbytes)	64	512*			
SIZE (mm: H x W x D)	180 x 375 x 520*	180 x 480 x 540			
FIRST CUSTOMER SHIPMENT	3Q89	2Q92			
COMMENTS	*Drive unit only.	Downward compatible with WDD-600. *Option to 4 MB.			

1996 DISK/TREND REPORT

1996 DISK/TREND REPORT

OPTICAL LIBRARY SPECIFICATIONS

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

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

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

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

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

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

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

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

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

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

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

1996 DISK/TREND optical disk product groups

For the 1996 report, products are classified in eight groups.

Optical disk drives:

Group 20: CD format read-only optical disk drives.
Group 21: CD format writable optical disk drives.
Group 22: Read/write optical disk drives, less than 2 gigabytes.
Group 23: Read/write optical disk drives, more than 2 gigabytes.

Optical disk libraries:

Group 50: CD format optical disk libraries.
Group 51: Optical disk libraries with 1 to 39 cartridge capacity.
Group 52: Optical disk libraries with 40 to 69 cartridge capacity.
Group 53: Optical disk libraries with 70 or more cartridge capacity.

MANUFACTURER	ALPS ELECTRIC	ASACA	ASM	ASM	ASM
LIBRARY	DC544C 4X4 Pak 4X Changer	ADL-450	CDR 40	CDR 80	CDR 100
DISK/TREND GROUP	50	53	50	50	50
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	130 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650	1200*/1300	540	540	540
Cartridge type	Magazine	ANSI/ISO	Caddy	Caddy	Caddy
DRIVE: Type	CD-ROM	Rewritable	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Alps	AMD-1341NS* H-P C1716T	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	4	450	40	72	100
Maximum disk capacity (units)	4	626	44	84	100
Number of drives: Maximum	1	24/4*	2	4	2
Interface: Library Drive	IDE/ATAPI	RS232C, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	2.6	814	23.8	45.4	54
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	2	1	1	1
Average media exchange time (sec)	7.5	15			
Spin-up + drive ready time (sec)	4.2	6*/2.8	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	1.2	3*/1.4	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	210	130*/31.8	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	7.5	13.5*/10.3	Drive dependent	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	.614	1.2240*/1.600	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	1	4*/24	2	2	2
FIRST CUSTOMER SHIPMENT	4Q95	2Q94			
COMMENTS	Size: 41.3 x 146.2 x 215.2 128K or 250K buffer.	*With Asaca 1341NS drive.			

MANUFACTURER	ASM	ASM	ASM	ASM	ASM
LIBRARY	CDR 200	CDR 300	CDR 500	CDR 900	CDR 1000
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	540	540	540	540	540
Cartridge type	Caddy	Caddy	Caddy	Caddy	Caddy
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	200	300	500	72	152
Maximum disk capacity (units)	200	300	500	80	168
Number of drives: Maximum	4	6	10	4	6
Interface: Library Drive	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	108	166	270	43.2	90.7
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	Y axis	X-Y axis
Pickers per positioner	1	1	1	2	2
Average media exchange time (sec)					6
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	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
Number of drive data paths: Max.	2	2	2-3	2	2
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	ASM	ASM	ASM	ASM	ATG CYGNET
LIBRARY	CDR 1100	CDR 1200	CDR 1300	CDR 1400	1602
DISK/TREND GROUP	50	50	50	50	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	12"
Nominal disk capacity (MB)	540	540	540	540	Drive dependent
Cartridge type	Caddy	Caddy	Caddy	Caddy	Drive dependent
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	Wr.Once,Rewrit.
Drive models	Various	Various	Various	Various	ATG, LMS, Sony, Nikon
LIBRARY MECHANISM					
Minimum disk capacity (units)	212	643	965	1394	29
Maximum disk capacity (units)	228	667	1037	1514	29
Number of drives: Maximum	8	16	27	42	2
Interface: Library Drive	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232C, SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	123	360	560	818	295*/232**
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)				10	6.5
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	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
Number of drive data paths: Max.	2	2-3	2-5	2-7	2
FIRST CUSTOMER SHIPMENT					10/91
COMMENTS					*With ATG drive **With Nikon drive.

1996 DISK/TREND REPORT

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
LIBRARY	AC 16000	ASM-123W	ASM-149M	ASM-176M	ASM-224W
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	10200	5600/12000	6800	8000	10200
Cartridge type	ATG Cygnet	Philips LMS	Nikon	Nikon	ATG Cygnet
DRIVE: Type	Write Once	Write Once	Rewritable	Rewritable	Write Once
Drive models	GD 16000	LD 4100	DD121-1AJ	DD121-1AJ	GD 9001/S
LIBRARY MECHANISM					
Minimum disk capacity (units)	1	22	22	22	22
Maximum disk capacity (units)	6	22	22	22	22
Number of drives: Maximum	1	2	2	2	2
Interface: Library Drive	SCSI-1 SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	96	123.2	149	176	224.4
Import/export module (disks)	1 or 6	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	2	2	2	2
Average media exchange time (sec)	2.5	7.2	8	8	7.2
Spin-up + drive ready time (sec)	2.4	3.5	4	4	2.6
Spin-down time (sec)	1.8	1.5	2.2	2.2	2
Average drive access time (msec)	119	115	76	76	116
Non-queued access time (sec)	4.9	7.1	8	8	7.1
Drive data transfer rate (MB/s)	3.3	1.0	1.1	1.1	1.5
Number of drive data paths: Max.	1	2 (1 per drive)	2 (1 per drive)	2 (1 per drive)	2 (1 per drive)
FIRST CUSTOMER SHIPMENT	3Q96	2Q94	1994	2Q94	2Q94
COMMENTS					

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET	ATG CYGNET
LIBRARY	GF 6910	1800/A2	1800/H1	1800/L2	1800/N1
DISK/TREND GROUP	51	53	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	12"	12"
Nominal disk capacity (MB)	10200	10200	7000	5600/12000	8000
Cartridge type	Proprietary	ATG	Hitachi	LMSI	Nikon
DRIVE: Type	Write Once	Write Once	Write Once	Write Once	Rewritable
Drive models	GD 6001 GD 9001 GD 9001S	ATG GD 9001S	Hitachi OD 321	Philips LMS4100 Philips LMS6100	Nikon DD121-1AJ
LIBRARY MECHANISM					
Minimum disk capacity (units)	6	61	61	61	61
Maximum disk capacity (units)	6	141	141	141	141
Number of drives: Maximum	1	5	5	5	5
Interface: Library Drive	SCSI SCSI-2	RS232C, SCSI-2 SCSI	RS232C SCSI-2	RS232C, SCSI SCSI	RS-232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	30.6	1438	987	789.6/1692	1128
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	2	2	2	2
Average media exchange time (sec)	2.5	7.2	8	7.2	9
Spin-up + drive ready time (sec)	3	2.6	3.5	3.5	5.8
Spin-down time (sec)	2	2.0	3.5	1.5	3.2
Average drive access time (msec)	Drive dependent	116	150	115	137
Non-queued access time (sec)	5.5	7.1	7.5	7.1	8
Drive data transfer rate (MB/s)	1.0	1.5	1.116-2.220	1.0	1.5
Number of drive data paths: Max.	1	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)	5 (1 per drive)
FIRST CUSTOMER SHIPMENT	1992	10/91	3Q93	7/91	1Q94
COMMENTS		Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.

MANUFACTURER	ATG CYGNET	ATG CYGNET	ATG CYGNET	BORETT AUTOMATION TECHNOLOGIES	BORETT AUTOMATION TECHNOLOGIES
LIBRARY	1800/S2	1800/SA	CASS	MMAS (CD)	MMAS (12")
DISK/TREND GROUP	53	53	53	50	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	12"	12"	12"	120 mm	12"
Nominal disk capacity (MB)	6550/15000	48 min.(analog)	10200	600	Drive dependent
Cartridge type	Sony	Sony Analog	ATG Cygnet	Caddy/None	Any
DRIVE: Type	Write Once	Analog Video	Write Once	CD-ROM, CD-R	Wr.Once,Rewrit.
Drive models	Sony WDD 930 Sony WDD 531	Sony LVR 5000A LVA 7000	ATG GD 9001S	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	61	48	111	100	128
Maximum disk capacity (units)	141	128	131	7000/16000**	1792
Number of drives: Maximum	5	5	4	100	28
Interface: Library Drive	RS232C SCSI-2	RS-232C SCSI-2	IBM channel --	RS232C, SCSI-2 SCSI	RS232C, SCSI-2 SCSI
Library capacity (Gbytes) (with maximum disk capacity)	923/2115	6144 minutes	1132	4570*/14784	17920
Import/export module (disks)	1	1		1/100	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Rotary* Industrial Robot	Rotary* Industrial Robot
Pickers per positioner	2	2	2	1, 2	1, 2
Average media exchange time (sec)	8	8	7.2	10	10
Spin-up + drive ready time (sec)	2.4	N/A	2.6	Drive dependent	Drive dependent
Spin-down time (sec)	1.2	N/A	2	Drive dependent	Drive dependent
Average drive access time (msec)	207	500 (max.)	116	Drive dependent	Drive dependent
Non-queued access time (sec)	6.4	8	7.1	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	.900	4.5/6.7 MHz	1.5	Drive dependent	Drive dependent
Number of drive data paths: Max.	5 (1 per drive)		4 (1 per drive)	NS	NS
FIRST CUSTOMER SHIPMENT	3Q93	1Q94	1995	--	--
COMMENTS	Includes model 1802 and 1803 assemblies.	Includes model 1802 and 1803 assemblies.	ESCON option.	Can mix media types. *Can slide on track. **Multiple stations.	Can mix media types. *Can slide on track.

MANUFACTURER	BORETT AUTOMATION TECHNOLOGIES	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL	CD INTERNATIONAL
LIBRARY	MMAS (5.25")	2100	CDC-2800	CDJ-2800	CDJ-2801
DISK/TREND GROUP	53	50	50	50	50
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	1300	650	650	650	650
Cartridge type	Any	N/A	N/A	N/A	N/A
DRIVE: Type	Wr.Once,Rewrit.	CD-ROM	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM
Drive models	Various	Includes 3 Nakamichi mechanisms	Includes 4 Nakamichi mechanisms	Includes 4 Nakamichi mechanisms	Includes 4 Nakamichi mechanisms
LIBRARY MECHANISM					
Minimum disk capacity (units)	288	21	28	28	28
Maximum disk capacity (units)	8064	21	28	28	28
Number of drives: Maximum	100	3	4	4	4
Interface: Library	RS232C, SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI
Drive	SCSI	SCSI-2	SCSI-2	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	20966	13.7	18.7	18.7	18.7
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Rotary* Industrial Robot	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1, 2	1	1	1	1
Average media exchange time (sec)	10	3	3	3	3
Spin-up + drive ready time (sec)	Drive dependent	2	2	2	2
Spin-down time (sec)	Drive dependent	1	1	1	1
Average drive access time (msec)	Drive dependent	200	200	200	200
Non-queued access time (sec)	Drive dependent	5.2	5.2	5.2	5.2
Drive data transfer rate (MB/s)	Drive dependent	.6	.6	.6	.6
Number of drive data paths: Max.	NS	1	1	1	1
FIRST CUSTOMER SHIPMENT	--	4Q95	9/95	2Q95	2Q95
COMMENTS	Can mix media types. *Can slide on track.	CD-ROM only.	Direct net attach.	Includes 1 GB rigid disk drive.	Includes 1 GB rigid disk drive.

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
LIBRARY	D1260	D210U	D300	D600	D630
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	640	640	640	640	640
Cartridge type	Caddy	Caddy	Caddy	Caddy	Caddy
DRIVE: Type	CD-ROM, CD-R*	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R*	CD-ROM, CD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	1170	140	249	498	585
Maximum disk capacity (units)	1478	238	361	722	739
Number of drives: Maximum	32	16	16	32	16
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)	961	152	235	469	480
Import/export module (disks)	2	1	1	2	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7	7	7	7	7
Spin-up + drive ready time (sec)	1-3	1-3	1-3	1-3	1-3
Spin-down time (sec)	2-3	2-3	2-3	2-3	2-3
Average drive access time (msec)	150	150	150	150	150
Non-queued access time (sec)	8	8	8	8	8
Drive data transfer rate (MB/s)	.6	.6	.6	.6	.6
Number of drive data paths: Max.	6-8	3	3-4	6-8	3-4
FIRST CUSTOMER SHIPMENT	7/94	9/95	7/94	7/94	7/94
COMMENTS	*Can mix CD ROM and 5.25" drives plus media in library.			*Can mix CD ROM and 5.25" drives plus media in library.	

1996 DISK/TREND REPORT

MANUFACTURER	DISC	DISC	DISC	DISC	DISC
LIBRARY	D1050-2	D150U	D245	D255U	D280U
DISK/TREND GROUP	53	53	53	53	53
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300/2600	1300/2600	1300/2600	1300/2600	1300/2600
Cartridge type	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
DRIVE: Type	Wr.Once,Rewrit.	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	Various	Maxoptix, H-P, Sony, Pinnacle	Maxoptix, H-P, Sony, Pinnacle	Maxoptix, H-P, Sony, Pinnacle	Maxoptix, H-P, Sony, Pinnacle
LIBRARY MECHANISM					
Minimum disk capacity (units)	914	170	247	247	290
Maximum disk capacity (units)	1054	170	247	247	290
Number of drives: Maximum	16	8	8	8	8
Interface: Library 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)	2376-2740	4420	6422	6422	7540
Import/export module (disks)	2	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	7	7	7	7	7
Spin-up + drive ready time (sec)	2-3	1-3	1-3	1-3	1-3
Spin-down time (sec)	2-3	2-3	2-3	2-3	2-3
Average drive access time (msec)	19-35	19-35	19-35	19-35	19-35
Non-queued access time (sec)	8	8	8	8	8
Drive data transfer rate (MB/s)	1.8	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Number of drive data paths: Max.	4	2	2	2	2
FIRST CUSTOMER SHIPMENT	5/92	4Q95	4Q95	4Q95	4Q95
COMMENTS	Custom configurations available.	Custom configurations available.	Custom configurations available.	Custom configurations available.	Custom configurations available.

MANUFACTURER	DISC	DISC	DISC	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	D350-1 D350U	D510-2	D525-1 D525U	CD60 TERADISC	CD61 TERADISC
DISK/TREND GROUP	53	53	53	50	50
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	1300/2600	1300/2600	1300/2600	650	650
Cartridge type	Drive dependent	Drive dependent	Drive dependent	Magazine	Magazine
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	Various	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	300	454	457	130	250
Maximum disk capacity (units)	350	514	527	170	290
Number of drives: Maximum	6	8	8	4	6
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	390-455	590-668	594-685	115.6	197.2
Import/export module (disks)	1	2	1	1/5	1/5
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	1	1
Average media exchange time (sec)	7	7	7		
Spin-up + drive ready time (sec)	2-3	2-3	2-3	Drive dependent	Drive dependent
Spin-down time (sec)	2-3	2-3	2-3	Drive dependent	Drive dependent
Average drive access time (msec)	19-35	19-35	19-35	Drive dependent	Drive dependent
Non-queued access time (sec)	8	8	8	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	1.8	1.8	1.8	Drive dependent	Drive dependent
Number of drive data paths: Max.	2	4	2	1	1
FIRST CUSTOMER SHIPMENT	5/92	5/92	5/92	8/96	8/96
COMMENTS	Custom configurations available.	Custom configurations available.	Custom configurations available.	Preliminary specification.	Preliminary specification.

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	CD62 TERADISC	CDR 40 CDR 51 TERASTORE	CDR 53 CDR 55 TERASTORE	CDR 71 CDR 72 CDR 73 CDR 74 TERASTORE	28 28-U TERASTORE
DISK/TREND GROUP	50	50	50	50	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	12"
Nominal disk capacity (MB)	650	600 (Mode 1)	600 (Mode 1)	600 (Mode 1)	Drive dependent
Cartridge type	Magazine	Caddy	Caddy	Caddy	Proprietary
DRIVE: Type	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM, CD-R	Write Once
Drive models	Various	Various	Various	Various	ATG, Optimem Sony, Toshiba, LMSI 4100
LIBRARY MECHANISM					
Minimum disk capacity (units)	350	28 (CDR 40)	142 (CDR 53)	273 (CDR 71)	10
Maximum disk capacity (units)	430	63 (CDR 51)	179 (CDR 55)	7435 (CDR 74)	28
Number of drives: Maximum	10	5	6	2*	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	292.4	42.8	121.7	1070	Drive dependent
Import/export module (disks)	1/5	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	2	2	2	2
Average media exchange time (sec)		3	6.5	4-6	6
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	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
Number of drive data paths: Max.	1	1-15	2-8	2	2
FIRST CUSTOMER SHIPMENT	8/96	1/94	7/94	2/95	11/89
COMMENTS	Preliminary specification.			*Field upgradable to 42 drives.	Model 28-U is field upgradable to model 48.

MANUFACTURER	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.	DSM GMBH & CO.
LIBRARY	4000 5100 TERASTORE	48 TERASTORE	100-2000 TERASTORE	5300 5500 TERASTORE	7100 7200 7300 7400 TERASTORE
DISK/TREND GROUP	52	52	53	53	53
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm	12"	12"	130 mm	130 mm
Nominal disk capacity (MB)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Cartridge type	ANSI/ISO	Proprietary	Proprietary	ANSI/ISO	ANSI/ISO
DRIVE: Type	Wr.Once,Rewrit.	Write Once	Write Once	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Various	ATG Gigadisc, Optim.,LMSI4100 Sony WDD600	ATG, Optimem, Sony, Hitachi, LMSI, Toshiba	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	24 (4000)	28	54	96 (5300)	234 (7700)
Maximum disk capacity (units)	63 (5100)	48*	2380*	179 (5500)	1645 (7400)
Number of drives: Maximum	2*	3	120	6	42
Interface: Library Drive	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	2	2	2	2
Average media exchange time (sec)	3	7	8-12	6.5	4-6
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	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
Number of drive data paths: Max.	1-2	2	Variable	2 to 8	2 to 8
FIRST CUSTOMER SHIPMENT	4/92	11/89	9/87	11/89	3/93
COMMENTS	*Option up to 5 drives.	*Field upgradable.	*Field upgradable.		

