1996 DISK/TREND® REPORT

REMOVABLE
DATA
STORAGE

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REMOVABLE DATA STORAGE

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FOREWORD

Although this is the 20th year of the DISK/TREND Report, it is only the third year that the DISK/TREND Report on removable data storage has been published as a separate annual volume. Despite the intense competition between many of the products included in this report, they are derived from a diverse mixture of rigid disk drive, flexible disk drive, optical disk drive and semiconductor technologies.

We hope that by combining these heterogeneous products into a single market study we will make it easier for you to find the information you need on the products, the manufacturers and the markets. Much of the material included is being published for the first time, such as the product groups covering flash cards, high capacity floppy drives and low capacity floppy drives. Some of the material appeared earlier in the 1996 DISK/TREND Reports on rigid disk drives and optical disk drives, such as the product groups on PC Card rigid disk drives, rigid disk cartridge drives and small optical disk drives.

DISK/TREND has published annual studies on the disk drive industry longer than any other company. Annual reports on rigid disk drives have been published since 1977, with reports on optical disk drives added in 1986 and on disk drive arrays in 1993. Availability of our extensive files on the industry and our data base management system was essential in organizing and presenting the data for this report on removable data storage.

We are always willing to help you at any time by providing additional information on the industry which we may have available. Your suggestions for improvements in the DISK/TREND Report are always welcome and are sincerely appreciated.

James N. Porter

Robert H. Katzive

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INTRODUCTION

Competition between distant cousins. There is intense sales competition between many of the very dissimilar data storage products covered in this report. However, despite the fact that each of the product groups included in the report competes with one or more of the other product groups, the competing products are not close relatives.

You will find differences in the way data is organized in each product group, due to the need to address the individual product technologies, markets and applications of each of the six product groups in this report. There are different product capacity groups, and the inclusion of some of DISK/TREND's standard table formats in some sections, but not in others. Naturally, the product specifications for each type of product are different from each other, but the same as the formats used in other DISK/TREND Reports, except for flash cards.

Combining new and slightly used data: Because of the nature of the product coverage by this report, it includes data published for the first time, plus some information included in other DISK/TREND Reports released earlier this year. The only place in which DISK/TREND data on low capacity flexible disk drives, high capacity flexible disk drives and flash cards is published is in this report on removable data storage. The product section on rigid disk cartridge drives is the same as the equivalent section from the DISK/TREND Report on rigid disk drives. The section on PC Card rigid disk drives has been extracted from the broader data base used in the report on rigid disk drives. In a similar way, the product section on small optical disk drives has been extracted from the DISK/TREND Report on optical disk drives, with the same data, but organized into tables unique to this report.

Selling prices reported at level of first public sale. If the DISK/TREND Report is new to you, please note the definitions used for the relative price differences in each market channel. As in all DISK/TREND Reports, we report revenues for the sale of individual products at the level of the first public sale, at the estimated net transaction price, whether the sale occurs at the captive, PCM/Distributor or OEM/Integrator level -- to accurately record the value of the business to the original seller.

DISK/TREND ON DISK. The statistical and specification tables are available on floppy disks, as a separately purchased option to buyers of this report. For easy reference, instructions are included in the last section of this report.

SUMMARY: REMOVABLE DATA STORAGE

Industry size

1995 sales revenues for all of the removable data storage products included in this report were $2.7 billion, with the overall revenue total for 1999 forecasted to increase to $5.5 billion. While all of the report's product groups are experiencing growth in unit shipments, and some are expected to have significant sales revenue increases during the next few years, overall sales revenue growth is limited by the continuing pattern of declining sales revenues for low capacity flexible disk drives.

Removability is the only feature shared by all of the data storage products covered in this report. Many of these dissimilar product groups are now vying for the same market opportunities, despite utilization of different technologies or recording materials. Intense rivalries are now developing among the manufacturers of rigid disk cartridge drives, high capacity flexible disk drives and small optical disk drives, as they each covet the growing markets for graphics and printing production, multimedia content preparation, backup of personal computer hard disks, downloading of Internet files, and a variety of other applications. Although unit shipments for the three product groups totaled only 1.8 million drives in 1995, a collective total of 35.8 million drives is forecasted for 1999.

Competition between the other three product groups is negligible, with different application patterns dictated by distinctive combinations of product features and price levels. Low capacity flexible disk drives typically offer only 1.44 megabytes per drive, but today's OEM average unit price of $19 keeps the 3.5" floppy drive a continuing part of the personal computer. PC Card rigid disk drives provide a unique combination of data storage capacity and performance in a standardized small package, but prices which are relatively high compared to small fixed disk drives have restricted usage to specialized applications. Shipments of flash cards are growing in numerous specialized and mobile applications requiring capacities generally below those offered by most disk drives except low capacity floppies, but flash price per megabyte levels are several times those of most disk drives, preventing penetration of markets requiring higher capacities.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

REMOVABLE DATA STORAGE

REVENUE SUMMARY

	REMOVABLE DATA STORAGE 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										
Other U.S. Captive	18.0	48.0	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	18.0	48.0	--	--	--	--	--	--	--	--
PCM/Distributor	217.2	316.2	525.5	714.8	824.1	1,190.6	985.3	1,458.6	1,016.5	1,531.8
OEM/Integrator	80.0	154.2	116.3	260.0	254.5	469.3	370.4	667.7	443.3	784.4
TOTAL U.S. NONCAPTIVE	297.2	470.4	641.8	974.8	1,078.6	1,659.9	1,355.7	2,126.3	1,459.8	2,316.2
TOTAL U.S. REVENUES	315.2	518.4	641.8	974.8	1,078.6	1,659.9	1,355.7	2,126.3	1,459.8	2,316.2
Non-U.S. Manufacturers										
Captive	--	163.6	--	258.9	23.1	253.4	34.0	245.3	41.9	226.7
PCM/Distributor	272.4	640.3	314.4	735.1	318.7	814.7	366.5	936.9	390.0	1,032.0
OEM/Integrator	505.3	1,416.4	482.9	1,375.8	649.0	1,622.2	758.7	1,808.6	796.6	1,886.5
TOTAL NON-U.S. REVENUES	777.7	2,220.3	797.3	2,369.8	990.8	2,690.3	1,159.2	2,990.8	1,228.5	3,145.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,092.9	2,738.7	1,439.1	3,344.6	2,069.4	4,350.2	2,514.9	5,117.1	2,688.3	5,461.4

Marketing channels

The price used for each product in the DISK/TREND Report is the estimated selling price at the first time it is sold to a nonaffiliated buyer, at captive end user, PCM/Distributor or OEM/Integrator levels. In general, you can expect that prices used in the DISK/TREND Report are equivalent to the level that the company which manufactures each completed data storage product uses in its financial statements.