MANUFACTURER	DYNATEK AUTOMATION	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK	EASTMAN KODAK
LIBRARY	infiniDISC	CD ADL 100	CD ADL-150 CD ADL-150R	2000 ADL+	2000E
DISK/TREND GROUP	50	50	50	53	53
MARKET	OEM			Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	14"	14"
Nominal disk capacity (MB)	650	600	600	14824	25000
Cartridge type	None	None	None	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM	CD-ROM	CD-ROM, CDR	Write Once	Write Once
Drive models	Various	Toshiba	Toshiba	2000	ODW25
LIBRARY MECHANISM					
Minimum disk capacity (units)	1	50	50	25	25
Maximum disk capacity (units)	2750	100	150	134	134
Number of drives: Maximum	44*	1	4	2	4
Interface: Library Drive	Serial, RS-232 SCSI-2	RS232 SCSI	RS232 SCSI	SCSI-2, RS232 SCSI-2	SCSI-2, RS232 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1780	60	90	1983	3350
Import/export module (disks)	1/250	1/50	1/50	1	1
PERFORMANCE					
Positioner type	Rotary	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	2	2
Average media exchange time (sec)	12-20	6	2	6.5	6.5
Spin-up + drive ready time (sec)	Drive dependent	2	2	2.4	2.5
Spin-down time (sec)	Drive dependent	1	1	1.4	1.5
Average drive access time (msec)	Drive dependent			170	170
Non-queued access time (sec)	Drive dependent	5	4	6.1	6.1
Drive data transfer rate (MB/s)	Drive dependent	.6 (4X)	.6 (4X)	1.0	2.4
Number of drive data paths: Max.	1-7	1	1	2	4
FIRST CUSTOMER SHIPMENT	4Q96	4Q95	4Q95	3Q94	4Q96
COMMENTS	*2-8 CD-ROM per 250 disk module.	NSM mechanism.	NSM mechanism. -150R model has CDR drive.	Expandable in modules of 25 disks. Depopulated versions available.	Expandable in modules of 25 disks. Depopulated versions available.

MANUFACTURER	EMASS	FILENET	FILENET	FILENET	FUJITSU
LIBRARY	AML/J	OSAR 50 GTL	Model 0140 OSAR GTX	Model 0150 OSAR 107/144 GT	M2522/AX
DISK/TREND GROUP	53	52	53	53	51
MARKET	OEM, PCM	Captive	Captive, OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	130 mm	12"	12"	12"	130 mm
Nominal disk capacity (MB)	2600	12000	7000	12000	1300
Cartridge type	ANSI/ISO	LMSI	Hitachi	LMSI	ANSI/ISO
DRIVE: Type	Rewritable	Write Once	Write Once	Write Once	Rewritable
Drive models	Various	LMSI 6100	Hitachi OD 301	LMSI LD 6100	M2504B
LIBRARY MECHANISM					
Minimum disk capacity (units)	396	40	96	107	28
Maximum disk capacity (units)	396	50	125	144	28
Number of drives: Maximum	4	3	6	6	2
Interface: Library Drive	SCSI-2 SCSI-2	RS232, SCSI SCSI-2	RS232, RS422 SCSI	RS232, RS422 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1030	600	875	1728	36
Import/export module (disks)	1/10	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	2	2	2	1
Average media exchange time (sec)		4	4.0	4.0	8
Spin-up + drive ready time (sec)	Drive dependent	3	3.0	3.0	5.5
Spin-down time (sec)	Drive dependent	1.5	2.5	1.5	3.5
Average drive access time (msec)	Drive dependent	120	150	130	40
Non-queued access time (sec)		5	6.0	6.0	9.5
Drive data transfer rate (MB/s)	Drive dependent	10.0	4.0	4.0	1.0-2.0
Number of drive data paths: Max.	1	4	6	6	1
FIRST CUSTOMER SHIPMENT		10/95	6/91	3/91	2Q95
COMMENTS	Library can store multiple media types.		Maximum capacity with 2 drives.	Maximum capacity with 2 drives.	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
LIBRARY	M2531A	M2531B	M2532B1	M2532B2	F6445/A1 M255X/A1
DISK/TREND GROUP	51	51	51	51	53
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	86 mm	86 mm	86 mm	86 mm	130 mm
Nominal disk capacity (MB)	230	230	640	640	644
Cartridge type	ISO	ISO	ISO	ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	M2512	M2512	Fujitsu M2513B	Fujitsu M2513B	M2507L
LIBRARY MECHANISM					
Minimum disk capacity (units)	35	35	35	35	390
Maximum disk capacity (units)	35	35	35	35	390
Number of drives: Maximum	2	2	1	1	6
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, Prop.* SCSI-2, Prop.*
Library capacity (Gbytes) (with maximum disk capacity)	8.1	8.1	22		251.2
Import/export module (disks)	35	35	1/35	1/35	10/10
PERFORMANCE					
Positioner type	X axis	X axis	X axis	X axis	Rotary Drum Y axis picker
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	5	6	6	10
Spin-up + drive ready time (sec)	5	5	7	7	5.5
Spin-down time (sec)	4	4	3	3	4.5
Average drive access time (msec)	43.3	43.3	43.3	43.3	40.6
Non-queued access time (sec)	7.4	7.4	10	10	10.5
Drive data transfer rate (MB/s)	1.3-2.1	1.3-3.1	1.0	1.0	2.08
Number of drive data paths: Max.	1	1	1	1	2
FIRST CUSTOMER SHIPMENT	3Q95	1Q95	1996		4Q91
COMMENTS	Includes 532 MB rigid disk drive.				Single pass write. *With DIR (M109X/F1785).

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	HEWLETT-PACKARD
LIBRARY	F6445/A2 M255X/A2	F6445/A2X2 M255X/A2X2	M2522/BX	M2522/CX	40fx
DISK/TREND GROUP	53	53	53	53	51
MARKET	Captive, OEM	Captive, OEM	OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	644	644	1300	644	2600
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Rewritable	Rewritable	Rewritable	Rewritable	Multifunct-(MO)
Drive models	M2507L	M2507L	M2504B	M2507B	H-P C1113F
LIBRARY MECHANISM					
Minimum disk capacity (units)	780	1560	78	78	16
Maximum disk capacity (units)	780	1560	78	78	16
Number of drives: Maximum	11	10	4	2	2
Interface: Library Drive	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2, Prop.* SCSI-2, Prop.*	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	502.3	1004.6	101	50	41.6
Import/export module (disks)	10/10	10/10	1*	1	1
PERFORMANCE					
Positioner type	Rotary Drum (2) 2 Y axis picker	Rotary Drum (4) 4 Y axis picker	Rotary Drum Y axis picker	Rotary Drum Y axis picker	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	10	10	9	9	12
Spin-up + drive ready time (sec)	5.5	5.5	5.5	5.5	5.5
Spin-down time (sec)	4.5	4.5	3.5	4.5	3.0
Average drive access time (msec)	40.6	40.6	40	40.6	35
Non-queued access time (sec)	10.5	10.5	10	10.5	11.5
Drive data transfer rate (MB/s)	2.08	2.08	1.0-2.0	2.08	3.4
Number of drive data paths: Max.	2	2	1	1	1
FIRST CUSTOMER SHIPMENT	4Q91	4Q91	4Q94	3Q95	2/96
COMMENTS	Single pass write. *With DIR (M109X/F1785).	Single pass write. *With DIR (M109X/F1785).	*20 cartridges. Available with DEE option.		

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	80fx	C1100A/B C1101A C1102A* C1103 Model 20xt	C1152C* 40st	C1700T C1710T Model 40T	C1713T Model 20T
DISK/TREND GROUP	51	51	51	51	51
MARKET	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2600	1300	1300	1300	1300
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 C1113F	H-P C1716T	H-P C1716T	H-P C1716T	H-P C1716T
LIBRARY MECHANISM					
Minimum disk capacity (units)	32	16	32	32	16
Maximum disk capacity (units)	32	16	32	32	16
Number of drives: Maximum	2	1	2	2	1
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2** SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	83.2	20.8	41.6	41.6	20.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	X-Y axis	Y axis
Pickers per positioner	1	1	2	1	1
Average media exchange time (sec)	10	8	6	7	7
Spin-up + drive ready time (sec)	5.5	2.5	2.5	2.5	2.5
Spin-down time (sec)	3.0	2.0	2	2.0	2.0
Average drive access time (msec)	35	36	36	36	36
Non-queued access time (sec)	10.5	6.5	8.5	6.0	6.0
Drive data transfer rate (MB/s)	3.4	1.6	1.6	1.6	1.6
Number of drive data paths: Max.	1	1	1	2	1
FIRST CUSTOMER SHIPMENT	2/96	4/94	1Q95	5/93	5/93
COMMENTS		**C1100A is single ended. C1101A is differential. C1103 is OEM version. *Dir. LAN conn.	*Direct LAN connect. Upgradable to 80st.		Upgradable to 40T.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	160fx	C1162C* 80st	200fx	300st	330fx
DISK/TREND GROUP	52	52	53	53	53
MARKET	OEM, PCM	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2600	1300	2600	1300/2600*	2600
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ISO	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)	Multifunct-(MO)
Drive models	H-P C1113F	H-P C1716T	H-P C1113F	H-P C1716T	H-P C1113F
LIBRARY MECHANISM					
Minimum disk capacity (units)	64	64	76	238	128
Maximum disk capacity (units)	64	64	76	238	128
Number of drives: Maximum	4	4	2	6	6
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	166.4	83.2	197.6	309.4/618.8	332.8
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	2	1	2	
Average media exchange time (sec)	10	6	10	3.5	10
Spin-up + drive ready time (sec)	5.5	2.5	5.5	2.5	5.5
Spin-down time (sec)	3.0	2	3.0	2	3
Average drive access time (msec)	35	36	35	36	35
Non-queued access time (sec)	10.5	8.5	10.5	8.5	10.5
Drive data transfer rate (MB/s)	3.4	1.6	3.4	1.6	3.4
Number of drive data paths: Max.	1	1	1	1-6	1
FIRST CUSTOMER SHIPMENT	2/96	1Q95	2/96	9/95	3/96
COMMENTS		*Direct LAN connect.		*When 2600 MB drives avail. Drives can be hot swapped.	Expandable to 600fx.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
LIBRARY	600fx	C1104A/B 165st	C1172C* 100st	C1704T C1714T Model 120T	C1705T C1715T Model 200T
DISK/TREND GROUP	53	53	53	53	53
MARKET	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2600	1300	1300	1300	1300
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 C1113F	H-P C1716T	H-P C1716T	H-P C1716T	H-P C1716T
LIBRARY MECHANISM					
Minimum disk capacity (units)	238	128	76	88	144
Maximum disk capacity (units)	238	128	76	88	144
Number of drives: Maximum	12	4	2	4	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2, LAN SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	618.8	166.4	98.8	114	187
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner		2	2	1	1
Average media exchange time (sec)	10	6	6	8	8
Spin-up + drive ready time (sec)	5.5	2.5	2.5	2.5	2.5
Spin-down time (sec)	3	2	2	2.0	2.0
Average drive access time (msec)	35	36	36	36	36
Non-queued access time (sec)	10.5	5.5	8.5	6.5	6.5
Drive data transfer rate (MB/s)	3.4	1.6	1.6	1.6	1.6
Number of drive data paths: Max.	1,2	1-4	1	4	4
FIRST CUSTOMER SHIPMENT	3/96	3Q95	1Q95	5/93	5/93
COMMENTS		Upgradable to 300st.	*Direct LAN connect.	Upgradable to 200T.	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
LIBRARY	A-6970-48	OL112-12 OL112-22	OL152-48	OL172-48	OL321-22
DISK/TREND GROUP	52	52	52	52	52
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	12"
Nominal disk capacity (MB)	2600	644	2022	1300	7000
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	Proprietary
DRIVE: Type	Rewritable	Rewritable	Multifunct-(MO)	Multifunct-(MO)	Write Once
Drive models	Hitachi OL-F172	Hitachi OD112-1	Hitachi OL-F152	Hitachi OL-F172	Hitachi OD321
LIBRARY MECHANISM					
Minimum disk capacity (units)	48	48	48*	48*	47
Maximum disk capacity (units)	60	48	60	60	47/127*
Number of drives: Maximum	4	4	2	4	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	156	30	121	156	329/889*
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	1	1	1	2
Average media exchange time (sec)	3	7.7	6	6	6.5
Spin-up + drive ready time (sec)	5	3.7	5	5	3
Spin-down time (sec)	2.5	2.7	3	2.5	3
Average drive access time (msec)	49	70	50	49	150
Non-queued access time (sec)	7.9	7.8	7.9	7.9	8.5
Drive data transfer rate (MB/s)	2.3-4.6	1.5	1.54-3.02	2.3-4.6	1.5/4.0
Number of drive data paths: Max.		1	4		2
FIRST CUSTOMER SHIPMENT	1Q96	1989	1Q94	4Q95	1Q91
COMMENTS	HSM subsystem.	-12 has single ended interface -22 has differential interface.	*With 4 drives. Available with single-ended or differential SCSI.	*With 4 drives. Available with single-ended or differential SCSI.	Dual picker. *With expansion unit.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
LIBRARY	OL321-32	A-6967-180	A-6967-48	A-6970-180	LD500
DISK/TREND GROUP	52	53	53	53	53
MARKET	Captive, OEM	OEM, PCM	OEM, PCM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	12"	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	7000	2000	2000	2600	1300/2600
Cartridge type	Proprietary	ANSI/ISO	ANSI/ISO	ANSI/ISO	
DRIVE: Type	Write Once	Rewritable	Rewritable	Rewritable	Multifunct-(MO)
Drive models	Hitachi OD321	Hitachi OL-F152	Hitachi OL-F152	Hitachi OL-F152	Hitachi OD172
LIBRARY MECHANISM					
Minimum disk capacity (units)	64	180	48	180	
Maximum disk capacity (units)	64/144*	192	192	192	153/306
Number of drives: Maximum	2	2	2 to 4	4	4
Interface: Library	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	448/1008*	388	121	500	398/796
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	1	1	1	1/2
Average media exchange time (sec)	6.5	3	3	6	6
Spin-up + drive ready time (sec)	3	5	5	5	5
Spin-down time (sec)	3	2.5	3	2.5	2.5
Average drive access time (msec)	150	49	50	49	49
Non-queued access time (sec)	8.5	16	7.9	8	8
Drive data transfer rate (MB/s)	1.5/4.0	3.37	1.54-3.02	2.3-4.6	2.3-4.6
Number of drive data paths: Max.	2	2	1	4	
FIRST CUSTOMER SHIPMENT	1Q91	4Q95	4Q94	1Q96	3Q96
COMMENTS	Dual picker. *With expansion unit.	HSM subsystem.	HSM subsystem.	HSM subsystem.	Not sold in U.S.

MANUFACTURER	HITACHI	HITACHI	HYUNDAI	IBM	IBM
LIBRARY	OL152-180	OL172-180	HAS-550	3995-023	3995-043
DISK/TREND GROUP	53	53	50	51	51
MARKET	Captive, OEM	Captive, OEM	OEM, PCM	Captive, OEM	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	120 mm	130 mm	130 mm
Nominal disk capacity (MB)	2022	1300	650	1300	1300
Cartridge type	ANSI/ISO		None	ISO	ANSI/ISO
DRIVE: Type	Multifunct-(MO)	Multifunct-(MO)	CD-ROM	Multifunction	Multifunction
Drive models	Hitachi OL-F152	Hitachi OL-F172	Philips	IBM 0632-CHC	IBM 0632-CHC
LIBRARY MECHANISM					
Minimum disk capacity (units)	180*	180	50	32	32
Maximum disk capacity (units)	192	192	50	32	32
Number of drives: Maximum	4	4	1	2	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	LAN SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	388	500	32.5	40	40
Import/export module (disks)	1		1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	6	NS	7	7
Spin-up + drive ready time (sec)	5	5	NS	3	3
Spin-down time (sec)	3	2.5	NS	1.3	1.3
Average drive access time (msec)	50	49	235	41.5	41.5
Non-queued access time (sec)	8	8	--	6.5	6.5
Drive data transfer rate (MB/s)	1.54-3.02	2.3-4.6	.600	1.561	1.561
Number of drive data paths: Max.	4		1	2	2
FIRST CUSTOMER SHIPMENT	1Q94	4Q95		8/93	6/94
COMMENTS	*With 4 drives. Available with single-ended or differential SCSI.	Available with single-ended or differential SCSI.	Tray loading.	For LAN. Hewlett-Packard mechanism. Rewritable and WORM media.	For AS/400. Hewlett-Packard mechanism. Rewritable and WORM media.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-063	3995-A23	3995-A43	3995-A63	3995-C60
DISK/TREND GROUP	51	51	51	51	51
MARKET	Captive, OEM	Captive, OEM	Captive	Captive, OEM	Captive, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1300	1300	1300	1300	650/1300/2600
Cartridge type	ISO	ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunc.-(MO)
Drive models	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	
LIBRARY MECHANISM					
Minimum disk capacity (units)	32	16	16	16	20
Maximum disk capacity (units)	32	16	16	16	20
Number of drives: Maximum	2	1	1	1	1
Interface: Library Drive	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	40	20	20	20	52
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	1	1	1	1	1
Average media exchange time (sec)	7	7	7	7	5.2
Spin-up + drive ready time (sec)	3	3	3	3	5.5
Spin-down time (sec)	1.3	1.3	1.3	1.3	3.5
Average drive access time (msec)	41.5	41.5	41.5	41.5	33.3
Non-queued access time (sec)	6.5	6.5	6.5	6.5	8.1
Drive data transfer rate (MB/s)	1.561	1.561	1.561	1.561	2.0-4.0
Number of drive data paths: Max.	2	1	1	1	1
FIRST CUSTOMER SHIPMENT	8/93	10/93	6/94	6/94	
COMMENTS	For RS/6000. Hewlett-Packard mechanism. Rewritable and WORM media.	For PS/2 with OS/2, AS/400. Hewlett-Packard mechanism. Rewritable and WORM media.	For AS/400. Hewlett-Packard mechanism. Rewritable and WORM media.	For RS/6000. Hewlett-Packard mechanism. Rewritable and WORM media.	Plasmon mechanism.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
LIBRARY	3995-C62	3995-113	3995-123	3995-133	3995-143
DISK/TREND GROUP	52	53	53	53	53
MARKET	Captive, PCM	Captive, OEM	Captive, OEM	Captive, OEM	Captive
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	650/1300/2600	1300	1300	1300	1300
Cartridge type	ANSI/ISO	ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunc.-(MO)	Multifunction	Multifunction	Multifunction	Multifunction
Drive models		IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC	IBM 0632-CHC
LIBRARY MECHANISM					
Minimum disk capacity (units)	52	144	144	144	144
Maximum disk capacity (units)	52	144	144	144	144
Number of drives: Maximum	2	4	5	5	4
Interface: Library	SCSI-2	SCSI	LAN	S/370*	SCSI
Drive	SCSI-2	SCSI	SCSI	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	135	188	188	188	188
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	X-Y axis
Pickers per positioner	2	1	1	1	1
Average media exchange time (sec)	5.2	8	8	8	8
Spin-up + drive ready time (sec)	5.5	3	3	3	3.1
Spin-down time (sec)	3.5	1.3	1.3	1.3	1.3
Average drive access time (msec)	33.3	41.5	41.5	41.5	67.5
Non-queued access time (sec)	8.1	7.1	7.1	7.1	7.1
Drive data transfer rate (MB/s)	2.0-4.0	1.272	1.561	1.561	1.561
Number of drive data paths: Max.	1	4	5	4	4
FIRST CUSTOMER SHIPMENT		6/93	8/93	1Q94	6/94
COMMENTS	Plasmon mechanism.	Expansion unit for libraries. Hewlett-Packard mechanism. Rewritable and WORM media.	For LAN. Hewlett-Packard mechanism. Rewritable and WORM media.	For MVS/ES systems. Hewlett-Packard mechanism. *OEMI channel, ESCON channel.	For AS/400. Hewlett-Packard mechanism. Rewritable and WORM media.

MANUFACTURER	IBM	IBM	IBM	IBM	K&S
LIBRARY	3995-163	3995-C64	3995-C66	3995-C68	CDJ-30
DISK/TREND GROUP	53	53	53	53	50
MARKET	Captive, OEM	Captive, PCM	Captive, PCM	Captive, PCM	OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	120 mm/80 mm
Nominal disk capacity (MB)	1300	650/1300/2600	650/1300/2600	650/1300/2600	540/600
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	Caddy
DRIVE: Type	Multifunction	Multifunc.-(MO)	Multifunc.-(MO)	Multifunc.-(MO)	CD-R
Drive models	IBM 0632-CHC				Philips, other
LIBRARY MECHANISM					
Minimum disk capacity (units)	144	104	156	258	30
Maximum disk capacity (units)	144	104	156	258	30
Number of drives: Maximum	4	2	4	4	1
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI, SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	188	270	405	671	18
Import/export module (disks)	1	1	1	1	1/15
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis	X-Y axis	Y axis
Pickers per positioner	1	2	2	2	1
Average media exchange time (sec)	8	5.4	5.8	6	30
Spin-up + drive ready time (sec)	3	5.5	5.5	5.5	Drive dependent
Spin-down time (sec)	1.3	3.5	3.5	3.5	Drive dependent
Average drive access time (msec)	41.5	33.3	33.3	33.3	Drive dependent
Non-queued access time (sec)	7.1	8.2	8.4	8.5	Drive dependent
Drive data transfer rate (MB/s)	1.561	2.0-4.0	2.0-4.0	2.0-4.0	Drive dependent
Number of drive data paths: Max.	4	1	1	1	1
FIRST CUSTOMER SHIPMENT	1Q94				1994
COMMENTS	For RS/6000. Hewlett-Packard mechanism. Rewritable and WORM media.	Plasmon mechanism.	Plasmon mechanism.	Plasmon mechanism.	

MANUFACTURER	K&S	K&S	K&S	K&S	K&S
LIBRARY	CDJ-M200	MCD-10	MCD-35	Megastore 1000	Megastore 1000/M
DISK/TREND GROUP	50	50	50	51	53
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Nominal disk capacity (MB)	540/600	650	540/600	654/1024	650/1500*
Cartridge type	Tray loading	Caddy	Tray loading	ISO	ANSI
DRIVE: Type	CD-ROM, CD-R	CD-R	CD-ROM, CD-R	Rewritable	Rewritable
Drive models	Various	Yamaha, Philips (option)	Various	Various	Sony, Maxoptix, Matsushita LF7300Z, Ricoh
LIBRARY MECHANISM					
Minimum disk capacity (units)	25	10	35	10	10
Maximum disk capacity (units)	200	10	35	10	80
Number of drives: Maximum	4	1	2	1	4
Interface: Library	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Drive	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI, SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	120	6.5	21	6.5/10.2	120*
Import/export module (disks)	25	1	35	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)	2.5	7-9*	2*	18	18
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	Drive dependent
Non-queued access time (sec)	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
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	4Q94		9/94	9/91	1994
COMMENTS	Expandable to 1600 disks. Label printer option.	*Includes spin-up and spin-down time.	*Includes spin-up and spin-down time.		*With LF7300Z. Available with 10, 20, 40 or 80 cartridges.

MANUFACTURER	KUBIK ENTERPRISES	KUBIK ENTERPRISES	KUBIK ENTERPRISES	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
LIBRARY	CD Tower	CDR240M CDR240MA	MO-120	LF-J100A LF-J100J	LF-J50A LF-J50J
DISK/TREND GROUP	50	50	53	50	50
MARKET	OEM	OEM	OEM	PCM	PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	650	650	650	650/668*	650/668*
Cartridge type	N/A	N/A	N/A	Magazine	None
DRIVE: Type	CD-ROM	CD-ROM, CD-R	Rewritable	PD	PD
Drive models	Toshiba, other	Toshiba, other	Sony	MEI LF1004 (4X)	MEI LF1004 (4X)
LIBRARY MECHANISM					
Minimum disk capacity (units)	480	240	120	100	50
Maximum disk capacity (units)	1680	240	120	100	50
Number of drives: Maximum	28	4	4	4	2
Interface: Library Drive	RS232C, SCSI SCSI	RS232C, SCSI SCSI	RS232C, SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1092	156	312	66.8	33.4
Import/export module (disks)	1	1	1	1/10	1/10
PERFORMANCE					
Positioner type	Rotary	Rotary	Rotary	Y axis	Y axis
Pickers per positioner	1-4	1-4	1-4	2	2
Average media exchange time (sec)	7	7	8	6	6
Spin-up + drive ready time (sec)	1	1	2	6	
Spin-down time (sec)	1	1	2	3	
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	177/222*	
Non-queued access time (sec)	NS	NS	NS	9	
Drive data transfer rate (MB/s)	.614/1.2	.614/1.2	Drive dependent	.614/.514-1.141	
Number of drive data paths: Max.	7	4	4	1	1
FIRST CUSTOMER SHIPMENT	1995	1992	4Q95	7/96	7/96
COMMENTS	Contains 2 to 7 CDR240.	CDR240MA is rack mount version.	Rack mount available. No cartridge required.	Disks mount in 10 disk magazine. *CD-ROM mode. 6X by 4Q96.	Disks mount in 10 disk magazine. *CD-ROM mode. 6X by 4Q96.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
LIBRARY	SQ-TC500N	LF-J7322	LF-J7324A LF-J7324AN	LF-J7328A LF-J7328AN	LF-J7330
DISK/TREND GROUP	50	51	51	51	51
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	120 mm/80 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	540/180*	650	1500	1500	650
Cartridge type	None*	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM	Wr.Once,Rewrit.	Multifunct-(PC)	Multifunct-(PC)	Wr.Once,Rewrit.
Drive models		Various	MEI LF-7394	MEI LF-7394	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	5	22	24	28	30
Maximum disk capacity (units)	5	22	24	28	30
Number of drives: Maximum	1	2	2	1	2
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	3.2	33	36	42	45
Import/export module (disks)	5	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)	5	5.3	6.5	6.5	5.2
Spin-up + drive ready time (sec)		5.5	6	6	5.5
Spin-down time (sec)		2.5	2.5	2.5	2.5
Average drive access time (msec)	200	8.2	57.5	57.5	8.2
Non-queued access time (sec)		8.4	9.25	9.25	8.4
Drive data transfer rate (MB/s)	.6	1.5	1.5/5.0*	1.5/5.0*	1.5
Number of drive data paths: Max.	1	1	1/2	1	1
FIRST CUSTOMER SHIPMENT		1996	3/94	1/94	1996
COMMENTS	*With 80 mm disk. 1.625" high.	Plasmon mechanism.	*SCSI synchronous mode. Also available with 1400 MB WORM drive.	*SCSI synchronous mode. Also available with 1400 MB WORM drive.	Plasmon mechanism.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
LIBRARY	LF-J7350A	LF-J7360	LF-J73120	LF-J73180	LF-J73300
DISK/TREND GROUP	52	52	53	53	53
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	1500	650	650	650	650
Cartridge type	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Multifunct-(PC)	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	MEI LF-7394	Various	Various	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	50	60	120	180	300
Maximum disk capacity (units)	50	60	120	180	300
Number of drives: Maximum	2	2	4	6	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)	75	90	180	270	450
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	X-Y axis	Y axis	Y axis	Y axis	Y axis W pivot
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	7	5.2	6.6	6.6	6.6
Spin-up + drive ready time (sec)	6	5.5	5.5	5.5	5.5
Spin-down time (sec)	2.5	2.5	2.5	2.5	2.5
Average drive access time (msec)	57.5	8.2	8.8	8.8	8.8
Non-queued access time (sec)	9.5	8.4	8.4	8.4	8.4
Drive data transfer rate (MB/s)	1.5/5.0*	1.5	1.5	1.5	1.5
Number of drive data paths: Max.	1/2	1	1	1	1
FIRST CUSTOMER SHIPMENT	2/94	1996	1996	1996	1996
COMMENTS	*SCSI synchronous mode. Also available with 1400 MB WORM drive.	Plasmon mechanism.	Plasmon mechanism.	Plasmon mechanism.	Plasmon mechanism.

1996 DISK/TREND REPORT

MANUFACTURER	NAKAMICHI	NAKAMICHI	NAKAMICHI	NEC	NEC
LIBRARY	MJ-4.4	MJ-4.6	MJ-4.8S	N1137-06	N1137-58
DISK/TREND GROUP	50	50	50	51	51
MARKET	OEM, PCM	OEM	PCM	Captive	Captive
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Nominal disk capacity (MB)	650	650	650	610	1300
Cartridge type	None	None	None	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM	CD-ROM	CD-ROM	Rewritable	Rewritable
Drive models	Nakamichi	Nakamichi	Nakamichi	NEC N1137-04	NEC N1137-57
LIBRARY MECHANISM					
Minimum disk capacity (units)	4	4	4	4	4
Maximum disk capacity (units)	4	4	4	4	4
Number of drives: Maximum	1	1	1	1	1
Interface: Library Drive	IDE/ATAPI	IDE/ATAPI	SCSI	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	2.6	2.6	2.6	2.4	5.2
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	10	6
Spin-up + drive ready time (sec)				4	8
Spin-down time (sec)				4	5
Average drive access time (msec)	235	165	150	60	42
Non-queued access time (sec)	NA	NA	NA	8	11
Drive data transfer rate (MB/s)	.6	.9	1.2	1.5	3.0
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	10/95	4/96	6/96	1991	1993
COMMENTS	43 mm high.	43 mm high.	43 mm high.		

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
LIBRARY	N7923	OL5120	OL5220	N5817-31/32 N7925-82	N7925-83
DISK/TREND GROUP	51	51	51	52	52
MARKET	Captive	OEM	OEM	Captive	Captive
MEDIA: Nominal disk diameter	12"	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	5000	1300	1300	610	1300
Cartridge type	Proprietary	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	Write Once	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	NEC N7913	NEC	NEC	NEC N7915 NEC N5817-11	NEC N7915-85
LIBRARY MECHANISM					
Minimum disk capacity (units)	36	20	20	46	60
Maximum disk capacity (units)	36	20	20	67	60
Number of drives: Maximum	2	1	2	4	2
Interface: Library Drive	NEC Proprietary	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI SCSI	SCSI SCSI
Library capacity (Gbytes) (with maximum disk capacity)	180	26	26	40	78
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	1	1	1	2
Average media exchange time (sec)	11	5.5	5.5	10	10
Spin-up + drive ready time (sec)	6	8	8	4	8
Spin-down time (sec)	5	5	5	4	5
Average drive access time (msec)	200	29	29	60	42
Non-queued access time (sec)	12	13.5	13.5	9	13
Drive data transfer rate (MB/s)	5.53-1.120	5.0	5.0	1.5	3.0
Number of drive data paths: Max.	2	1	1	1	1
FIRST CUSTOMER SHIPMENT	6/90	10/95	10/95	1992	1993
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC HOME ELECTRONICS	NEC HOME ELECTRONICS
LIBRARY	N7925-84	OL5260	OL5453	CDR-4300	CDR-C251 MultiSpin 4X4
DISK/TREND GROUP	52	52	52	50	50
MARKET	Captive	Captive	Captive	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	120 mm	120 mm
Nominal disk capacity (MB)	1300	1300	1300	680	650
Cartridge type	ANSI/ISO	ISO	ISO	None	None
DRIVE: Type	Rewritable	Rewritable	Rewritable	CD-ROM	CD-ROM
Drive models	NEC	NEC	NEC	NEC	NEC
LIBRARY MECHANISM					
Minimum disk capacity (units)	60	60	53	4	4
Maximum disk capacity (units)	60	60	53	4	4
Number of drives: Maximum	2	2	4	1	1
Interface: Library Drive	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	IDE/ATAPI IDE/ATAPI	IDE/ATAPI IDE/ATAPI
Library capacity (Gbytes) (with maximum disk capacity)	78	78	69	2.6	2.6
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	2	2	2	1	1
Average media exchange time (sec)	8	8	8	4	4
Spin-up + drive ready time (sec)	8	8	8	2	2
Spin-down time (sec)	5	5	5	1	1
Average drive access time (msec)	42	39	39	165	250
Non-queued access time (sec)	13	11	13	3	3
Drive data transfer rate (MB/s)	3.0	5.0	5.0	.9	.6
Number of drive data paths: Max.	1	1	1	1	4Q95
FIRST CUSTOMER SHIPMENT	1995	1995	1995	2Q96	
COMMENTS				Tray loading.	MS, XA, CD-I compatibility. Nakamichi mechanism. Tray loading.

MANUFACTURER	NEC HOME ELECTRONICS	NIKKYO	NIKKYO	NIKKYO	NIKKYO
LIBRARY	CDR-C302 MultiSpin 4Xc CD Jukebox	NOL-102	NOL-161	NOL-322	NOL-604
DISK/TREND GROUP	50	51	51	51	52
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	120 mm/80 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	680	1300	1300	1300	1300
Cartridge type	None	ANSI/ISO	ANSI/ISO	ANSI/ISO	ANSI/ISO
DRIVE: Type	CD-ROM	Rewritable	Rewritable	Rewritable	Rewritable
Drive models	NEC MultiSpin 4	Sony SMO-F521, IBM 0632-C2D	Sony SMO-F521, IBM 0632-C2D	Sony SMO-F521 IBM 0632-C2D	Sony SMO-F521 IBM 0632-C2D
LIBRARY MECHANISM					
Minimum disk capacity (units)	7	10	16	32	60
Maximum disk capacity (units)	7	10	16	32	60
Number of drives: Maximum	1	2	1	2	4
Interface: Library	SCSI-2	SCSI	SCSI	SCSI	SCSI
Drive	SCSI-2	SCSI	SCSI	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	4.8	10.3	20.8		
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)	2.5	5	5	5	5
Spin-up + drive ready time (sec)	2	7	7	7	7
Spin-down time (sec)	1	4	4	4	4
Average drive access time (msec)	380	100	100	100	100
Non-queued access time (sec)	3	9.5	9.5	9.5	9.5
Drive data transfer rate (MB/s)	.6	1.2	1.2	1.2	1.2
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	2Q95	4Q92	3Q93	3Q94	2Q94
COMMENTS	128K buffer. Nakamichi mechanism. Tray loading.	Sold under Alaya brand.	Sold under Alaya brand.	Sold under Alaya brand.	Sold under Alaya brand.

MANUFACTURER	NIKKYO	NIPPON COLUMBIA (DENON)	NISTEC	NSM	NSM
LIBRARY	NOL-642	DRD-1400	ALW-501	CDR 100 Recordable	CDR 100 XA
DISK/TREND GROUP	52	50	50	50	50
MARKET	OEM	PCM	PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	1300	650	650	650	650
Cartridge type	ANSI/ISO	None	None	None	None
DRIVE: Type	Rewritable	CD-ROM	CD-R	CD-R	CD-ROM
Drive models	Sony SMO-F521 IBM 0632-C2D		Philips CDD 2000	Yamaha	Toshiba
LIBRARY MECHANISM					
Minimum disk capacity (units)	64	200	--	100	100
Maximum disk capacity (units)	64	200	50	100	100
Number of drives: Maximum	2	2	1	1	1
Interface: Library	SCSI	SCSI-2, RS232	RS232C	SCSI-2, RS232	SCSI-2, RS232
Drive	SCSI	SCSI-2	SCSI-2	SCSI	SCSI
Library capacity (Gbytes) (with maximum disk capacity)	83.2	130	N/A	65	65
Import/export module (disks)	1/16	1/100	1/50	1/50	1/50
PERFORMANCE					
Positioner type	Y axis	X axis	Y axis, Pivot	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	25	NS	4.5	4.5
Spin-up + drive ready time (sec)	7	2	NS	1.5	1.5
Spin-down time (sec)	4	2	NS	1.0	1.0
Average drive access time (msec)	100	.3	300	500	150
Non-queued access time (sec)	9.5	15	--	4.3	4.3
Drive data transfer rate (MB/s)	1.2	.3	.6	.6	.6
Number of drive data paths: Max.	1	2	1	1	1
FIRST CUSTOMER SHIPMENT	4Q93	2Q96	1996	3/94	1/94
COMMENTS	Sold under Alaya brand.		Recorder/ transport.		