Although major changes may occur within a few of the individual product groups, evolutionary development of the overall shares for each marketing channel employed by removable data storage products during the five year span covered by this report will be less dramatic, with noncaptive channels remaining dominant. The PCM/Distributor channel held 34.9% of 1995's total sales revenues, and is expected to retain 46.9% of the 1999 total. OEM/Integrator sales revenues were 57.4% of the overall total for 1995, with 1999 projected at 48.9%. Captive revenues are expected to be only 4.2% of the 1999 total for all revenues. It should be noted, however, that some of the individual product groups have marketing channel patterns which differ significantly from the overall averages.

OEM/Integrator shipments have historically dominated the low capacity flexible disk drive product group, and are expected to retain 71.4% of the 1999 total. OEM shipments are also expected to reflect the major changes under way in the high capacity floppy drive product group, as increasing sales to personal computer system manufacturers supplement the aftermarket add-on market which currently predominates. OEM/Integrator shipments of high capacity floppy drives are forecasted to increase from 7.4% of the 1995 total to 50.3% in 1999. The OEM market is also preeminent in shipments of PC Card rigid disk drives, with 84.1% of 1995 shipments going through the OEM/Integrator channel, many to producers of systems for specialized applications, and with little change expected through 1999. The same pattern applies to flash card shipments, which were 64.3% OEM in 1995, and are forecasted at 82.3% OEM in 1999.

PCM/Distributor shipments of rigid disk cartridge drives, 98% of the group's 1995 total, are expected to hold 79.4% of the 1999 total, down modestly in share due to sales growth with specialized OEMs. Small optical disk drives are currently sold mostly through PCM/Distributor channels, and the 1999 total for that channel is forecasted to decline only slightly, to 75.9%.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
REMOVABLE DATA STORAGE
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1995 Revenues $M	1995 Revenues %	Forecast 1996 $M	1996 %	1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %
U.S. Manufacturers										
Other U.S. Captive	48.0	1.7%	--	--	--	--	--	--	--	--
	+180.7%		-100.0%		--		--		--	
PCM/Distributor	316.2	11.5%	714.8	21.3%	1,190.6	27.3%	1,458.6	28.5%	1,531.8	28.0%
	+62.1%		+126.1%		+66.6%		+22.5%		+5.0%	
OEM/Integrator	154.2	5.6%	260.0	7.7%	469.3	10.7%	667.7	13.0%	784.4	14.3%
	+61.3%		+68.6%		+80.5%		+42.3%		+17.5%	
Total U.S. Manufacturers	518.4	18.8%	974.8	29.0%	1,659.9	38.0%	2,126.3	41.5%	2,316.2	42.3%
	+68.4%		+88.0%		+70.3%		+28.1%		+8.9%	
Non-U.S. Manufacturers										
Captive	163.6	5.9%	258.9	7.7%	253.4	5.8%	245.3	4.7%	226.7	4.1%
	-25.2%		+58.3%		-2.1%		-3.2%		-7.6%	
PCM/Distributor	640.3	23.3%	735.1	21.9%	814.7	18.7%	936.9	18.3%	1,032.0	18.8%
	-2.6%		+14.8%		+10.8%		+15.0%		+10.2%	
OEM/Integrator	1,416.4	52.0%	1,375.8	41.4%	1,622.2	37.5%	1,808.6	35.5%	1,886.5	34.8%
	-18.0%		-2.9%		+17.9%		+11.5%		+4.3%	
Total Non-U.S. Manufacturers	2,220.3	81.2%	2,369.8	71.0%	2,690.3	62.0%	2,990.8	58.5%	3,145.2	57.7%
	-14.7%		+6.7%		+13.5%		+11.2%		+5.2%	
Worldwide Recap										
Captive	211.6	7.7%	258.9	7.7%	253.4	5.8%	245.3	4.8%	226.7	4.2%
	-10.2%		+22.4%		-2.1%		-3.2%		-7.6%	
PCM/Distributor	956.5	34.9%	1,449.9	43.4%	2,005.3	46.1%	2,395.5	46.8%	2,563.8	46.9%
	+12.2%		+51.6%		+38.3%		+19.5%		+7.0%	
OEM/Integrator	1,570.6	57.4%	1,635.8	48.9%	2,091.5	48.1%	2,476.3	48.4%	2,670.9	48.9%
	-13.8%		+4.2%		+27.9%		+18.4%		+7.9%	
Total All Manufacturers	2,738.7	100.0%	3,344.6	100.0%	4,350.2	100.0%	5,117.1	100.0%	5,461.4	100.0%
	-5.9%		+22.1%		+30.1%		+17.6%		+6.7%	

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

Product groups

Low capacity flexible disk drives continue to be the removable data storage product with the highest shipments and the highest sales revenues, and they also remain the most frequently mentioned competitive target for most of the other removable data storage products included in this report. Healthy growth in personal computer shipments has continued to result in increased shipments of standard 1.44 megabyte 3.5" floppy drives, a trend expected to last for another year or two. However, annual shipment growth for low capacity floppy drives is expected to slow to only 2.6% by 1999, impacted by the tendency of notebook computer manufacturers to include floppy drives in fewer models and gradually increasing displacement in desktop PC markets by high capacity floppy drives. Despite shipment growth, sales revenues for low capacity floppy drives will continue to be driven down by falling unit prices, with only $1.7 billion forecast for 1999.

High capacity flexible disk drives are expected to achieve the highest growth rate among removable data storage products through 1999, as the Iomega Zip drive, the Matsushita-Kotobuki Electronics LS-120 drive, and other promised products stimulate new demand by offering capacities of 100 megabytes or more, combined with competitive prices. 1995's shipments of 827,700 drives and revenues of $122.6 million are forecasted to increase to 25.5 million drives and revenues of $1.3 billion in 1999.

Major changes are also under way in the rigid disk cartridge drive product group, as higher capacity drives at lower prices develop new business and consumer markets, pioneered by the Iomega Jaz 3.5" one gigabyte drive. The consumer applications supplement established specialized markets, which are also growing, as "prepress" and graphics applications continue to demand more storage capacity, and video applications emerge as significant markets. SyQuest's 5.25" drives have achieved staying power as the prepress interchange standard, and are expected to remain in production though 1999, although in declining numbers, as higher capacity 3.5" drives assume shipment leadership. Total shipments for the product group are forecasted to climb from 606,300 units in 1995 to 6.3 million drives in 1999, with sales revenues for that year reaching $1.4 billion.

Small optical disk drives must compete in a diversified market, with direct competition in most applications from magnetic rigid disk cartridge drives and high capacity floppy drives. 3.5" optical disk drives are currently enjoying strong growth as the result of aggressive pricing, combined with heavy usage in Japan, where optical disks are widely used for data interchange because of limited utilization of local area networks. 1995 overall shipments of small optical disk drives totaled 518,500 units, with 1999 shipments forecasted to reach 1.3 million drives. Although rapidly increasing use of networks in Japan will probably reduce the Japanese domestic market, availability of higher capacity drives and continually falling unit prices are expected to make it possible for manufacturers of small optical disk drives to maintain growth through 1999, but at declining rates.

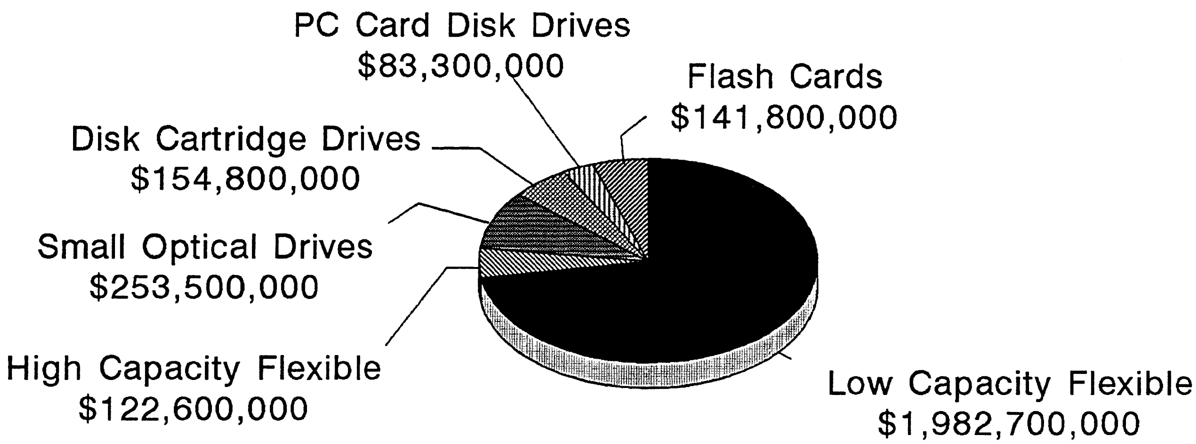
During 1995, almost all of the 859,100 flash memory cards shipped worldwide were in the PC Card format used for a diverse set of applications, ranging from mobile computers to industrial equipment, and 75.8% of the cards had less than 10 megabytes capacity. With the advent of smaller card formats and the developing market opportunities provided by newly emerging applications, such as digital cameras and portable telecommunication equipment, the 1999 market is forecasted to reach 10.7 million cards. By 1999, these flourishing new markets will still be consuming cards with capacities less than 10 megabytes, with usage increasing to 84.3% of the overall flash card total, and the new miniaturized card formats will provide 67.9% of all flash card shipments.

PC Card rigid disk drives have continued to ship at levels lower than previously forecasted, due to slowness in the computer industry's movement to the smaller and lighter weight subnotebook computers, with a tendency to use 1.8" rigid disk drives, and the fact that the eagerly anticipated PDA and personal communicator markets turned out to be nonevents. Despite the problems, shipments of PC Card drives are increasing, with the possibility of higher growth rates in future years. Critical to the future of this drive format will be the emergence of applications now in the early growth phase, such as high-end digital cameras and automotive mapping equipment. Total shipments are forecasted to increase from 340,000 drives in 1995 to 1.1 million in 1999. By 1999, PC Card drives with at lease 1 gigabyte capacity are expected to be in production.