MANUFACTURER	NSM	NSM	NSM	NSM	NSM
LIBRARY	Jupiter PD	Mercury 31	Mercury Net	Mercury-20	Mercury-31
DISK/TREND GROUP	50	50	50	50	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	120 mm	120 mm
Nominal disk capacity (MB)	650	650	650	650	650
Cartridge type	None	None	None	None	None
DRIVE: Type	PD	CD-ROM, CD-R	CD-ROM, CD-R	CD-ROM	CD-ROM, CD-R
Drive models		Toshiba (3) Yamaha (1)	Toshiba	Toshiba	Toshiba Yahama
LIBRARY MECHANISM					
Minimum disk capacity (units)	150	150	150	150	150
Maximum disk capacity (units)	150	150	150	150	150
Number of drives: Maximum	4	4	4	2	4
Interface: Library Drive	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	RS232, SCSI-2 SCSI-2	
Library capacity (Gbytes) (with maximum disk capacity)	100	100	100	100	100
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)	>3	>3	>3	>3	>3
Spin-up + drive ready time (sec)		.150/.500	.150	1.5	1.5
Spin-down time (sec)				1.5	1.5
Average drive access time (msec)		150/500	150	150	150/500
Non-queued access time (sec)	7	7	7	4.5	4.5
Drive data transfer rate (MB/s)	1.140/.6	.6	.6	.6	.6
Number of drive data paths: Max.	1	2	1	1-2	
FIRST CUSTOMER SHIPMENT		4/95	1/96	4Q94	12/95
COMMENTS			Novell network ready.		

MANUFACTURER	NSM	OPTOMEDIA ENGINEERING	PFU	PFU	PHILIPS LMS
LIBRARY	Mercury-40 Mercury-40 Net	Hawk	MC700A	MC700B	LF 4500
DISK/TREND GROUP	50	50	51	51	51
MARKET	OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	86 mm	86 mm	12"
Nominal disk capacity (MB)	650	650	230	230	5600
Cartridge type	None	Caddy	ISO	ISO	LMSI
DRIVE: Type	CD-ROM	CD-R	Rewritable	Rewritable	Write Once
Drive models	Toshiba	Yamaha CDR-100	Fujitsu	Fujitsu	LMSI LD 4100
LIBRARY MECHANISM					
Minimum disk capacity (units)	150	36	32	32	5
Maximum disk capacity (units)	150	72	32	32	5
Number of drives: Maximum	4	4	1	2	1
Interface: Library Drive	RS232, SCSI-2* SCSI-2	 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	100		7.4	7.4	28
Import/export module (disks)	1/50	12	32	32	5
PERFORMANCE					
Positioner type	Y axis	Y axis	X axis	X axis	Moving Magazine
Pickers per positioner	1	1	1	1	N/A
Average media exchange time (sec)	>3	20	3	6	3
Spin-up + drive ready time (sec)	1.5	NS	2	2	2.5
Spin-down time (sec)	1.5	NS	1	1	1.5
Average drive access time (msec)	150	NS	30	30	90*
Non-queued access time (sec)	4.5	--	5	8	5.5
Drive data transfer rate (MB/s)	.6	1.4	1.3-2.1	1.3-2.1	.7/1.8**
Number of drive data paths: Max.	1-4	4	1	1	1
FIRST CUSTOMER SHIPMENT	4Q94		1994	1994	4Q91
COMMENTS	*Net version interfaces Ethernet.	CD-R autoloader	Purchased mechanism.	Purchased mechanism.	*Includes command overhead. **Asynchronous mode. Dual head drive

MANUFACTURER	PHILIPS LMS	PHILIPS LMS	PHILIPS LMS	PIONEER	PIONEER
LIBRARY	LF 4502	LF 6600	LF 6602	DRJ-5004X	DRM-1004X
DISK/TREND GROUP	51	51	51	50	50
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	12"	12"	12"	120 mm	120 mm
Nominal disk capacity (MB)	5600	12000	12000	540	650
Cartridge type	LMSI	Philips LMS	Philips LMS	N/A	Magazine
DRIVE: Type	Write Once	Write Once	Write Once	CD-ROM, CD-R	CD-ROM, CD-R
Drive models	LMSI LD 4100	Philips LMS LD 6100	Philips LMS LD 6100	Pioneer D504X Pioneer R504X	Pioneer
LIBRARY MECHANISM					
Minimum disk capacity (units)	10	6	12	100	50
Maximum disk capacity (units)	10	6	12	500	100
Number of drives: Maximum	2	1	2	4	4*
Interface: Library Drive	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)	56	72	144	270	65
Import/export module (disks)	5	6	6	100	1/50
PERFORMANCE					
Positioner type	Moving Magazine	Moving Magazine	Moving Magazine	Y axis	Y axis
Pickers per positioner	N/A	N/A	N/A	1	1
Average media exchange time (sec)	3	2.5	2.5	18	5
Spin-up + drive ready time (sec)	2.5	3	3	3	3 RD/4 WR
Spin-down time (sec)	1.5	1.5	1.5	2	2 RD/1.5 WR
Average drive access time (msec)	90	100	100	300	110 RD/650 WR
Non-queued access time (sec)	5.5	4.5	4.5	12	5.5
Drive data transfer rate (MB/s)	.7/1.8*	2.7	2.7	.614	.614 WR/.673 RD
Number of drive data paths: Max.	2	1	2	4	1
FIRST CUSTOMER SHIPMENT	1Q92	2Q95	2Q95	3Q94	9/96
COMMENTS	2 LF 4500 in single cabinet. *Asynchronous mode. Dual head drive	Dual head drive	Dual head drive	Photo CD. Multisession.	*4 CD-ROM or 2 CD-ROM plus 1 CD-R.

MANUFACTURER	PIONEER	PIONEER	PIONEER	PLASMON DATA	PLASMON DATA
LIBRARY	DRM-1804X	DRM-5004X DRM-5004XR	DRM-624X	RF20J-695 RF22J-703 MiniMulti	RF26J-695 RF30J-703 MicroMulti
DISK/TREND GROUP	50	50	50	51	51
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm	130 mm	130 mm
Nominal disk capacity (MB)	540	660	540	1300/1500/2600	1300/1500/2600
Cartridge type	N/A	N/A	N/A	ANSI/ISO/Panas.	ANSI/ISO/Panas.
DRIVE: Type	CD-ROM	CD-ROM, CD-R	CD-ROM	Wr.Once,Rewrit.	Wr.Once,Rewrit.
Drive models	Pioneer (integrated with drive)	Pioneer 4X	Pioneer (integrated with drive)	Various	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	18	100	6	20	26
Maximum disk capacity (units)	18	500	6	22*	30*
Number of drives: Maximum	1	4	1	2	2
Interface: Library Drive	SCSI SCSI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	9.72	330	3.24	52	67
Import/export module (disks)	18	100	6	1	1
PERFORMANCE					
Positioner type	NS	Y axis	NS	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	29	5	4	5.2
Spin-up + drive ready time (sec)	3	2	NS	Drive dependent	Drive dependent
Spin-down time (sec)	2	1	NS	Drive dependent	Drive dependent
Average drive access time (msec)	300	300	150	Drive dependent	Drive dependent
Non-queued access time (sec)	NS	31	NS	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	.614/.154	.614	.676	Drive dependent	Drive dependent
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	4Q93	4Q94	2Q95		2/94
COMMENTS	Photo CD. Multisession.	Photo CD. Multisession. DRM-5004X has CD-ROM only.	Photo CD. Multisession. 128K buffer.	*Depends upon drive height.	*Depends upon drive height.

MANUFACTURER	PLASMON DATA	PLASMON DATA	PLASMON DATA	PLASMON DATA	REGAL ELECTRONICS
LIBRARY	M52J-695 RF60J-703 Multi I	M104J-695 RF120J-703 Multi II	M156J-695 RF180J-703 Multi III	M285J-695E RF300J-703 Multi IIIE	CDC-4X
DISK/TREND GROUP	52	53	53	53	50
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	120 mm/80 mm
Nominal disk capacity (MB)	1300/1500/2600	1300/1500/2600	1300/1500/2600	1300/1500/2600	540/630
Cartridge type	ANSI/ISO/Panas.	ANSI/ISO/Panas.	ANSI/ISO/Panas.	ANSI/ISO/Panas.	Magazine
DRIVE: Type	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	Wr.Once,Rewrit.	CD-ROM (4X)
Drive models	Various	Various	Various	Various	
LIBRARY MECHANISM					
Minimum disk capacity (units)	52	104	156	258	5
Maximum disk capacity (units)	60*	120*	180*	300*	5
Number of drives: Maximum	2	4	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)	135	270	405	670	2.7/3.1
Import/export module (disks)	1	1	1	1	5
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis w/pivot	Y axis
Pickers per positioner	1	1	1		1
Average media exchange time (sec)	4	4	4	4	5
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
Spin-down time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
Average drive access time (msec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	220
Non-queued access time (sec)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	Drive dependent	Drive dependent	.614
Number of drive data paths: Max.	1	1	1	1	1
FIRST CUSTOMER SHIPMENT	11/93	4/94	4/94	6/94	4Q95
COMMENTS	*Depends upon drive height.	*Depends upon drive height.	*Depends upon drive height.	*Depends on drive height.	256K buffer.

MANUFACTURER	REGAL ELECTRONICS	SANYO	SONY	SONY	SONY
LIBRARY	CDC-4Xi	CDR-C3G	CDL 2100	CDL 2200	OSL 2001-11
DISK/TREND GROUP	50	50	50	50	51
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	120 mm/80 mm	120 mm	120 mm	120 mm	130 mm
Nominal disk capacity (MB)	540/630	540	650	650	1300
Cartridge type	Magazine	Proprietary			ANSI/ISO
DRIVE: Type	CD-ROM (4X)	CD-ROM	CD-ROM, CD-R	CD-ROM, CD-R	Multifunction
Drive models		Sanyo 4X	Sony CDU 76S, CDU 920S	Sony CDU 76S, CDU 920S	Sony SMO-F531
LIBRARY MECHANISM					
Minimum disk capacity (units)	5	3	100	225	20
Maximum disk capacity (units)	5	3	125	275	20
Number of drives: Maximum	1	1	2	6	1
Interface: Library Drive	IDE/ATAPI	IDE/ATAPI	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	2.7/3.1	1.6			26
Import/export module (disks)	5	3	1	1	1/10
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	6	4	4	5
Spin-up + drive ready time (sec)		2			2.5
Spin-down time (sec)		1			2
Average drive access time (msec)	220	250	190	190	47
Non-queued access time (sec)		5.3			5
Drive data transfer rate (MB/s)	.614	.614	.6-1.2	.6-1.2	2.4
Number of drive data paths: Max.	1	1	2	2-6	1
FIRST CUSTOMER SHIPMENT	2Q96	1Q95	10/96	10/96	1994
COMMENTS	256K buffer. Fits half 5.25" height slot.	256K buffer.			

MANUFACTURER	SONY	SONY	SONY	SONY	SONY
LIBRARY	OSL 2001-12 OSL 2001-22	OSL 2001-21	OSL 6000-21	OSL 6000-22 OSL 6000-42	OSL 6000-41
DISK/TREND GROUP	51	51	52	52	52
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Nominal disk capacity (MB)	2600	1300	1300	2600	1300
Cartridge type	ANSI/ISO	ANSI/ISO	ISO/ANSI	ISO/ANSI	ISO
DRIVE: Type	Multifunction	Multifunction	Multifunction	Multifunction	Multifunction
Drive models	Sony SMO-F541	Sony SMO-F531	Sony SMO-F541	Sony SMO-F541	Sony SMO-F531
LIBRARY MECHANISM					
Minimum disk capacity (units)	20	20	60	50	50
Maximum disk capacity (units)	20	20	60	60	50
Number of drives: Maximum	2	2	2	4	4
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2	SCSI-2 SCSI-2	SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	52	26	78	156	65
Import/export module (disks)	1/10	1/10		1/10	1/10
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	Y axis	Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	5	5	4	5	4
Spin-up + drive ready time (sec)	2.5	2.5	2.5	2.5	2.5
Spin-down time (sec)	2.2	2	2	2.2	2
Average drive access time (msec)	29	47	47	29	47
Non-queued access time (sec)		5	5		5
Drive data transfer rate (MB/s)	4.06	2.4	2.4	4.06	2.4
Number of drive data paths: Max.	1-2	1	1	2-4	1
FIRST CUSTOMER SHIPMENT	3/96	1994	4Q95	3/96	4Q95
COMMENTS					

MANUFACTURER	SONY	SONY	SONY	TILTRAC	TILTRAC
LIBRARY	WDA-E550	WDA-E930	WDA-EX5	M3C CDMultiServer	M3T CDMultiServer
DISK/TREND GROUP	53	53	53	50	50
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	12"	12"	12"	120 mm	120 mm
Nominal disk capacity (MB)	15000	6552	15000	650	650
Cartridge type	Sony	Proprietary	Sony	Caddy	None
DRIVE: Type	Write Once	Write Once	Write Once	CD-ROM	CD-ROM
Drive models	Sony WDD 530	Sony WDD 930-01	Sony WDD 530	Plextor	Various
LIBRARY MECHANISM					
Minimum disk capacity (units)	46	47	48	70	100
Maximum disk capacity (units)	76	77	78	175	250
Number of drives: Maximum	4	4	3	28*	28*
Interface: Library Drive	SCSI-2 SCSI-2	SCSI-2 SCSI-2	SCSI-2 SCSI-2	RS232C SCSI-2	RS232C SCSI-2
Library capacity (Gbytes) (with maximum disk capacity)	1140	504	2310	113.8	162.5
Import/export module (disks)	1	1	1	1	1
PERFORMANCE					
Positioner type	Y axis	Y axis	Y axis	X-Y axis	X-Y axis
Pickers per positioner	1	1	1	1	1
Average media exchange time (sec)	6	5	7.5		
Spin-up + drive ready time (sec)	4	2.4	4	Drive dependent	Drive dependent
Spin-down time (sec)	1.5	1.2	1.5	Drive dependent	Drive dependent
Average drive access time (msec)	190/800	208/637	190/800	Drive dependent	Drive dependent
Non-queued access time (sec)	5.3	4.9	6.1	Drive dependent	Drive dependent
Drive data transfer rate (MB/s)	2.7	.9	2.7	Drive dependent	Drive dependent
Number of drive data paths: Max.	1	1	--	1, 4	1, 4
FIRST CUSTOMER SHIPMENT	5/95	4Q92	5/95	2Q96	2Q96
COMMENTS			Expansion unit for WDA-E550.	*7 drives minimum.	*7 drives minimum.

MANUFACTURER	TILTRAC	TILTRAC	TODD ENTERPRISES		
LIBRARY	M6C CDMultiServer	M6T CDMultiServer	TAJ-2000		
DISK/TREND GROUP	50	50	50		
MARKET	OEM, PCM	OEM, PCM	OEM, PCM		
MEDIA: Nominal disk diameter	120 mm	120 mm	120 mm		
Nominal disk capacity (MB)	650	650	680		
Cartridge type	Caddy		Caddy		
DRIVE: Type	CD-ROM	CD-ROM	CD-ROM		
Drive models	Plextor	Various	Hitachi CDR-6750		
LIBRARY MECHANISM					
Minimum disk capacity (units)	210	300	174		
Maximum disk capacity (units)	385	550	203		
Number of drives: Maximum	42*	42*	14		
Interface: Library Drive	RS232C SCSI-2	RS232C SCSI-2	Ethernet SCSI		
Library capacity (Gbytes) (with maximum disk capacity)	250.3	357.5	132		
Import/export module (disks)	1	1	--		
PERFORMANCE					
Positioner type	X-Y axis	X-Y axis	X-Y axis		
Pickers per positioner	1	1	1		
Average media exchange time (sec)			12		
Spin-up + drive ready time (sec)	Drive dependent	Drive dependent	8-9		
Spin-down time (sec)	Drive dependent	Drive dependent	2		
Average drive access time (msec)	Drive dependent	Drive dependent	235		
Non-queued access time (sec)	Drive dependent	Drive dependent	14		
Drive data transfer rate (MB/s)	Drive dependent	Drive dependent	.307		
Number of drive data paths: Max.	1, 6	1, 6			
FIRST CUSTOMER SHIPMENT	2Q96	2Q96	1994		
COMMENTS	*7 drives minimum.	*7 drives minimum.	Photo CD. Multisession. UNIX server.		

1996 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing optical disk drives or optical disk libraries, or those which are expected to enter the market, are listed in this section. DISK/TREND normally estimates the annual volume of disk drive sales by manufacturers. Because few companies had a high level of optical library or disk drive sales in 1995, this figure is reported explicitly only for firms with major 1995 optical disk drive or library sales. "1995 total net sales" covers the fiscal year ending in 1995 for each manufacturer unless noted otherwise, or for the parent company if the manufacturer is a subsidiary. All fiscal years end on December 31, 1995, 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 1995 are used, as reported by the U.S. Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
Canada	Canadian dollar	1.37
France	French franc	4.99
Germany	Deutschmark	1.43
Hong Kong	Hong Kong dollar	7.73
Japan	Yen	94.0
Malaysia	Ringgit	2.51
Netherlands	Guilder	1.60
Singapore	Singapore dollar	1.42
South Korea	Won	773.0
Taiwan	Taiwan dollar	26.5
United Kingdom	Pound	0.633

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

BORETT AUTOMATION TECHNOLOGIES
31324 Via Colinas
Westlake Village, CA 91362

Founded in 1988, Borett Automation manufactures modular library systems capable of simultaneously handling optical or tape media units in multiple cartridge sizes. The library is equipped with appropriate drives and storage bays for the cartridges to be used. A general purpose industrial robot capable of exchanging its picking mechanism on the fly permits handling of different cartridge types. Borett announced its product at the 1992 AIIM show, and has since made several improvements to the basic design. Borett libraries can handle disks in CD-ROM caddies, and 5.25" and 12" optical disk cartridges, as well as various tape cartridges. In mid-1995, the product line was redesigned to improve flexibility and reduce costs.