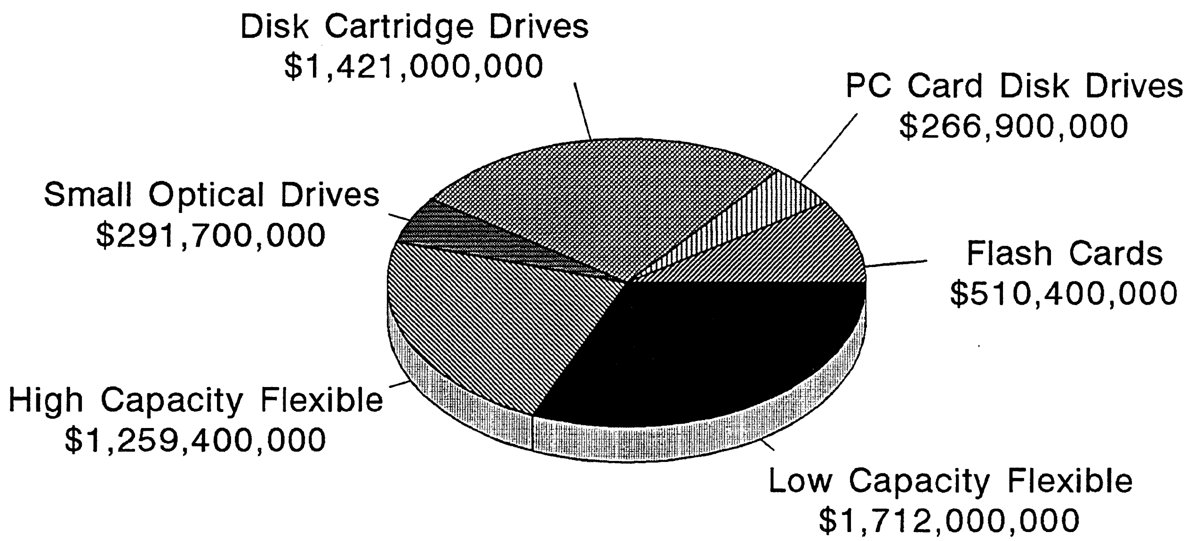
Figure 1

CHANGING PRODUCT MIX

Worldwide Removable Data Storage Revenue



1995



1999

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
REMOVABLE DATA STORAGE
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1995 Revenues $M	1995 Revenues %	Forecast 1996 $M	1996 %	1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %
FLASH CARDS	141.8	5.2%	218.9	6.5%	360.2	8.3%	468.2	9.1%	510.4	9.3%
	+77.7%		+54.4%		+64.6%		+30.0%		+9.0%	
PC CARD RIGID DISK DRIVES	83.3	3.0%	89.9	2.7%	150.3	3.5%	200.6	3.9%	266.9	4.9%
	+130.7%		+7.9%		+67.2%		+33.5%		+33.1%	
RIGID DISK CARTRIDGE DRIVES	154.8	5.7%	448.4	13.4%	903.6	20.8%	1,220.9	23.9%	1,421.0	26.0%
	+38.3%		+189.7%		+101.5%		+35.1%		+16.4%	
SMALL OPTICAL DISK DRIVES	253.5	9.3%	277.5	8.3%	290.5	6.7%	297.6	5.8%	291.7	5.3%
	-22.6%		+9.5%		+4.7%		+2.4%		-2.0%	
HIGH CAPACITY FLEXIBLE	122.6	4.3%	421.8	12.6%	793.0	18.1%	1,119.8	21.9%	1,259.4	23.1%
DISK DRIVES	+105.4%		+244.0%		+88.0%		+41.2%		+12.5%	
LOW CAPACITY FLEXIBLE	1,982.7	72.5%	1,888.1	56.5%	1,852.6	42.6%	1,810.0	35.4%	1,712.0	31.4%
DISK DRIVES	-13.6%		-4.8%		-1.9%		-2.3%		-5.4%	
Total Worldwide Revenue	2,738.7	100.0%	3,344.6	100.0%	4,350.2	100.0%	5,117.1	100.0%	5,461.4	100.0%
	-5.9%		+22.1%		+30.1%		+17.6%		+6.7%	