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.

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

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

DISC was founded in 1986 specifically to develop and manufacture customized optical libraries. The firm's products are built around a modular concept of configuring a system with an appropriate number of 5.25" optical drives, disk storage slots and picker mechanisms to meet customer performance needs. Trade-offs may be made between the number of drives (up to 32) and disk storage slots (up to 1,478). The first commercial showing of the system was at the 1990 AIIM conference. Shipments began in 1991, with production volumes beginning in 1992. A library capable of handling CD-ROM media was introduced at the 1994 AIIM conference. In early 1995, the company changed its name to DISC, expanded its operations and moved to larger quarters. CD-ROM libraries are becoming an increasingly important part of the firm's product mix.

DISC is strengthening its OEM orientation and relying less upon distributors as it grows, adding additional service and support capabilities through staff expansion and third party arrangements.

DOCUPOINT CORPORATION (See Sigma Designs Imaging Systems)

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

Dynatek Automation is a privately owned firm established in 1985 as a system integrator. The firm specializes in packaged SCSI-based disk and tape storage subsystems used with a broad variety of hardware platforms. In November of 1994, the firm introduced the infiniDISC CD-ROM library, a modular system that can contain up to 44 CD-ROM/CD-R drives and up to 2,750 disks. Disks can be added in increments of 250 disks. Shipments have been delayed, but are expected to begin in late 1996.

EASTMAN KODAK COMPANY
343 State Street
Rochester, NY 14650

1995 total net sales: $14,980,000,000 Net income: $1,252,000,000

Eastman Kodak has had two publicly announced optical disk drive production efforts, one a very high capacity 14" write-once optical disk drive and the

other a low-end 3.5" magneto-optical drive. The latter product originated at Verbatim Corporation, acquired by Eastman Kodak in 1985. In 1989, Eastman Kodak purchased a 40% ownership in Laserdrive and transferred the 3.5" drive development to Laserdrive. Laserdrive was merged into the now defunct Literal Corporation, in which Eastman Kodak had a 26% interest, in 1990. Verbatim, sold to Mitsubishi Kasei in 1990, continued optical media and head development.

The Eastman Kodak Photo CD system, which permits photo processing centers to transfer photographic images to write-once CD disks, began shipping in the last half of 1992. CD-ROM players, operating as part of a CD-I system, are supplied by Philips to attach to consumer TV sets for playback of the images. Philips is also supplying the CD recorders used by participating photo processors, although Kodak is in production of its own 6X CD-R drive (Kodak also provides the media) using a purchased mechanism. Kodak has expanded the role of the Photo CD products to include recording and distribution of other types of data, and is marketing software enabling use of Photo CD images and other types of files with IBM compatible personal computers.

The 14" drive began its production run in 1987, but production has been modest to date. It uses a zoned format and employs proprietary dye-polymer media. A 7.4 gigabyte per side version was announced in 1994. The drive is used in Eastman Kodak's image storage product lines and is also offered on an OEM basis as a computer peripheral. The firm introduced a two headed drive with 25 gigabyte capacity per disk in mid-1996 for shipment in mid-1997. The drive will be able to read earlier Kodak 14" media. A rewritable 14" disk drive and media are also targeted for release in 1997.

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 library units for systems using 12" drives from other manufacturers. CD-ROM libraries are also sold by Eastman Kodak, but these are purchased from a third party.

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.

FILENET CORPORATION
3565 Harbor Boulevard
Costa Mesa, CA 92626

1995 total net sales: $215,477,000 Net income: $14,830,000

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

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

FileNet has shifted the thrust of its product development activities to libraries able to store larger numbers of disks and to the development of complete systems and software for document imaging, processing and storage. However, the new generation of higher capacity 12" drives has caused the firm to reconsider the role of smaller 12" libraries in future systems.

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

1995 total net sales: $31,519,000,000 (FY ending 10/31/95) Net income: $2,433,000,000

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

Write-once technology using magneto-optic media (Continuous Composite WORM) was proposed in 1990 by a group of 14 companies including H-P as the lead proponent. Despite large increases in production, Hewlett-Packard has increasingly moved towards a view of internal optical drive manufacturing as nonstrategic and is halting optical drive production, becoming a drive purchaser for future generations of drives.

H-P remains the leading revenue producer in the 5.25" optical library market, with a product line spanning the range from 16 to 144 cartridge capacities. The libraries are used in H-P systems, but H-P also sells them to OEM accounts and through resellers.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1995 total net sales: $71,940,000,000 Net income: $6,300,000,000

IBM started slowly in the optical storage area, but eventually manufactured or remarketed a variety of products, including CD-ROMs, write-once and erasable drives and optical libraries. IBM has been a very active participant in the optical drive and media standards committees and has also become a major distributor of software and documentation on CD-ROM disks. IBM relies on outside purchases of CD-ROM drives and is judged unlikely to manufacture its own CD-ROM drives. IBM is actively involved in the design of systems using multimedia techniques involving a variety of optical drive types, including CD-ROM and magneto-optic drives. The company has been an active participant in generating standards for magneto-optic drives and has played an important role in resolving industry conflicts regarding DVD 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.

In 1991, IBM announced a 3.5" 128 megabyte MO drive designed at its Fujisawa facilities. The drive was sold with some PS/2 system models and on an OEM basis. IBM's entry into the 3.5" drive marketplace encouraged other firms

to announce similar optical disk drives in the 1991-1992 time period, but IBM's slow rate of adoption, lack of 3.5" OROM published titles, and media interchange problems hampered initial sales. IBM, along with Sony, pushed for a 230 megabyte standard for the next generation of 3.5" drives. IBM did introduce such a drive, though Sony did not. In October of 1993, IBM announced a 1 inch high 3.5" MO drive developed in conjunction with Philips Key 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 with write-once drives. Hewlett-Packard (and now Plasmon) are the suppliers of the library mechanisms, while Mitsubishi write-once drives were used with the libraries until IBM put its own 5.25" multifunction drive into production. IBM then used its own 650 megabyte per side multifunction drives to provide storage for its libraries. The company offers its optical library systems as attachments to large and 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. As of the time of publication, IBM was seeking an alternative manufacturing source for its multifunction 5.25" drive. The 3995 optical library product line is expected to continue, but IBM is broadening its supplier base for optical libraries in order to reduce costs.

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. The firm has developed a significant customer base in the government and military sectors.

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

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

MOST, INC.
11205 Knott Avenue
Cypress, CA 90630

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

Production of a 128 megabyte 3.5" drive developed by MOST and Nakamichi began in late 1990. A 256 megabyte drive using a GCR recording format was announced in 1991, with shipments beginning in 1992. A 384 megabyte drive (also capable of operating at 128, 230 and 256 megabytes) went into production in the third quarter of 1994. In early 1993, Nakamichi, MOST's parent firm, acquired the Optical Products Division of Applied Magnetics and placed it within MOST, where it continues to produce optical drive heads and mechanisms, most of which are sold to other manufacturers. MOST produced a significant fraction of all 5.25" optical drive mechanisms shipped in 1994 and 1995.

In 1995, MOST began shipping a 2.6 gigabyte per cartridge 5.25" optical drive, the first of its breed. A direct overwrite version using light intensity modulation began shipment in July, 1996. 3.5" drives have been deemphasized in favor of the higher capacity 5.25" models.

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

MountainGate is the successor corporation to Cherokee Data Systems. Cherokee Data was founded in March, 1984. The firm's key founders included

managers previously with Storage Technology Corporation and Sperry Corporation. Cherokee designed a 300 megabyte ruggedized 5.25" write-once drive that it supplied to customers in the defense and mineral resources industries. Shipments began in 1988. The first major customer for the Cherokee drive was Lockheed Corporation, which in 1986 invested $2,000,000 in Cherokee, intending to modify the product for potential use in airborne electronic navigation systems for fighter aircraft. Later investments brought Lockheed's share of the ownership to 36%. A nonruggedized version of the drive became available in late 1989.

In 1992, Lockheed purchased the remaining interest in Cherokee and the company moved to new facilities in Reno. The name of the organization was changed from Cherokee Data Systems to MountainGate Data Systems at that time. As of mid-1995, the optical drives were being produced only under contract for military programs, with all other models discontinued. However, the 1995 acquisition of Metrum by MountainGate may revive interest in optical drives, as Metrum's product line included a large optical library.

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

Mountain Optech, founded in 1985, specializes in optical disk drives for ruggedized and military applications. Its first product was a modified version of the Optotech 5.25" write-once drive, delivered in 1986. The modified drives are used in harsh environments such as seismic survey, aircraft maintenance, and manned spacecraft. The mechanism and electronics have been modified for ruggedized or militarized requirements. Current products emphasize fast MO drives using Maxoptix mechanisms.

OPTEX CORPORATION
2 Research Court
Rockville, MD 20850

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

PINE HILL DEVELOPMENT COMPANY
Boca Raton, FL

Pine Hill is a new startup company preparing a very fast disk autochanger

mechanism that can be added to existing CD-ROM drives. The firm expects to be in production by the end of the year.

PINNACLE MICRO
19 Technology Drive
Irvine, CA 92718

1995 total net sales: $81,844,000 Net profit: ($2,459,000)

Rapidly growing Pinnacle Micro, founded in 1987, started as a subsystem producer and remarketer of optical drives and libraries, but in 1992 the firm began assembling 5.25" rewritable drives using purchased mechanisms and internally supplied electronics. The firm established a development center for optical products in Colorado Springs in 1993. Pinnacle Micro has started an optical drive factory, also in Colorado Springs, to produce complete high performance, high capacity 5.25" magneto-optical drives and other products. Pinnacle Micro also remarkets 3.5" MO drives and CD-R drives.

In 1994, Pinnacle Micro began manufacturing the Orray, an array of 5.25" optical drives with a controller that can operate them concurrently. The company also began production of a CD-R drive using a purchased mechanism. In 1995, Pinnacle Micro announced a non-ISO standard drive, the Apex 4.6 gigabyte MO drive, but was unable to put it into production. However, the drive's high capacity, coupled with an unusually low OEM selling price, stimulated substantial customer interest. The Vertex, a more conventional 2.6 gigabyte drive, went into production in mid-1996. The firm hopes to restart Apex manufacturing later in 1996.

QUINTA CORPORATION
1415 Koll Circle
San Jose, CA 95112

Quinta, founded by several executives from the disk drive industry, is one of several new U.S. startup corporations planning to develop high capacity, high performance optical disk drives.

REGAL ELECTRONICS
4251 Burton Drive
Santa Clara, CA 95054

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

SIERRA TECHNOLOGIES CORPORATION
2938 Janitell Road
Colorado Springs, CO 80906

Founded in November, 1993, by former employees of defunct Literal Corporation, Sierra is doing end-of-life assembly of drives and media inherited from Literal and its licensee, Maximum Storage. A very limited supply of new drives is available to existing customers, but media is plentiful. In addition, the firm is remarketing high capacity drives from Matsushita Electric, and is slowly converting the old Literal customer base to the MEI phase change media based product line.

TERASTOR CORPORATION
70 West Plumeria Drive
San Jose, CA 95134

Founded in 1996 by several disk drive industry veterans, Terastor is developing a high capacity, high performance optical disk drive. Quantum is also a major investor in the firm.

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

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

TODD ENTERPRISES
31 Water Mill Lane
Great Neck, NY 11021

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

Asian Manufacturers

(All fiscal years end in March, 1995, unless otherwise noted. All companies are in Japan unless otherwise noted.)

ACER, INC.
156 Ming Sheng East Road, Section 3
Taipei
Taiwan

Acer was founded as Multitech International in 1976, and after a period of growth changed its name to Acer for improved recognition. The company is Taiwan's largest producer of personal computers. The company also produces its own CD-ROM drives, based upon purchased mechanisms, although it has future plans to develop its own mechanisms.

ACER PERIPHERALS
6, Feng Shu Tsuen
Kweishan, Taoyuan
Taiwan

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

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 6X drives.

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

1995 total net sales: $2,781,693,000 Net income: $65,453,000

Aiwa was formed in 1951 and originally was a producer of telephone and audio equipment. Sony holds a 50.6% share in the company. The firm today manufactures audio and video products, disk drive arrays, helical scan tape drives, modems and CD-ROM drives. Aiwa began shipping a double speed drive in 1994 and planned higher performance drives, but decided that its share

was too small for the rapid pace of product evolution, and elected to discontinue its CD-ROM product line. A three disk CD-ROM rotary autochanger began shipments in 1995, but has since been withdrawn.

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

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

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

1995 total net sales: $4,256,624,000 Net income: $48,040,000

Alps Electric is a major manufacturer of electronic components and subassemblies for audio, television, instrument and computer applications. Peripheral devices, including printers and floppy disk drives, accounted for 26% of revenues in 1995. Alps supplies components to other companies wishing to make CD-ROMs and can supply design assistance and components, or will manufacture on a contract basis. In 1994, the firm began to market CD-ROM drives under its own name, but subsequently withdrew its branded CD-ROM drive products, except for small CD-ROM autochangers that began shipments in 1996.

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

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

cations remain the primary target markets. Asaca has shown a prototype 1,200 cartridge library, but the company's library focus is on a 450 cartridge unit now in production.

AZTECH SYSTEMS LTD.
31 Ubi Road 1
Singapore 1440

1995 total net sales: $472,900,000 (FY ending 12/31/95) Net income: $17,900,000

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 6X and 8X drives has followed as mechanisms have become available. About 18% of Aztech's 1995 business was CD-ROM drives, but the majority of the firm's business is in sound cards.

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 has upgraded its line of CD-ROM products and expects to be producing 8X drives and above in the future.

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

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

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

1995 total net sales: $23,063,110,000 (FY ending 12/31/95) Net income: $586,113,000

Canon is a major supplier of business machines, copiers, and cameras, but about 47% of the firm's business is in computer peripherals. Another 15% is in other data and communications equipment. Disk drive products include flexible and erasable optical drives. Canon's rewritable optical drive and media were announced in 1988 when Canon formulated an exclusive agreement with NeXT to supply a 256 megabyte 5.25" magneto-optic drive. Shipments began in 1988, making Canon, along with Sony, one of the early suppliers of rewritable drives. In 1989, Canon acquired a 16% interest in NeXT. NeXT was not successful in establishing optical drives as a major system peripheral storage device, and currently Canon ships its optical drives only for use in its own Canofile document management systems.

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

1995 total net sales: $306,400,000 Net income: ($74,260,000)

Chinon is best known for its cameras and lenses, but 86% of its sales come from floppy disk drives, printers and other equipment for information systems. Eastman Kodak holds approximately 12.1% ownership through Kodak Japan. Chinon has been producing head assemblies for CD equipment and in 1988 began supplying CD-ROM drives to Atari as a custom product. A similar drive has since appeared under Chinon's own label for use with IBM and Apple personal computers and the product line was expanded in 1993 to include double speed drives. 4X drive production began in late 1994, and 6X was added in 1995. A 128 megabyte 3.5" drive was announced in 1992 and began shipping in early 1993. In late 1995, as a result of limited volume and the rapid rate of technological change in the CD-ROM industry, Chinon elected to cease production of CD-ROM drives.

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

1995 total net sales: $1,199,800,000 (FY ending 6/30/95) Net income: $27,400,000

Creative Technology, founded in July, 1981, and its U.S. subsidiary, Creative Labs (established in 1988) are the largest suppliers of soundboards, multimedia

add-on kits and related products for personal computers. The company had been primarily a purchaser of CD-ROM drives, but has assembled substantial quantities of drives since 1994 using purchased mechanisms, filling in with OEM drive purchases as required. The firm ships CD-ROM drives as a component of its multimedia kits, but does not sell individual drives. In 1996, the firm formed an alliance with Samsung to jointly develop a 12X CD-ROM drive, and indicated at that time that it intended to cease CD-ROM drive assembly.

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

1995 total net sales: $464,100,000 (FY ending 12/31/95) Net income: $48,900,000

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, and has begun production of 8X 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, where 6X and 8X drives are being produced.

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

1995 total net sales: $363,200,000 (FY ending 12/95) Net income: ($400,000)

Motherboards and accessories for personal computers are Elitegroup's primary business. The firm showed a family of CD-ROM drives manufactured with Sony mechanisms at the 1994 COMPUTEX show in Taipei and has since produced a moderate number of drives, many of which are sold through reseller channels under the Vertos brand name.

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

1996 total net sales: $40,053,248,000 (FY ending 3/31/96) Net income: $670,927,000

Fujitsu is Japan's largest producer of computer systems and also manufactures a wide variety of other electronic equipment. Computer products represented about 66% of Fujitsu's 1995 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. It is currently available only in Japan, but has been displayed in the U.S. and elsewhere. The CD-ROM drive is purchased from another firm. 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 is largely responsible for the growth of the 3.5" MO market in 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 early 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 4X, 6X and 8X versions in more recent periods.

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

Group Sense is a producer of handheld electronic products such as games, translators and palmtop computers. Double speed CD-ROM drives manufac-

tured with purchased mechanisms were added to the product line in 1994, but the firm has since ceased production of CD-ROM drives.

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

1995 total net sales: $80,854,803,000 Net income: $1,213,120,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major producer of computer systems. It manufactures rigid disk drives and other peripherals as well as processors. About 50% of 1995 revenues were derived from computing and electronic equipment.

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

CD-ROM drives began shipping in 1985, and since 1987 Hitachi has targeted the high performance drive segment of the market because of its more stable price structure and higher margins. The CD-ROM product line was expanded in 1986 and 1987 to include 5.25" form factor drive packaging and some new features. Later products have emphasized performance improvements and half high form factors. Hitachi is also a major producer of components used in CD-ROM drives. Hitachi's OEM sales for CD-ROM drives dipped after 1990, but an effort is under way to revitalize the OEM oriented CD-ROM product line.

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

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

Hopax got started in the CD-ROM business as a manufacturer of optical pickups. The firm leveraged this experience with its own double speed drives starting in 1994, and with a quad speed drive in 1995. 6X and 8X drives were announced at the 1996 COMPUTEX show.