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

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Millions of Units

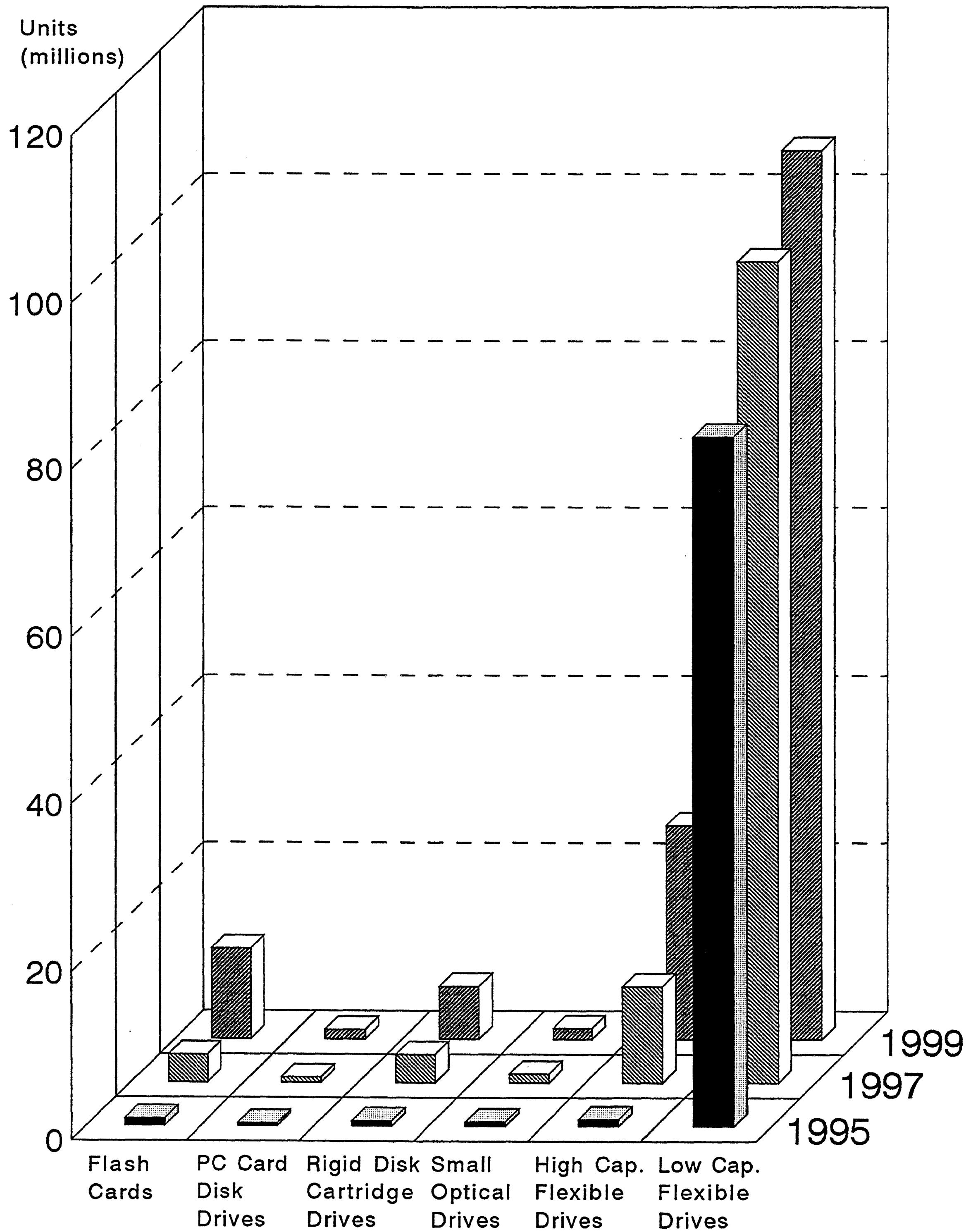


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
REMOVABLE DATA STORAGE
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1995 Shipments Units	1995 %	Forecast 1996 Units	1996 %	Forecast 1997 Units	1997 %	Forecast 1998 Units	1998 %	Forecast 1999 Units	1999 %
FLASH CARDS	859.1	1.0%	1,566.0	1.6%	3,311.3	2.8%	6,841.9	5.0%	10,739.5	7.1%
	+74.6%		+82.3%		+111.4%		+106.6%		+57.0%	
PC CARD RIGID DISK DRIVES	340.0	.4%	369.0	.4%	630.0	.5%	865.0	.6%	1,120.0	.7%
	+113.7%		+8.5%		+70.7%		+37.3%		+29.5%	
RIGID DISK CARTRIDGE DRIVES	606.3	.7%	1,818.0	1.8%	3,360.0	2.8%	4,940.0	3.6%	6,320.0	4.2%
	+29.4%		+199.9%		+84.8%		+47.0%		+27.9%	
SMALL OPTICAL DISK DRIVES	518.5	.6%	865.3	.9%	1,072.0	.9%	1,194.0	.9%	1,288.0	.9%
	+7.4%		+66.9%		+23.9%		+11.4%		+7.9%	
HIGH CAPACITY FLEXIBLE DISK DRIVES	827.7	.9%	5,102.0	5.1%	11,470.0	9.7%	18,910.0	13.9%	25,470.0	16.8%
	+306.7%		+516.4%		+124.8%		+64.9%		+34.7%	
LOW CAPACITY FLEXIBLE DISK DRIVES	82,225.0	96.4%	89,728.0	90.2%	98,069.0	83.3%	103,548.0	76.0%	106,200.0	70.3%
	+8.9%		+9.1%		+9.3%		+5.6%		+2.6%	
Total Worldwide Shipments	85,376.6	100.0%	99,448.3	100.0%	117,912.3	100.0%	136,298.9	100.0%	151,137.5	100.0%
	+10.4%		+16.5%		+18.6%		+15.6%		+10.9%	
% U.S. Manufacturers	2.7%		7.4%		10.6%		13.7%		15.3%	

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

Noncaptive market

Relatively few of the removable data storage products covered by this report are sold on a captive basis by the original manufacturers with their own systems. Removable data storage products are sold primarily on a noncaptive basis, defined in the DISK/TREND Report as any public sale of a product, except a sale of an internally manufactured product by a computer system manufacturer primarily for use with their own systems. The report classifies noncaptive shipments as PCM/Distributor (sales by "plug compatible manufacturers" or through distributing organizations, subsystem producers, value-added resellers, retail chains, mail order firms and individual retail dealers) or OEM/Integrator (products sold by the original producer to system manufacturers or system integrator, to be included in complete systems).

Worldwide captive sales revenues for removable data storage products were $211.6 million in 1995, 7.7% of the total for all marketing channels. Increased captive shipments are expected in the 1997-99 period, mostly in the high capacity flexible disk drive product group, but captive sales revenue for all removable data storage products in 1999 is projected at only 4.2% of the overall total.

All flash card sales are currently noncaptive, and are forecasted to remain noncaptive through 1999. OEM/Integrator shipments are clearly in the lead, with 64.3% of the 1995 worldwide total. The OEM lead is expected to grow to 82.3% in 1999, since the system manufacturers producing the numerous specialized devices using flash cards will control distribution to most of their customer base. The balance of noncaptive flash card sales, moving through PCM/Distributor channels, will largely be driven by applications such as notebook computers, PDAs, personal communicators and similar nonspecialized devices, the users of which may be efficiently reached through normal electronic product distribution channels. This split will be affected by the manner in which the digital camera market develops during the next few years. If any one of the new small card formats becomes predominant, it is likely that the standardization will encourage the more rapid development of flash card shipments through distribution and retail dealers to a wide end-user market.

PC Card rigid disk drive shipments have also been predominantly through OEM/Integrator sales channels, accounting for 84.1% of the 1995 total. Like the flash card product group, PC Card rigid disk drives are expected to continue to find the majority of their customers in specialized applications, with system manufacturers making the buying decisions. As a result, the OEM channel is expected to remain the major market for PC Card drives, with the PCM/Distributor channel retaining about the same share in the next few years, based on the assumption that the outlook for PDAs, subnotebook computers and personal communicators is not expected to be significantly greater during the rest of the decade.

For a decade, the leader in rigid disk cartridge drive shipments has been SyQuest Technology, which has sold its drives primarily in the PCM/Distributor channel, through a variety of storage subsystem vendors who combine drives with enclosures, cables and software appropriate for specific target system markets. SyQuest's dominance of the product group is now being challenged by Iomega's Jaz 3.5" drive, also with heavy reliance on aftermarket add-on sales through distribution channels. With the substantial increase in shipments forecasted for this product group, it is expected that OEM shipments will grow rapidly, as a variety of specialized system manufacturers add rigid disk cartridge drives as standard system features. However, stronger aftermarket sales are expected to keep PCM/Distributor shipments in the lead, declining modestly from 1995's 98% of the worldwide total to 79.4% in 1999.

Small optical disk drives tend to follow a sales pattern similar to that of the rigid disk cartridge drives, in that system manufacturers frequently regard them as nonstandard products, priced at a level above the drives they consider to be industry standard. Sales resistance by system manufacturers confines most of the market opportunity to aftermarket add-on storage requirements, predominantly in applications for which removable disks provide a functional advantage. 79.0% of the product group's 1995 shipments were through the PCM/Distributor channel, with the 1999 total projected at 75.9% of the worldwide total.

Low capacity floppy drive shipments follow a stable pattern, predominantly OEM sales to system manufacturers, with the OEM/Integrator channel holding 73.7% of 1995 total shipments, and forecasted to retain 71.4% in 1999. The outlook for high capacity floppy drives is more fluid, as the success of new 3.5" drives such as Iomega's Zip in the aftermarket is supplemented with growing OEM sales. 92.6% of 1995's shipments were in the PCM/Distributor channel, but 1999 OEM/Integrator shipments are forecasted at 50.3% of the worldwide total.