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

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

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

IPC is a manufacturer of CD-ROM drives and a distributor of certain other CD-ROM drives and storage products. Production of CD-ROM drives using purchased mechanisms began in 1995. As of mid-1996, the firm was assembling 8X drives using purchased mechanisms.

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

1995 total net sales: $8,170,575,000 Net income: $6,294,000

JVC, as it is commonly known, is a major producer of consumer audio equipment, including CD players. Since 1985 it has experimented with several computer peripheral programs. The firm introduced CD-ROM drives and went into low volume production in the last half of 1987, but has since withdrawn from the CD-ROM market except for some contract manufacturing. A CD-R drive first shown at the 1990 Fall COMDEX conference went into sample production in late 1991, along with additional mastering subsystems. Full production began in the second quarter of 1992. Drives with 4X read and 2X write are currently in production.

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

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

KONICA CORPORATION
1-26-2 Nishi Shinjuku
Tokyo 163

1995 total net sales: $5,512,247,000 Net income: $40,916,000

Konica is a major supplier of photochemicals and photo related equipment and a significant supplier of business machines. For some years, the company has been a behind the scenes supplier and developer of optical disk drives. The firm has announced a 640 megabyte 3.5" MO drive jointly developed with Seiko Epson for production in the latter part of 1996.

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

1995 total net Sales: $10,798,435,000 Net income: $214,079,000

Established in 1930, Kubota is best known for agricultural machinery and iron pipe. In recent years the company has aggressively diversified into electronics and has made investments in a number of firms, including Maxoptix, which it acquired completely in early 1995. Maxoptix and Kubota jointly manufacture the Maxoptix line of optical disk drives, and Kubota began shipping them in Japan under its own name in 1994.

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

1995 total net sales: $3,368,797,000 Net income: $41,800,000

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. The company has begun

manufacturing CD-ROM pickup and positioning assemblies with one of the fastest seek times available (180 milliseconds) and has begun manufacturing drives for other companies. KME has become a significant supplier of thin CD-ROM mechanisms for notebook computers, offering some as thin as 1/2 inch.

LASERBYTE CORPORATION
Subsidiary of Hyundai
1330 Bordeaux Drive
Sunnyvale, CA 94089

LaserByte was founded in 1990 by former employees of Verbatim who had developed Verbatim's 3.5" magneto-optic drive technology. In early 1991, the founders sold a 55% share in LaserByte to Hyundai, in order to obtain development funds and technical assistance. The firm announced its first product, a 3.5", 128 megabyte MO drive in June, 1993, but actual production started with a 230 megabyte model in 1994. The drive also supported OROM and PROM media. The firm was restructured in 1995 and new management brought in, with ownership split between Hyundai, Philips and private investors. Ultimately, the investors decided that the firm could not be competitive with existing products and terminated operations.

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

1995 total net sales: $8,527,400,000 (FY ending 12/31/95) Net income: $102,500,000

All of the companies in the Lucky-GoldStar group adopted the "LG" name in early 1995. LG Electronics was founded in 1959, and is one of Korea's major producers of consumer electronics. The company's current strategy involves expansion of its industrial electronics divisions, including computers and peripherals. The company currently offers internal and external 6X and 8X speed CD-ROM drives, as well as a CD-I player, produced in Korea under a Philips license. A 3DO type player was introduced in 1995.

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

Lion Optics is a joint venture between the Lion Group, a Malaysia based organization and a group of U.S. managers and investors. The company was

formed in 1993 and began operations in 1994, with a charter to manufacture CD-ROM drives and related products for the OEM marketplace. The firm does a considerable amount of contract manufacturing as well as producing its own brand of drives. Production of a 2X CD-ROM drive using the Philips mechanism began in mid-1994, with initial sales going to a number of system integrators in the United States. The company's production is done in Malaysia. The initial product had a Sony-type AT bus interface, but subsequent products are available with SCSI and ATAPI interfaces as well. 4X drives went into production in 1994, followed by 6X drives, and 8X drives in 1996.

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

1995 total net sales: $662,800,000 (FY ending 12/31/95) Net income: $24,000,000

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. 10X and 12X drives using JVC mechanisms have been announced, but the firm's major rampup is expected in 1997 when new production capacity is added.

LONGSHINE ELECTRONICS CORPORATION
245, Section 3
Roosevelt Road
Taipei
Taiwan

Longshine was started in 1981 as a manufacturer of communication and computer equipment. The firm and its subsidiaries now make personal computers, rigid disk drives, automotive electronics and security products and CD-ROM drives, which began production in 1994 using purchased mechanisms. Production of 4X drives commenced in mid-1995, but the firm has since elected to remarket drives produced by other firms.

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

1995 total net sales: $73,995,304,000 Net income: $963,727,000

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 pro-

duces CD-ROM drives for sale by MEI. High volume production commenced in 1992, and MKE became 1994's largest producer of CD-ROM drives and mechanisms. Although a bit late in starting production of 4X drives, 1995 production by MKE increased rapidly and Matsushita remains the largest producer of CD-ROM drives.

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

In 1989, the Disk Division of MEI acquired the responsibility for manufacturing and marketing of the Matsushita Communication Industrial optical disk drive product line, adding rewritable drives and optical libraries to the MEI product line. Production of a 470 megabyte 5.25" write-once drive began in the Fall of 1989. MEI captured a major share of the 5.25" write-once market with this drive and its 700 megabyte per side successor, introduced in late 1993. The company currently offers a line of 5.25" optical disk libraries as well as its drives.

In 1990, Matsushita announced the first commercially available rewritable phase change drive and media. The 5.25" drive also accepts write-once media, permitting it to operate as a multifunction drive as well. Because no overwrite pass is required, write throughput exceeds that of magneto-optic rewritable drives. However, its unique format and technology have inhibited broad industry acceptance. However, the firm appears to be on the way to success with the PD drive, a 12 centimeter drive capable of reading CD-ROM disks and writing/reading phase change media, although the phase change media can be read only on PD drives. The PD drive technology has been licensed to NEC and TEAC.

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

MACO, as the company is often known, produces a wide variety of electronic items, including audiovisual equipment, appliances, communications and data processing equipment, and instrumentation. Data storage products have included CD-ROM drives and floppy disk drives. Half-high CD-ROMs began shipping in 1987, mostly to customers in Japan, for which MACO was a significant OEM supplier of CD-ROM drives. The firm shipped mostly mechanisms to other firms which integrated them into complete drives. Responsibility for CD-ROM drives has now been transferred to MKE and the MACO products have been withdrawn.

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

1995 total net sales: $4,776,709,000 Net income: $90,532,000

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

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

Maxoptix began in 1986 as a research program within Maxtor Corporation. In March of 1989, Maxtor and Kubota, Ltd. formed Maxoptix, a joint venture 63% owned by Maxtor. The first 5.25" MO drives produced by Maxoptix were shipped in 1990. Kubota purchased Maxtor's share in early 1995. Maxoptix designs, produces and markets rewritable optical disk drives. Kubota has worldwide manufacturing rights and exclusive sales rights in Japan for Maxoptix products. Maxoptix historically followed a strategy of emphasizing leading edge performance and capacity, as well as increasing the functional capabilities of its optical drives with each new product introduction, but its current strategy emphasizes optical subsystem integration and reduces the firm's reliance upon drive sales for growth. Kubota now does the volume manufacturing of Maxoptix optical drives. Maxoptix retains design, sales and marketing responsibilities for optical disk drives, and remains a significant supplier of high performance drives, although emphasizing its system integration business.

MICROBOARDS
31-8 Takasecho
Funabashi-shi, Chiba 273

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

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

1995 total net sales: $34,620,618,000 Net income: $448,296,000

Mitsubishi is most noted for heavy machinery production, but is also active in defense electronics and consumer electronics. Data and communications systems represent about 38% of revenues, while consumer electronics accounts for 19% of sales.

In the past, Mitsubishi has manufactured 5.25" MO drives, write-once drives (sold to IBM) and optical libraries, but left the optical storage peripherals business in 1993. In 1996, the firm announced a DVD-ROM drive and mechanism, with samples to be delivered in August and production planned for late 1996. The drive has a dual laser pickup, and thus will be able to read CD-R disks as well as DVD-ROM and CD-ROM disks.

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

1995 total net sales: $2,102,929,000 (FY ending 1/30/95) Net income: $21,576,000

Mitsumi, founded in 1949, is primarily a manufacturer of electronic components, but 29% of 1995 revenues were derived from CD-ROM drives and 12% from floppy drives. The firm introduced CD-ROM drives in 1988, with most of the drives being sold as attachments to personal computers. Later models have been designed for use with games. Front tray loading drives not requiring a caddy were introduced in 1993. Mitsumi is making a major effort to market CD-ROM drives to firms selling multimedia equipment, and after a rough start seems to have found the formula, showing excellent growth in CD-ROM drive shipments since 1993. In 1995, the firm made very large quantities of 4X CD-ROM drives, becoming the second-largest producer of CD-ROM drives. The firm has since transitioned to faster models.

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

1995 total net sales: $216,539,000 (FY ending 2/28/95) Net income: ($13,717,000)

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 27% of 1995 sales were computer related items. Nakamichi established or purchased several organizations in the United States, including MOST, Mountain Computer, and Ocean Microsystems. Ocean Microsystems is responsible for marketing optical subsystems using the MOST drive. In September, 1990, Nakamichi established Nakamichi Peripherals Corporation, a holding company that supervises the operations of MOST, Mountain, and Ocean.

Responsibility for Nakamichi's line of optical disk test equipment has been transferred to Mountain Computer, which manufactures a variety of test and certification equipment. A 128 megabyte 3.5" rewritable drive developed by MOST and Nakamichi appeared in 1990, the first 128 megabyte 3.5" MO drive to reach the marketplace. Nakamichi markets the MOST drives in Japan.

In 1994, Nakamichi began marketing a seven disk tabletop CD-ROM library derived from an audio library design. The firm has aggressively priced the library and has captured significant market share, including some OEM accounts. Half height CD-ROM autochangers were introduced in 1995.

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

1996 total net sales: $46,828,456,000 (FY ending 3/31/96) Net income: $821,789,000

NEC has defined its product area as communications and computers, with computer products accounting for about 45% of 1995 revenues. The firm has the largest share of the Japanese personal computer market. NEC makes a variety of data storage products, including floppy, rigid and optical disk drives. The firm's first optical drive, introduced in 1983, was a 1 gigabyte, 12" unit used primarily for NEC captive document storage systems, but also sold on an OEM basis. A 1.8 gigabyte drive was marketed in 1987 and a 2.5 gigabyte drive was introduced in 1990. A 5.25" MO rewritable drive started production in mid-1989, and a 650 megabyte per side version was introduced in mid-1993. A direct overwrite version with 1.3 gigabyte per side capacity began shipping in early 1996.

NEC has licensed Matsushita's PD drive and phase change technology. The PD production ramp was scheduled for the spring of 1996, but technical difficulties have forced a rescheduling to the fall of 1996. NEC also offers optical libraries with 12" drives and with 5.25" drives, mostly sold in Japan.

NEC Home Electronics is producing CD-ROM drives for both captive use and worldwide OEM sale, and has had moderate success with a modified CD audio drive as a CD-ROM add-on to its popular PC Engine consumer system. A 1990 attempt to market a similar product in the U.S. was not successful.

In 1992, NEC introduced CD-ROM drives that operate with a doubled rotation and data transfer rate in order to accommodate multimedia video requirements and followed that up with 3X and 4X models in 1993 and 1994 respectively. A 6X drive was introduced in 1995. The firm also produces a similar series of portable CD-ROM units easily switched between computers. As a result of increased demand beginning in late 1992, NEC has significantly expanded its production capacity for CD-ROM drives and has become one of the market's major suppliers. 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.

NIKKYO CORPORATION (NISTEC)
480 Minoridai
Matsudo-shi, Chiba 271

Nikkyo was founded in 1947 and started as a producer of metal parts. Starting in 1956, the company diversified into the production of electrical and electronic components and equipment.

Optical libraries are produced for the data processing and entertainment markets. Videodisk changers proved to be an entry into similar products for computer applications. The computer related products include both 12" and 5.25" libraries manufactured on a contract basis for a number of system producers. Nikkyo is one of Japan's highest volume producers of optical libraries for computer use and a major producer of libraries for videodisks. Having established itself as a manufacturer of optical libraries on a contract basis, Nikkyo began selling 5.25" optical libraries under the Alaya brand in 1993. In 1995, the firm created a separate company, Nistec, to market its libraries. Nistec also has engineering responsibilities for libraries.

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

1995 total net sales: $3,072,258,000 Net income: $16,347,000

Nikon, a member of the Mitsubishi group, is best known for its popular line of cameras and other optical equipment. The firm is also a significant supplier of semiconductor production equipment, medical optical instruments, microscopes and telescopes, and other optical instruments. As a way of expanding its scope of business, in 1992, Nikon introduced the first 12" magneto-optic drive sold as a computer peripheral device, a 2 gigabyte per side erasable optical drive. Additional opportunity for Nikon may lie in an innovative media design that solves the overwrite problem exhibited by current magneto-optic media designs. Nikon's

drive was initially sold only in Japan, but after a round of redesign and cost reduction was also marketed in the U.S., where it is one of the drives supported by ATG Cygnet in its 12" libraries. A 5.25" LIM-DOW MO drive, developed in conjunction with Hitachi, was introduced in 1996.

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

1995 total net sales: $1,098,797,000 Net income: ($6,358,000)

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.

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

1995 total net sales: $19,190,554,000 Net income: ($407,881,000)

NKK, founded in 1912, originally was a steel pipe producer. It is now one of Japan's largest steel producers and is diversifying into other areas such as electronics, automation, CAD/CAM systems, biotechnologies, advanced materials and urban development. Steel represents about 64% of the firm's revenues. Optical libraries were originally the responsibility of the Electronics Division, but in 1993, optical libraries were transferred to NK-EXA, a subsidiary originally formed to support NKK's internal data processing operations, but which acquired an expanded role and provided system integration services and peripheral equipment to outside customers. The NKK brand name was retained.

NK-EXA offered optical libraries with both 5.25" write-once and rewritable drives. The 56 disk library unit was developed jointly with another manufacturing company. First shown in 1989 at the Spring COMDEX show, it was marketed on a worldwide basis and has appeared in numerous document management systems. A variety of write-once and erasable drives were available in the library. In 1992, a larger library with a maximum capacity of 160 cartridges was added to the NK-EXA product line. A 20 cartridge 5.25" library was introduced in 1993.

Restrained by high procurement costs and an unfavorable exchange rate, in 1995 NK-EXA decided to leave the optical library business, and has terminated operations in this area.

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 products are marketed under the Octek brand name, and include 8X and 10X drives assembled with purchased mechanisms.

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

1995 total net sales: $2,684,739,000 Net income: $33,024,000

Founded in 1919, Olympus Optical company is known primarily for cameras and optical instruments. In recent years the company has broadened its activities to include electronics and some specialty products, including optical heads for disk drives. Development of optical disk drive technology began in 1981 when Olympus and Fujitsu began a joint project that resulted in one of the first commercial write-once optical disk drives. The firm's optical electronic products include optical heads, an optical card reader compatible with the Drexler Lasercard and a 5.25" erasable optical disk drive announced in November, 1987. The disk drive, which has a capacity of 326 megabytes per side, was provided in sample quantities as of mid-1988, and Olympus mechanisms have been adopted by several manufacturers as the basis of their own rewritable drives.

Olympus began marketing under its own name in 1992 when it introduced a 3.5" 128 megabyte drive. This was followed by a 230 megabyte version in early 1994. At that time the firm also announced 5.25" full height and half height MO drives. The company is currently expanding its marketing channels in the United States for the drives, and in early 1994 adopted the brand name "Deltis" for its externally packaged drive subsystems and related products, including libraries and CD-R drives. In 1996, the firm introduced a reduced cost and aggressively priced ($299) 3.5" 1 inch high MO drive and a 1.3 gigabyte per side 5.25" drive.

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

In June, 1993, Optics Storage was created to develop and manufacture products with CD-ROM technology. The company was started by rigid drive industry veterans with experience at IBM and Conner Peripherals. Product strategy emphasizes early development and introduction of high performance drives.

The firm's initial products were based upon double speed Philips mechanisms and are equipped with PC AT interfaces. Production began in late 1993. Subsequent products include 4X (production started in late 1994), 6X, 8X, and 10X drives.

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

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

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

1995 total net sales: $5,429,073,000 Net income: ($12,705,000)

Pioneer, founded in 1947, is a major manufacturer of consumer electronic equipment. 94% of Pioneer's 1995 revenues came from sales of audio, video and automotive electronic equipment. The firm is especially strong in the laserdisc and automotive audio CD markets.

Pioneer and Ricoh had a joint development program on an 8" 750 megabyte optical write-once disk drive, with Ricoh being Pioneer's most significant customer for the product. First shipments began in late 1985, and Pioneer has established a separate division to make and sell the product. Pioneer has also developed a 5.25" write-once drive, with first shipments in mid-1988. The media used in these drives is a cyanine dye-based type that appears to offer superior resistance to corrosion. Pioneer's media was the first commercial version of dye-based media to be brought to market. In 1990, Pioneer introduced a multifunction drive using dye or MO media interchangeably. The drive uses sampled servo format.

In 1989, Pioneer introduced a CD-ROM drive integral to an automatic library mechanism. The library contains up to six disks and is derived from a design developed for use with audio CD players and disks. A version with quadruple rotation and data transfer rate was first shipped in the Fall of 1992. At the 1993 AIIM show, Pioneer displayed prototypes of an 18 disk version, which began production in late 1993. Pioneer became the leading producer of small CD-ROM libraries, but is now being challenged by Nakamichi, Sanyo and others. At the 1994 AIIM show, Pioneer displayed a 500 disk CD-ROM library based upon a karaoke system also produced by Pioneer. A 100 disk unit will begin shipping in

the second half of 1996. In the second half of 1996, Pioneer began a marketing effort to sell Pioneer brand CD-ROM and DVD products in the U.S. Pioneer has also begun marketing a 10X CD-ROM drive with dual CAV and CLV modes, the first CD-ROM drive of that type.

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

Shinano Kenshi was founded in 1918 as a silk spinning company. The company has produced CD players, printers, and floppy disk drives under contract for other companies. In 1989, the firm began selling a CD-I encoding system. CD-ROM drives bearing the firm's own label first shipped in 1990, but subsequently have appeared under the Texel brand. The half high drives are available in internal and external configurations. In 1992, Texel began shipping a double speed RPM drive in internal and external configurations, following up in 1993 with a high performance version. The firm achieved a moderate degree of success selling through reseller channels in the United States. In 1994, the firm changed its identity and now markets CD-ROM drives under the Plextor name. Plextor was one of the first companies to announce and produce a 6X CD-ROM drive, which began its production run in mid-1995. 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.

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

1995 total net sales: $10,865,772,000 Net income: $198,009,000

Copiers, photographic equipment, and sensitized papers provide most of Ricoh's revenues, but the firm also produces a growing line of data processing equipment, which accounted for 22% of 1995 revenues. Ricoh and Pioneer developed an 8" write-once optical drive which Ricoh used in a document storage system. However, Ricoh concentrated upon developing optical disk drives in the 5.25" form factor, rather than expending further effort on an 8" product.

In early 1987, Ricoh and Maxtor entered an agreement whereby Maxtor became the exclusive marketing agent for Ricoh OEM 5.25" write-once optical disk drives in the United States. Ricoh marketed subsystems containing optical drives in the U.S., an activity permitted under the terms of the Ricoh-Maxtor agreement. In the years following 1987, Ricoh supplied more write-once drives than any other manufacturer, largely as a result of its collaboration with Maxtor. However, in mid-1994, Ricoh announced it would cease production of write-once drives and concentrate upon MO and CD-R drives. Ricoh has also announced

two generations of 5.25" optical libraries, the newer of which is made for Ricoh on a contract basis.

In 1988, a half high version of its original 5.25" optical disk drive design was announced. Also in 1988, Ricoh adopted a rewritable drive mechanism supplied by Olympus on an exclusive basis, and, supplying the required electronics and packaging, began shipping a rewritable 5.25" 300 megabyte per side optical drive in the second quarter of 1989.

In early 1990, Ricoh announced a multifunction drive using magneto-optic rewritable media with 220 megabyte capacity per side and 393 megabyte per side write-once media. An ISO-standard high performance 5.25" rewritable drive was introduced in 1991. A 3.5" 128 megabyte drive announced in 1991 was made for Ricoh by another Japanese firm, but Ricoh has since begun manufacturing a drive of its own design. A 230 megabyte version began production in early 1995.

Ricoh began manufacturing CD-R recorders in 1993, and is among the more aggressive marketers for this type of drive. A cost reduced double speed drive went into production in early 1995, followed by a 4X read, 2X write model in 1996. Ricoh has indicated plans to manufacture CD-E drives beginning in 1997.

SAMSUNG ELECTRONICS
7 Soonwha-Dong
Seoul
Korea

1995 total net sales: $20,944,200,000 Net income: $3,241,200,000

Founded in 1969, Samsung Electronics is Korea's largest manufacturer of electronic products, which range from semiconductor components to telecommunications equipment and computers. About one fifth of the firm's revenues are derived from information systems and related products. Disk drive products include rigid, flexible and optical disk drives. In 1992, a 5.25" MO drive was announced, but the firm decided not to place it into production. A double speed CD-ROM drive was announced in late 1993, and was joined by a 4X drive in mid-1995. 6X and 8X drives have recently been added to the product line.

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

1995 total net sales: $18,554,696,000 (FY ending 11/30/95) Net income: 165,612,000

Sanyo is a major supplier of facsimile equipment, consumer electronics, appliances, batteries and components such as solar cells, and is one of Japan's

more active offshore manufacturers, especially in China. About 30% of sales are computing and business equipment. Sanyo is actively involved in CD equipment, component and media production and introduced a CD-ROM drive in 1987. Shipments began in 1988. Half high drives began shipping in 1989, and a portable version was introduced in 1991, a CD-ROM product category that Sanyo continues to emphasize. Sanyo and its subsidiaries currently produce several models of CD-ROM drives. In 1995, Sanyo entered the CD-ROM auto-changer market with a 3 disk model capable of fitting into a standard 5.25" half height form factor. It incorporates a 4X drive with IDE/ATAPI interface. A large portion of Sanyo's production is committed to OEM customers, notably Gateway Computer.

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

1995 total net sales: $4,084,963,000 Net income: $54,462,000

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 company sells more CD-ROM drive based game equipment sets than any other producer. The CD-ROM drives included with the games are made on a contract basis for Sega by several firms.

SEIKO EPSON CORPORATION
80 Hirooka
Shiojiri-shi, Nagano 399-07

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also controls Japan's Seiko companies, known for watches and electronics. Epson is best known for its printers, but also manufactures portable computers, displays, and floppy disk drives. In 1988, Epson agreed to supply Maxtor with a 160 megabyte 3.5" MO disk drive and media then under development. While plans to deliver such a drive to Maxtor were terminated, Seiko Epson continued its development program, announcing a 128 megabyte 3.5" drive in 1992. However, the firm has elected to remarket 230 megabyte 3.5" optical disk drives rather than produce them internally.

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

1995 total net sales: $17,227,050,000 Net income: $473,994,000

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 21% of sales are derived from computer or computer related products, including desktop and transportable personal computers. In mid-1987, the firm announced a 5.25" 190 megabyte MO drive. An improved 325 megabyte version began production in 1990 and was upgraded to a 41.3 millimeter high version in 1992. In early 1994, Sharp began shipments of a 650 megabyte per side half high 5.25" MO drive. Sharp also has announced an 8 centimeter CD-ROM drive as a part of its Electronic Organizer system.

Sharp is a Sony licensee for the MiniDisc system and is expected to produce a computer peripheral version of the MiniDisc after the audio version is launched.

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

1996 total net sales: $48,909,105,000 (FY ending 3/31/96) Net income: $577,764,000

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 68% of revenues. Sony also holds a significant share of the magneto-optic disk drives and high performance CD-ROM drive markets, although this leadership position is being severely assaulted by other competitors. The company is vertically integrated and supplies its own media, and is currently the largest producer of magneto-optic media. Sony has consistently ranked among the three largest CD-ROM drive producers for the past several years.

Because of its strong position in the audio CD player market, Sony is very competitive in the CD-ROM marketplace with products aimed at the personal computer and small systems market. Sony, together with Philips, has been a moving force in establishing standards for CD and CD-ROM devices and in the CD-I multimedia standards effort. Sony showed a write-once CD format recorder as part of a CD-ROM mastering system at the 1990 Microsoft Conference, but has lagged behind other manufacturers in providing a low cost CD-R drive. In 1996, Sony announced CDRFS, a CD-R packet writing system for which it hopes to gain industry acceptance.

Sony fields a product line of CD-ROM, write-once and rewritable optical drives. The write-once product line includes 12" drives with up to 7.5 gigabytes per side capacity, while the rewritable drives are 5.25" and 3.5" MO models. The 5.25" rewritable drive product line is being further developed, although Sony skipped the 230 megabyte 3.5" drive generation to concentrate upon development of higher capacity models. To support its 12" write-once drives, Sony offers an automated library unit, first shown at COMDEX in the Fall of 1985. A smaller library holding 12 cartridges was introduced in mid-1992. In 1994, Sony introduced a 20 disk 5.25" library, followed by a 60 disk library in 1995. Both are manufactured in the United States. Sony has filled in its line of optical libraries

with models purchased from other suppliers. A CD-ROM library is scheduled for production in late 1996.

In mid-1990, Sony introduced the Data Discman, a portable CD-ROM system using the first 8 centimeter CD-ROM drive to go into production. The product was introduced in the U.S. in late 1991, although software availability is still limited. The Sony PlayStation, a game system introduced in 1995, appears to have brighter prospects, although competition from CD-ROM games for personal computers have restrained sales.

In 1987, Sony announced and shipped its first few erasable 5.25" optical drives, using magneto-optical technology. Production units were shipped in late 1988, and from 1989 through 1994, Sony has been the largest supplier of 5.25" rewritable optical disk drives. Sony, with IBM and others, was a proponent of the 654 megabyte per side proposed standard, and announced such a drive in the Spring of 1993. 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 is currently the leading producer of 5.25" MO drives.

Sony introduced a 3.5" 128 megabyte rewritable drive in mid-1991. The drive had a specified average seek time of 40 milliseconds and rotated at 3,000 RPM, among the faster optical drives. Sony surprised the industry when it failed to announce a 230 megabyte 3.5" drive in early 1994, but it now appears that the firm has made a strategic decision to leapfrog the competition and go directly to higher capacity drives with a 650 megabyte drive. The new design is not compatible with any other product and has received only lukewarm industry support, although Hitachi has indicated it may produce a similar product and 3M has indicated an intention to produce media. Sony started production in late 1995.

Sony announced the MiniDisc, a 2.5" magneto-optic drive intended for use in a portable audio recorder, and currently in production as an audio device, in 1991. In mid-1993, Sony announced a proposed standard for the MD-DATA, a 140 megabyte CLV 2.5" magneto-optic drive with 150 kilobyte per second data transfer rate. A separate erase pass is not required. Modest shipments began in 1994. Sony is also looking for opportunities to apply the MD-DATA technology to other form factors.

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

1995 total net sales: $341,700,000 (FY ending 12/31/95) Net income: $5,800,000

Founded in 1983, Tae-Il is a major producer of magnetic heads and media. The firm recently entered the floppy disk drive and CD-ROM drive markets. A 6X drive was introduced in 1995 and an 8X drive in 1996.

TATUNG COMPANY
22 Chungshan North Road, Section 3
Taipei 10451
Taiwan

1995 total net sales: $1,548,100,000 (FY ending 12/31/95) Net income: $223,000,000

Tatung was founded in 1918 and has grown to become a major supplier of industrial and electronic equipment. The company recently entered the CD-ROM market, assembling 6X and 8X drives using purchased mechanisms.

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

1995 total net sales: $1,169,862,000 Net income: ($118,605,000)

TEAC is best known for its leadership position in the flexible disk drive industry, but the firm also has a development program for optical disk drives. A 3.5" 128 megabyte drive was announced in 1991, but production shipments did not begin until 1992. TEAC is also offering a line of CD-ROM drives, starting with 4X drives introduced in 1994. Faster models have been subsequently introduced, as well as 17 millimeter and 14 millimeter high drives for use in notebook computers. TEAC has also introduced a 4X CD-R drive. The firm expects to be in production of PD drives in late 1996.

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

1996 total net sales: $54,527,007,000 (FY ending 3/31/96) Net income: $962,599,000

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 59% 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 level 5.25" write-once optical disk drives in early 1989, although it began shipping samples of it in 1986. However, 5.25" drive shipments never reached appreciable levels and the company withdrew from the write-once market in 1992. Toshiba showed a 3.5" MO drive at the 1991 Tokyo Business show, but sold it only in Japan and has since withdrawn it.

CD-ROM shipments also began in 1986 and fared much better. Toshiba's later CD-ROM models have unusually short seek times for CD-ROM drives, and

this has helped Toshiba capture a significant and growing market share. The high performance drives are particularly favored by system integrators building file servers incorporating CD-ROM, and in 1990, Toshiba CD-ROM drives appeared in the product lines of major system manufacturers, including IBM. An 8 centimeter CD-ROM drive was announced in 1992, but has since been withdrawn.

Toshiba introduced 4X drives in 1994, and has followed up with 6X and 8X models. DVD drives are a major Toshiba initiative, and Toshiba is expected to be an early introducer and shipper of DVD and DVD-ROM drives, although expected delivery has slipped past the originally anticipated September, 1996 date.

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

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

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

Umax offers CD-ROM drives based upon Sony mechanisms. Production of the drives began in 1994 with 2X drives. Faster 4X, 6X and 8X models have since been introduced.

UNITRON INC.
542-3 Chung Cheng Road
Hsin Tien 23138
Taipei
Taiwan

Unitron has been assembling CD-ROM drives using purchased mechanisms since 1995. The current product line includes 6X and 8X drives. Most of Unitron's drives are sold in Japan.

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

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

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

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

YAMAHA CORPORATION
10-1 Nakazawa-machi
Hamamatsu, Shizuoka

1995 total net sales: $5,139,020,000 Net income: $56,858,000

Yamaha is the world's largest manufacturer of musical instruments, which account for 61% of the firm's sales. The firm is also a major supplier of thin film heads for rigid disk drives and is rapidly increasing its output of heads.

Among more recent activities is the development of a CD-R system capable of recording on write-once media. The Yamaha system is intended for use in situations where fast preparation of a master disk is required or where relatively few copies are needed. Yamaha's was the first commercial write-once CD format drive, and the firm followed up with a greatly cost reduced 4X recorder that went into production in 1994. An aggressively priced 2X write/4X read model was introduced in 1996.

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

Marketing through Lxycon Enterprise Corporation, Yung Fu produces CD-ROM drives using purchased mechanisms. Production of the double speed unit began in late 1994, with production of 4X, 6X and 8X drives following in later periods.

European Manufacturers

AMBER TECHNOLOGY LIMITED
5 Colne Way Court
Watford, Hertford WD2 4NB
United Kingdom

Amber made its entrance into the optical library market in 1993 when it displayed a 52 cartridge library at the 1993 AIIM show. The unit could be expanded to hold 104 cartridges, and subsequently announced models held up to 124 disks. The design of the autochanger was unusual in that cartridges were placed in a circle around a rotary picker mechanism rather than employing the usual X-Y axis picker movement. A CD-ROM version was added in 1994, but the company never achieved significant sales.

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/ATG CYGNET
1270 Avenue General Eisenhower
31047 Toulouse
France

Beginning as the optical disk operation of Thomson-CSF, ATG was formed as a joint venture in 1984 when CIT-Alcatel, a maker of image processing systems, joined with Thomson-CSF, Rhone-Poulenc, Bull, and several other French companies to form Alcatel-Thomson-Gigadisc. Drive and media production began in Toulouse in early 1986. ATG was one of the first firms to get into production of optical drives, but media shortages hampered its growth. Disappointing sales caused Alcatel to decide to withdraw from the venture, and for a short time ATG was dormant while new investors were found. Officially renamed Art Tech Gigadisc, the firm became known as ATG Gigadisc.

In 1993, ATG Gigadisc purchased Cygnet Systems, 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 has had difficulty in

achieving financial stability, and is currently in "judicial review" status, the French equivalent of Chapter 11.

ATG SA 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. ATG Cygnet produces the line of larger 12" library units. The Cygnature, a 5.25" disk library capable of mixing several types of media, was originally expected to be shipped in 1995, but after an extended development effort, the Cygnature program was discontinued. A dual head 16 gigabyte 12" WORM drive is still scheduled for production in late 1996.

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

DSM, established in 1987, is a small, specialty products engineering firm. It has produced a small number of custom optical libraries which can be configured with various numbers of drives and cartridge storage slots. Some standard configurations are also available. Library configurations with either 12" WORM, CD-ROM/CD-R drives or 5.25" drives are produced. Drives from most manufacturers are supported in the library systems. DSM announced capabilities include optical libraries with up to 2,380 storage slots for disks.

K & S SYSTEMTECHNIK U. VERTRIEBSGESELLSCHAFT MBH
Gerberstrasse 5
90411 Nurnberg
Germany

K & S was founded in 1985 as a consulting firm for data processing and automation. The company began development of a family of tabletop optical libraries in 1990. A few evaluation units of a 10 cartridge 5.25" library were shipped in 1991, but formal introduction and the start of production shipments occurred in 1992. Grundig acquired 51% of the company in mid-1995.

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 the growing library business 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 the second quarter of 1994. The new library is offered with CD-R drives as well as CD-ROM drives. A direct network attached version became available in 1996.

NSM originally marketed primarily in Europe, but has established 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

1995 total net sales: $40,288,750,000 Net income: $1,573,750,000

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 effort has been intermittent. Philips supplied 3.5" MO mechanisms for other manufacturers for a few years.

Manufacturing of CD-ROM drives, CD-R drives and MO drives (and mechanisms) is the responsibility of Philips Key Modules Group, which sells large quantities of mechanisms to CD-ROM drive producers, some of which manufacture complete drives for resale under the Philips label.

In 1985, Philips entered into a joint venture with DuPont, named Philips and DuPont Optical (PDO), to produce optical media of various types in large quantities. PDO did not meet financial expectations and was put up for sale in late 1990. The CD-ROM portion of PDO was sold to Disc Manufacturing, Inc. in mid-1991. Mitsubishi Kasei acquired U.S. manufacturing and marketing operations for plastic substrate writable media, while the remainder of PDO, including European marketing and the manufacture of 3.5", 5.25" and 12" glass substrate media, is now owned completely by Philips.

In 1986, OSI, a joint venture between Philips and Control Data, was reorganized as Laser Magnetic Storage and charged with the responsibility of manufacturing and marketing the Philips CD-ROM, write-once optical disk drives designed by OSI using Philips-developed technology, and magnetic tape drives previously produced by another CDC joint venture. Philips owned 51% of LMSI while Control Data held the other 49%. In 1990, Philips purchased Control Data's share and became the sole owner of LMSI, now renamed as Philips LMS.

Philips' Professional Interactive Media Systems (IMS) is responsible for CD-ROM, CD-I, CD-ROM XA, CD-R, and supporting the Kodak Photo CD effort. Mechanisms are sold on an OEM basis by Philips Key Modules, which also provides drive mechanisms to other Philips business units.

Philips began volume shipments of CD-I players in mid-1992. In 1992, the firm began sales of CD-ROM drive subsystems bundled with software. Write-once compact disk drives, also known as CD-R (CD-Recordable) or CD-WO drives began shipping in 1992 and Philips is currently one of the leading manufacturers of CD-R equipment.

OPTOMEDIA ENGINEERING LIMITED
Chalke House, 3 Brunel Road
Salisbury, Wiltshire SP2 7PU
United Kingdom

Optomedia supplies a CD-R duplicator using from one to four CD-R drives. Up to 72 disks can be stored. The loaders use 2X write, 4X read Yamaha drives. Media can be loaded 12 disks at a time, although each disk must be enclosed in a caddy.