TABLE 5

NONCAPTIVE WORLDWIDE REVENUES
REMOVABLE DATA STORAGE
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1995 Revenues $M	1995 Revenues %	Forecast 1996 $M	Forecast 1996 %	Forecast 1997 $M	Forecast 1997 %	Forecast 1998 $M	Forecast 1998 %	Forecast 1999 $M	Forecast 1999 %
FLASH CARDS	141.8	5.6%	218.9	7.1%	360.2	8.8%	468.2	9.6%	510.4	9.8%
	+77.7%		+54.4%		+64.6%		+30.0%		+9.0%	
PC CARD RIGID DISK DRIVES	83.3	3.3%	89.9	2.9%	150.3	3.7%	200.6	4.1%	266.9	5.1%
	+130.7%		+7.9%		+67.2%		+33.5%		+33.1%	
RIGID DISK CARTRIDGE DRIVES	154.8	6.1%	448.4	14.5%	903.6	22.1%	1,220.9	25.1%	1,421.0	27.1%
	+38.3%		+189.7%		+101.5%		+35.1%		+16.4%	
SMALL OPTICAL DISK DRIVES	195.5	7.7%	257.2	8.4%	269.3	6.6%	275.6	5.6%	270.1	5.2%
	-35.6%		+31.6%		+4.7%		+2.3%		-2.0%	
HIGH CAPACITY FLEXIBLE DISK DRIVES	122.6	4.9%	404.7	13.1%	765.8	18.6%	1,086.7	22.3%	1,225.2	23.4%
	+105.4%		+230.1%		+89.2%		+41.9%		+12.7%	
LOW CAPACITY FLEXIBLE DISK DRIVES	1,829.1	72.4%	1,666.6	54.0%	1,647.6	40.2%	1,619.8	33.3%	1,541.1	29.4%
	-12.2%		-8.9%		-1.1%		-1.7%		-4.9%	
Total Worldwide Revenues	2,527.1	100.0%	3,085.7	100.0%	4,096.8	100.0%	4,871.8	100.0%	5,234.7	100.0%
	-5.5%		+22.1%		+32.8%		+18.9%		+7.4%	

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

TABLE 6

NONCAPTIVE WORLDWIDE SHIPMENTS
REMOVABLE DATA STORAGE
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

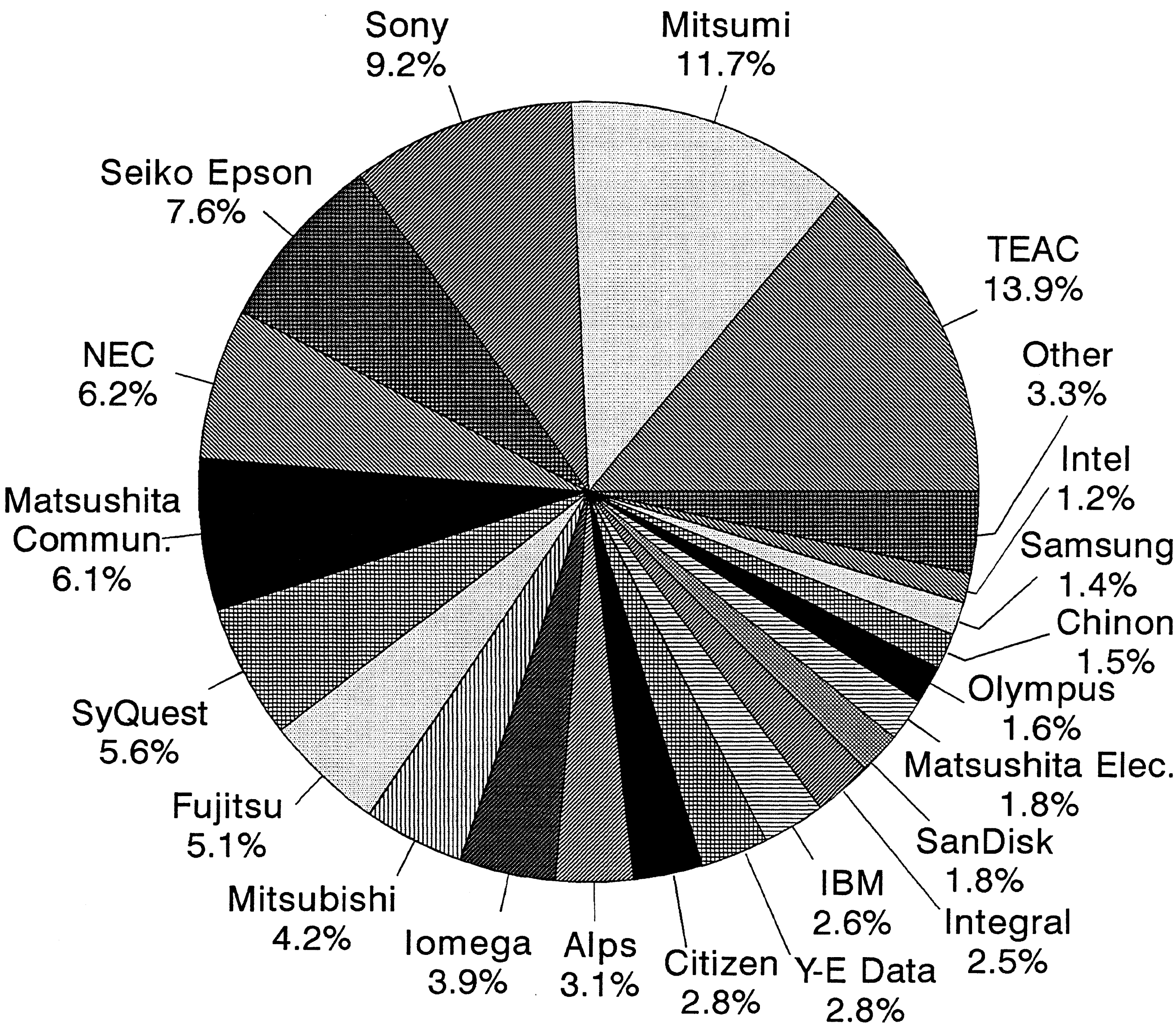
UNIT SHIPMENTS IN THOUSANDS	1995 Shipments Units	1995 Shipments %	Forecast 1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %	1999 Units	1999 %
FLASH CARDS	859.1	1.0%	1,566.0	1.6%	3,311.3	2.9%	6,841.9	5.1%	10,739.5	7.3%
	+74.6%		+82.3%		+111.4%		+106.6%		+57.0%	
PC CARD RIGID DISK DRIVES	340.0	.4%	369.0	.4%	630.0	.6%	865.0	.7%	1,120.0	.8%
	+113.7%		+8.5%		+70.7%		+37.3%		+29.5%	
RIGID DISK CARTRIDGE DRIVES	606.3	.7%	1,818.0	1.9%	3,360.0	2.9%	4,940.0	3.7%	6,320.0	4.3%
	+29.4%		+199.9%		+84.8%		+47.0%		+27.9%	
SMALL OPTICAL DISK DRIVES	466.5	.6%	825.3	.9%	1,022.0	.9%	1,139.0	.9%	1,228.0	.8%
	--		+76.9%		+23.8%		+11.4%		+7.8%	
HIGH CAPACITY FLEXIBLE DISK DRIVES	827.7	1.0%	5,012.0	5.1%	11,300.0	9.8%	18,670.0	14.0%	25,165.0	17.0%
	+306.7%		+505.5%		+125.5%		+65.2%		+34.8%	
LOW CAPACITY FLEXIBLE DISK DRIVES	80,705.0	96.3%	86,807.0	90.1%	94,889.0	82.9%	100,388.0	75.6%	103,030.0	69.8%
	+10.0%		+7.6%		+9.3%		+5.7%		+2.7%	
Total Worldwide Shipments	83,804.6	100.0%	96,397.3	100.0%	114,512.3	100.0%	132,793.9	100.0%	147,602.5	100.0%
	+11.5%		+15.0%		+18.8%		+16.0%		+11.2%	
% U.S. Manufacturers	2.7%		7.7%		10.9%		14.1%		15.7%	