PHILIPS LMS (Previously Laser Magnetic Storage International)
Subsidiary of N.V. Philips
4425 ArrowsWest Drive
Colorado Springs, CO 80907

LMSI was formed in 1986 through the combination of Optical Storage International, Computer Peripherals International, and Philips' CD-ROM operations. Philips owned 51% of the company. CPI was a Control Data and NCR joint

venture that produced tape drives. OSI, formed in 1984, was a joint venture of Philips and Control Data. The organization originally was managed by Control Data and combined two earlier joint ventures, Optical Peripherals Laboratory in Colorado and Optical Media Laboratory in the Netherlands. The entire U.S. operation, at one time split between California and Colorado, was consolidated at the Colorado facility in 1986. In 1986, Philips assumed management responsibility for LMSI and in 1990 purchased Control Data's interest. In 1992, LMSI was placed in the Philips Technologies Group and received new senior management. The firm was renamed Philips LMS in 1994.

The company makes optical disk drives and also produces magnetic tape drives. Philips LMS optical disk drives currently include a 12" write-once drive, and 12" automated libraries. A 5.25" write-once drive, introduced at the Fall COMDEX conference in 1987, has since been discontinued. Philips LMS produced CD-ROM drives for a few years, but CD-ROM production has now been transferred to Philips Key Modules Group.

In 1990, Philips LMS introduced the first optical disk drive with two independently operating heads scanning both sides of the disk media. The drive uses 12" media and is available as a freestanding disk drive or as part of a jukebox unit containing the drive and five disks. Production of the new 12" products was delayed until the latter part of 1991, and production was sporadic until late 1992 when the manufacturing process was stabilized. Media is obtained from a Philips LMS manufacturing operation sharing Philips manufacturing facilities at Blackburn in the UK. Philips and Dupont Optical (PDO) is also a qualified media supplier.

PLASMON DATA SYSTEMS, INC. (Formerly International Data Engineering)
Division of Plasmon PLC
2045 Junction Avenue
San Jose, CA 95131

1995 total net sales: $41,274,882 (FY ending 3/31/96) Net income: $1,415,482

Founded in 1985 as the U.S. subsidiary of Plasmon PLC, an optical media manufacturer, in 1994, Plasmon acquired the assets of International Data Engineering 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 ten 5.25" cartridges and a single 5.25" drive. A 20 cartridge, two drive model was introduced in 1990. The libraries are remarketed by many subsystem producers and some optical drive producers. Because of the library's very low OEM and distributor prices, the firm was able to sell more libraries in 1990 and 1991 than any other producer. A five cartridge version was introduced in 1991, and an 8 cartridge library for 3.5"

drives made its debut in 1992. A 26 cartridge 5.25" drive library was introduced in late 1993, and a 53 cartridge model was first shipped in December of 1993.

Plasmon Data Systems is now one of the leading suppliers of 5.25" optical libraries, and has broadened its product line with increasingly larger library systems over the past few years, with the largest library capable of storing 300 disk cartridges. The firm has acquired several major OEM customers in 1995 and 1996 and is the second largest producer of optical libraries, following Hewlett-Packard.

1996 DISK/TREND REPORT

DISK/TREND ON DISK

Introduction

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

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

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

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

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

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

The authors of this manual assume that you are familiar with personal computers, Lotus 1-2-3 or other spreadsheets, and MS-DOS, and do not cover their operation in this manual. This manual deals specifically with how to load and use the files supplied on the floppy disks.

Note: Please read the license on the following page.

DISK/TREND ON DISK

Information License

DISK/TREND supplies diskettes containing selected information from the 1996 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1996 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.

2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.

3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.

2. Transfer the information through or within a computer network.

3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.

4. Transfer this license to another party.

AUTOIMPORT

Use of AutoImport is subject to license terms and conditions of White Crane Systems, Inc.

Trademarks

IBM, Lotus and Lotus 1-2-3 are trademarks of International Business Machines Corporation.
MS-DOS is a trademark of Microsoft Corporation.
AutoImport is a trademark of White Crane Systems, Inc.

1996 DISK/TREND REPORT

Getting started

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

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

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

DISK/TREND ON DISK is normally shipped on 1.44 megabyte 3.5" diskettes, but is also available on 1.2 megabyte 5.25" diskettes if requested.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked "Tables" in a floppy disk drive able to read your size disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the Lotus 1-2-3 system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the "Tables" disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which Lotus 1-2-3 normally stores worksheet files. Using the DOS 'COPY' command, copy all the statistical table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?T*.*

   Several utility files should also be copied. The command is:

   COPY A:*.PRN (if you are using the Lotus 1-2-3 data parsing commands)
   COPY A:*.MSK (if you are using AutoImport)

   The utility files named FORMLIN?.PRN are specifically for usage with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   Installing AutoImport V3.xx: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place AutoImport disk 1 in drive A and type: COPY A:*.* and then ENTER. Follow any instructions appearing on the screen until installation is complete. To make AutoImport accessible from any directory, place C:\AIMP in your AUTOEXEC.BAT file's 'PATH' statement. See your MS-DOS instruction manual for information about this step.

   If you are using a floppy-only system, copy the AutoImport disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

3. If you are using AutoImport (highly recommended) for translation of files to spreadsheet format, do the translation at this point. See the following section on using AutoImport for details.

4. Now you are ready to start your spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the spreadsheet system disk in drive A. If you are using a rigid disk system, place a copy of the spreadsheet system disk in floppy drive A if required by the security provisions of your spreadsheet program. Now start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the appropriate file retrieval command to select a file. An example of a Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XTYY.WK1, where: X= Type of data

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

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

   Examples:
   File RT10.WK1 is Rigid Disk Drive Report Table 10
   File OT1.WK1 is Optical Disk Drive Report Table 1
   File AT3.WK1 is Disk Drive Array Report Table 3
   File VT2.WK1 is Removable Data Storage Report Table 2

   The file selected will be loaded as a worksheet. If this is the first time the file has been loaded, you may want to create your own formulas linking the cells of the spreadsheet. See your spreadsheet reference manual for details on numerical manipulations and graphics.

If you don't use AutoImport

If you don't use AutoImport but still want to translate ASCII files to your spreadsheet format, you will have to use spreadsheet tools such as the Lotus 1-2-3 Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics. Let's take Lotus 1-2-3 as an example. Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

The trickiest and most time-consuming part of using the Data Parse commands is setting up the format line. Several utility files have been provided on

the tables disk to make this process easier. These are used with various table formats encountered in the DISK/TREND Reports and correspond with the precomputed masks provided for use with AutoImport:

o FORMLINA.PRN	Used with Tables 1 and 2, and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
o FORMLINB.PRN	Used with Tables 3 and 4.
o FORMLINF.PRN	Used with Tables 5 through 12.
o FORMLIND.PRN	Used with Application tables.
o FORMLINE.PRN	Used with Drive Height, Drive Capacity and Track Density tables for flexible disk drives in the Removable Data Storage report

There are no FORMLIN format files for disk diameter tables or market share tables, as these are variable in format. You will have to construct the format line directly, but after you have seen how it is done for the other tables, this should not be too big a job.

After you have used spreadsheet tools to translate a file, you will understand why we recommend AutoImport for this function.

Using AutoImport

Using AutoImport is a two-step process. Step one is creation of a translation mask for each format used in files to be converted. The typical DISK/TREND Report uses 5 to 7 standard mask designs (which have been precomputed and included on your Statistical Tables disk) plus additional masks that are dependent upon table content, as some table types have variable numbers of columns. You will have to create your own masks for such tables, but this can be done easily as shown below.

Step two is the translation process. Once the mask has been created, it can be used with any table matching the mask format. See the tables below which relate table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Removable Report	Optical Report	Array Report
MASKA	<-------- Table 1--------->		Tables 1,2	Table 1
	<-------------- Product Group Revenue ---------->			
	<-------------- Product Group Shipment ---------->			
MASKB	<-------- Table 2 -------->		Tables 3,4	Table 2
MASKC	Tables 3,4,6,9, 10,11	Tables 3 to 6, 11,12,24,25	Tables 5 to 12	Tables 3 to 7
MASKD	<-- All Product Group Application Tables ---->			Table 21
MASKE	N/A	N/A	Write-Once/ Erasable Analysis	N/A
MASKH	Tables 7,8	Table 31	N/A	N/A
MASKI	<----- Product Group -----> Price/Megabyte		N/A	N/A

N/A = Not applicable to this report

* Variable format depending upon number of disk diameters in the product group.

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1996 Rigid Report	1995 Removable Report	1996 Optical Report	1995 Array Report
1	MASKA	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA	MASKB
3	MASKC	MASKC	MASKB	MASKC
4	MASKC	MASKC	MASKB	MASKC
5	MASKC	MASKC	MASKC	MASKC
6	MASKC	MASKC	MASKC	MASKC
7	MASKH	--	MASKC	MASKC
8	MASKH	--	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKA	MASKC	MASKA
11	MASKC	MASKC	MASKC	MASKA
12	--	MASKC	MASKC	--
13	--	--	--	--
14	MASKA	MASKI	--	--
15	MASKA	--	--	--
16	--	MASKI	--	MASKA
17	--	--	MASKA	MASKA
18	MASKD	MASKI	MASKA	--
19	MASKI	--	--	--
20	--	MASKI	--	--
21	MASKA	--	MASKD	MASKD
22	MASKA	MASKA	--	--
23	--	MASKA	MASKA	MASKA
24	--	MASKC	MASKA	MASKA
25	MASKD	MASKC	--	--
26	MASKI	MASKA	--	--
27	--	MASKA	MASKD	--
28	MASKA	MASKA	--	--
29	MASKA	MASKA	MASKA	MASKA
30	--	MASKA	MASKA	MASKA
31	--	MASKH	--	--
32	MASKD	MASKD	--	--
33	MASKI	--	MASKD	--
34	--	MASKA	--	--
35	MASKA	MASKA	MASKA	
36	MASKA	--	MASKA	
37	--	--	--	
38	--	MASKI	--	
39	MASKD	MASKD	MASKE	
40	MASKI	--	MASKD	
41	--	MASKA	--	
42	MASKA	MASKA	MASKA	
43	MASKA	--	MASKA	
44	--	--	--	
45	--	MASKD	--	
46	MASKD	--	MASKA	
47	MASKI	MASKA	MASKA	

Cross-reference (continued)

Table Number	1996 Rigid Report	1995 Removable Report	1996 Optical Report	1995 Array Report
48	--	MASKA	--	
49	MASKA	--	--	
50	MASKA	--	MASKE	
51	--	MASKD	MASKA	
52	--	--	MASKA	
53	MASKD		--	
54	MASKI		--	
55	--		MASKE	
56	MASKA		MASKA	
57	MASKA		MASKA	
58	--		--	
59	--		--	
60	MASKD		MASKE	
61	MASKI			
62	--			
63	MASKA			
64	MASKA			
65	--			
66	--			
67	MASKD			
68	MASKI			
69	--			
70	MASKA			
71	MASKA			
72	--			
73	--			
74	--			
75	MASKD			
76	MASKI			
77	--			

-- indicates that the format of this table is variable. Create a mask using AutoImport if a spreadsheet is needed.

Translation using precomputed masks

1. First, copy the files you wish to translate to the AIMP directory from DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

   COPY A:?T*.*
   COPY A:MASK?2.MSK *.MSK (if using AutoImport version 2.xx)
   COPY A:MASK?3.MSK *.MSK (if using AutoImport version 3.xx)

   These commands copy the data files and mask files you need.

   If you are using a two floppy disk system, copy the files you want to translate to a second floppy disk along with the mask files. Make sure that no more than half of the floppy disk is filled, because you will need space for the converted files.

2. Now start AutoImport. When the opening screen appears, select the "File" menu bar item using the mouse keys or just type /F. (The AutoImport menu system works like the menus in Lotus 1-2-3.)

3. When the next screen appears (File Selection Menu), use the arrow keys or the mouse to select the Mask Name option, then press (or click on) the down arrow to get a list of mask names. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press 'ENTER' (or double click on the selected name). Now position the cursor on the "RETRIEVE MASK" button and select it to load the mask.

4. Select the Input File Name option on the File Selection Menu.

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

   Examples: RT4.96R OT14.96O AT19.96A VT6.96V

5. Select the Output File Name option on the File Selection Menu. (Should always be done after mask retrieval.)

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (A, R, V, or O), T is just that, and nn is the DISK/TREND Report table number matching the file being translated. You should not enter the file name extension as the system adds it automatically for you. Press 'ENTER'.

   Examples: RT4 OT14 AT19 VT6

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

7. You are ready to translate. Please recheck all the file names displayed to be CERTAIN they are correct. Select the "CONVERT" button using the mouse or arrow keys and ENTER. If you are asked "Do you want to load input file named in mask?", answer "NO". You will see the file being translated scroll by as the translation proceeds. If it does not scroll during translation, you may have a damaged mask file. See the next section for details on mask file creation.

8. If you want to do more translations, repeat from step 3.

9. When you are done translating, leave AutoImport by typing /Q (Quit) to leave AutoImport and return to DOS. It will save you some keystrokes if you copy your new spreadsheet files to your spreadsheet directory. If you are using a two floppy system, just remove the AutoImport disk from drive A and substitute your spreadsheet disk.

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select "File" using the mouse or type /F.

2. Name the input file you will use as the template to create the mask. The file name will be of the form ?Tnn.yy?, where ? is the type of report (R, V, O, or A), nn is the table number and yy is the report year.

   Example: OT10.96O

   To name the file, select Input file from the File selection menu. Type the desired file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now select "Lines" from the menu bar, then select "Header" from the pop-up window that opens. Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'ENTER'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, selecting "Lines" and "Headings" again, and extending the highlight area over the note and pressing 'ENTER'.

4. Next, locate the longest left margin label (excluding the header lines) in the table. Position the cursor so that it is at the left margin of the line containing the longest label. Select "Column" from the menu bar, then "Auto Define". This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

   In a few cases, the automatic feature may be confused by a table layout and all values will not be picked for conversion. In these unusual cases, you may be able to get the overlooked values included by repeating this step on another line.

   Another unusual case can occur in which the right-hand part of a label is somehow included in a value occurring in the next column to the right. Deal with this rare case as follows:

   o Place cursor in left margin of offending line. Select "Column", then "Width & move". Select the column you wish to adjust with mouse (or arrows & ENTER), and then use arrow keys to move right column margin clear of the column of values. You can also shift the entire column by depressing the CONTROL key and using the appropriate arrow key (or drag with the mouse).

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

   Example: MYMASK.MSK, or just MYMASK

6. Save the output file. Type /FO (File:Output). Now enter the file name.

   Example: OT10. You don't need to enter the file extender.

7. To make more masks, repeat from step 2. To quit the mask function, type /QY (quit).

Other AutoImport Functions

AutoImport can do much more than the functions described above, which are those concerned with a basic understanding of how to create spreadsheets from DISK/TREND ON DISK files. See the separate AutoImport manual provided for details of these other functions.

SPECIFICATION TABLES

Loading

1. Place the floppy disk marked "Specifications" in a floppy disk drive able to read your size disks. This is usually drive A, but if you are using a dual floppy only system, use drive B and put the spreadsheet system disk in drive A. Use the DOS "DIR" command to examine the file directory on the "Tables" disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which your spreadsheet normally stores worksheet files. Using the DOS "COPY" command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus spreadsheet system disk in drive A. If you are using a rigid disk system, place the spreadsheet system disk in floppy drive A. If your spreadsheet is not Lotus 1-2-3, you will have to translate the data from Lotus 1-2-3 to your format. Almost all spreadsheet packages of recent vintage are able to do this translation. After translation, if needed, start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the spreadsheet File Retrieve command to select a file. The equivalent Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XSYZZ.WK1 or XSYZZ.WKS, depending upon which version of Lotus 1-2-3 you are using. X,Y, and Z are:

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

Y= Table number. Usually, there is only one table, but if the specification file is so large as to need multiple disks to hold it, there may be several.

ZZ= Year of report.

Example: OS196 Optical disk drive specification table.
LS196 Optical library specification table.

Note that the specification tables load directly as a data base. You can use the data base functions of Lotus 1-2-3 to sort, count or otherwise manipulate the data for purposes of special analysis. Other spreadsheets may have similar capabilities.

Using the specification data base

Introduction: If you have not used the Lotus 1-2-3 /DATA QUERY commands, it will be helpful for you to review the sections of the Lotus 1-2-3 reference manual that pertain to their use before proceeding further.

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon which type of storage device is involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND Report. Each column represents a specific specification parameter, and is equivalent to one row of the DISK/TREND Report.

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

Operating tips

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

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

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

Saving time

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

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

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

If you are interested only in a subset of specific product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and then use the second file for analysis. The smaller file will take less time to process.

Technical support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: **415-961-6209**

Ask for Technical Support for DISK/TREND ON DISK

In order to make this process efficient, when you call...

1. Tell us what is on the diskette label.

2. Have your computer up and displaying the data or operation that is the subject of your call.

3. Have this manual and the Lotus 1-2-3 reference manual handy.

If you have questions about AutoImport as it is used with DISK/TREND ON DISK, contact DISK/TREND at the number above. Questions about other functions of AutoImport should be referred to White Crane Systems.

Apple Macintosh compatibility: While DISK/TREND ON DISK has been prepared for use on IBM PC compatible computers, users have reported that they are able to translate files into Macintosh format using Apple Computer software. The specific software reported used is Apple File Exchange.

Special data

The specification data base contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

In order to make it easier to do sorting or extraction analysis on the data, the contents of certain fields have been modified and are not exactly the same as in the printed report tables. Some affected fields have been converted to purely numeric fields as described below. Where multiple values existed, the value representing the highest level of performance or capability has been retained.

Comments and asterisks in the affected fields have been eliminated. A '0' means that no data was available. Asterisks are retained in the comment field so that you will have an indication that one or more characteristics of the drive was referenced to a comment. Check the printed report table for details.

The affected fields for the optical disk drive 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 ??93 in the criterion field for the First Ship Date column will cause all products first shipped in 1993 to be extracted.