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

Figure 3

1995 ESTIMATED MARKET SHARE

Removable Data Storage Worldwide Revenue



1995 Revenue: $2,738,700,000

TABLE 7

1995 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL REMOVABLE DATA STORAGE
(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								
IBM	48.0	22.7	12.9	1.3	9.6	.6	70.5	2.6
Integral Peripherals	--	--	7.5	.8	61.9	3.9	69.4	2.5
Intel	--	--	19.5	2.0	12.7	.8	32.2	1.2
Iomega	--	--	105.8	11.1	2.1	.1	107.9	3.9
SanDisk	--	--	4.9	.5	45.5	2.9	50.4	1.8
SyQuest Technology	--	--	150.0	15.7	2.8	.2	152.8	5.6
Other U.S.	--	--	15.6	1.6	19.6	1.2	35.2	1.3
U.S. Total	48.0	22.7	316.2	33.1	154.2	9.8	518.4	18.9
NON-U.S. MANUFACTURERS								
Alps Electric	--	--	17.9	1.9	67.9	4.3	85.8	3.1
Chinon	--	--	8.9	.9	33.0	2.1	41.9	1.5
Citizen	--	--	.5	.1	77.0	4.9	77.5	2.8
Fujitsu	10.0	4.7	113.4	11.9	15.7	1.0	139.1	5.1
Matsushita Communication Indust.	--	--	90.4	9.5	76.7	4.9	167.1	6.1
Matsushita Electric Industrial	--	--	--	--	50.0	3.2	50.0	1.8
Mitsubishi Electric	.8	.4	--	--	114.1	7.3	114.9	4.2
Mitsumi Electric	--	--	81.9	8.6	238.8	15.2	320.7	11.7
NEC	124.1	58.6	33.3	3.5	13.1	.8	170.5	6.2
Olympus Optical	--	--	33.2	3.5	9.8	.6	43.0	1.6
Samsung Electronics	18.7	8.8	11.4	1.2	9.3	.6	39.4	1.4
Seiko Epson	9.9	4.7	78.8	8.2	118.2	7.5	206.9	7.6
Sony	--	--	86.2	9.0	167.1	10.6	253.3	9.2
Teac	--	--	51.5	5.4	328.4	20.9	379.9	13.9
Y-E Data	--	--	10.5	1.1	65.0	4.1	75.5	2.8
Other Non-U.S.	--	--	22.4	2.3	32.3	2.1	54.8	2.0
Non-U.S. Total	163.6	77.3	640.3	66.9	1,416.4	90.2	2,220.3	81.1
WORLDWIDE TOTAL	211.6	100.0	956.5	100.0	1,570.6	100.0	2,738.7	100.0

Note: The DISK/TREND estimates of revenue for each manufacturer include net sales of removable data storage products only and do not represent total revenues for individual companies

Codes:

PIII = PC Card III C = Captive
2 = 2.5" P = PCM
3 = 3.5" O = OEM
5 = 5.25"
8 = 8"
FD = Flash disk
FM = Flash memory

TABLE 8

CURRENT PRODUCT LINES
MANUFACTURERS OF REMOVABLE DATA STORAGE

DISK/TREND PRODUCT GROUP		40/41/42/43	2/3/4	1	22	14	13
U.S. Manufacturers (19)	Type	Flash Cards	PC Card Disk Drives	Rigid Disk Cartridge Drives	Small Optical Disk Drives	High Capacity Flexible Disk Drives	Low Capacity Flexible Disk Drives
ActionTec	O,P	FD,FM					
Advanced Micro Devices	O	FM					
AMP	O,P	FM					
Avatar Systems	O			2			
Centennial Technologies	O,P	FD,FM					
Cirrus Logic	O	FD					
IBM Microelectronics	C,O,P	FD					
Integral Peripherals	O,P		PIII				
Intel	O,P	FM					
Iomega	O,P			3		3,5	
MagicRAM	P	FM					
Mountain Optech	O				3		
New Media	O,P	FM					
SanDisk	O,P	FD					
Simple Technology	P	FM					
Smart Modular Technologies	O,P	FM					
Swan Instruments	O,P					3	
SyQuest Technology	O,P			3,5			
VisionTek	P	FD					
Asian Manufacturers (28)							
Alps Electric	O,P						3
Carry Computer	O,P	FM					
Chinon	O,P						3
Citizen Watch	O,P						3
Fuji Photo Film	O,P	FD,FM					
Fujitsu	C,O,P	FM			3		
Hyundai Electronics	O,P	FM					
Kingmax Technology	O,P	FD,FM					
Konica	O				3		
Matsushita Communication Ind.	C,O,P						3,5
Matsushita Electric Ind.	O,P	FD,FM			3		
Matsushita Electronic Comp.	O						3
Matsushita-Kotobuki Electron.	O					3	
Mitsubishi Electric	O,P	FM				3	3
Mitsumi Electric	O,P						3
Momentum Peripherals	O,P		PIII				
NEC	C,O						3
Olympus Optical	O,P				3		
O.R. Technology	O,P					3	
Samsung Electronics	C,O,P						3,5
Seiko Epson	O,P	FD,FM	PIII		3	3	3
S.F.R.	O,P						3
Sony	C,O,P				2,3		3
Tae-Il Media	O						3,5
TEAC	O						3,5
Toshiba	O,P	FD,FM					
Transcend	O,P	FM					
Y-E Data	O,P						3,5,8
European/Middle East Manufacturers (5)							
Calluna Technology	O,P		PIII				
M-Systems	O	FM					
Memory Card Technology	P	FM					
Nomai	O,P			3			
SCM Microsystems	O,P	FM					

TECHNICAL REVIEW

This section briefly reviews the status and significant technology trends for removable data storage in the following areas:

* Flash cards
* PC Card rigid disk drives
* Rigid disk cartridge drives
* Small optical disk drives
* High capacity flexible disk drives
* Low capacity flexible disk drives

Flash card technology

The development of flash memory dates back to work done by Toshiba in 1984, although U.S. firms have done the most to commercialize the technology. Flash memory is nonvolatile and rewritable, making it suitable for use in removable or power-off environments. The manufacturing technology involved is essentially CMOS technology, which permits flash memory manufacturers to take advantage of improvements in semiconductor manufacturing processes. There are several flash cell architectures, NOR, NAND, and EEPROM, which differ largely in erasable block sizes, power demand and access times, but otherwise have similar characteristics as viewed from outside the chip. The majority of flash chips are manufactured using NOR architecture for producibility reasons.

Because of their low power drain, immunity to shock and vibration, and fast read access time, flash cards are well suited for providing mass storage for portable systems, but their relatively high cost per megabyte in most cases limits their use to applications where only a few megabytes or less of storage are needed. Military or severe environment applications are often an exception, because cost is subordinate to function in these cases. An example of such an application is Raymond Engineering's flash disk array, a RAID configuration using SanDisk flash disk modules instead of disk drives.

Notebook computers, subnotebook computers, pen-based computers, and PDAs (Personal Digital Assistants) have created demand for removable mass storage, much of which can be satisfied by flash cards. Some noncomputer applications, such as storage for digital cameras, voice recorders and consumer telecommunications devices, are beginning to fuel increased demand. In addition to providing primary or secondary storage for small systems, flash cards can also be used to transfer data between systems, both mobile and desktop. While most flash memory cards have been used in industrial applications, consumer applications involving small form factor cards are expected to be dominant in the future.

In order to provide for card interchangeability between systems, a set of standards has been developed by PCMCIA (Personal Computer Memory Card Industry Association) and JEIDA (Japan Electronic Industry Development Association) that defines a package and 68 pin interface for removable memory, I/O device and other functional cards suitable for use with portable computing systems. Release 1 of the PCMCIA specification covered memory cards (including flash cards), but strong industry demand resulted in the formulation of Release 2, which also covers peripheral devices. Release 2.1 specified Card Services and Socket Services software support requirements for the interface. Release 3, formally the PC Card Standard, was announced in late 1994 and defines support required for multifunction cards, a 32 bit bus architecture (CardBus), and dual 3.3 volt/5 volt power. Both PCMCIA and JEIDA now encourage usage of the phrase "PC Card" in place of "PCMCIA Card". PC Card flash memory and PC Card flash disks (which emulate a disk drive) are becoming major applications for flash memory, but smaller form factor cards are expected to eventually command larger markets.

Three small form factors are receiving significant industry support: Compact Flash (ATA flash disk), Miniature Card (flash memory), and Solid State Floppy Disk Card (flash memory). None of these are interchangeable with each other. Industry associations have been formed to support each proposed standard, but there is not yet an apparent winner, and it will take a year or two for the market to decide. The small size of these cards makes them ideal for use with cameras, phones, and other handheld equipment, but they can also be used with adapters that provide connections to standard PC Card interface connectors.

Some important aspects of flash cards are reviewed below.

* Chip density and card capacity: Because a flash card carries a limited number of chips, the capacity of the chip, or chip density, is a major factor in establishing card capacity and cost per megabyte. Current designs use 1 megabit chips, 4 megabit chips, and 16 megabit chips in PC Card flash cards, and the 16 megabit chips are becoming mainstream elements. The use of 64 megabit chips is anticipated in the next few years. SanDisk and NEC have a joint development program to create a 256 megabit chip, planned for 1997, which is intended to bypass the 64 megabit step and achieve an advantageous cost per megabit position relative to other chip densities. In mid-1994, Intel announced it was developing multiple bit per cell chip designs that also are intended to result in major improvements in chip density within a few years.

* Flash disk versus flash memory: Some flash cards are designed to emulate a disk drive when plugged in and are equipped with a PCMCIA-ATA interface, which is similar to the ATA interface used in personal computers. Such memory cards, which are designated as "flash disk" cards operate as if they were an IDE drive, and their organization can be described in terms of disk drive equivalent heads, sectors and data cylinders. SanDisk is the most significant supplier of flash disk cards.

  Most flash memory, however, does not look like a disk drive to the system, although with the use of software "flash file systems" they can be presented to the host operating system as virtual disk drives. When installed as flash memory (sometimes called "linear flash"), flash cards can act as an extension to the host system's memory, permitting software stored on the card to execute directly from the card (XIP, or execute in place capability) without having to be loaded from card to host memory first. Host based software can provide disk-like functionality with minimum hardware cost, but at the expense of performance.

* Performance: Because there are no moving parts, average access time for reads on flash cards can be very short compared to rigid disk drives. However, writes are inefficient (an entire block of data must be erased and then rewritten with any required changes). Accordingly, flash memory writes can take considerably longer than with a rigid drive because of the considerable amount of data management required. A memory that has been "put to sleep" for power conservation reasons may take a millisecond or two to become fully functional, but after that access times are measured in hundreds of nanoseconds.

* Power requirements: Because the primary application for flash cards is in portable equipment, minimization of power requirements is critical. Earlier flash card designs required multiple voltages (usually +12 volts and +5 volts) to operate, but more recent designs require only 5 volt power. 3.3 volt or dual 3.3 volt/5 volt cards are also becoming available. Some cards manage power internally, reducing power when the memory is inactive,

although this results in short delays upon reactivating the memory card as well as creating compatibility problems in some systems.

* Packaging: The PC Card standards define a set of standard packages of various thickness but with the same width and length. PC Card Type I cards are 3.3 millimeters thick, PC Card Type II cards are 5 millimeters thick, and PC Card Type III cards are 10.5 millimeters thick. All PC Cards are 54 millimeters wide and 85.6 millimeters long. An additional thicker "Type IV" package has been suggested by JEIDA (Japan Electronic Industries Development Association), but has not been approved by PCMCIA. As noted above, sub-PC Card form factors are becoming the preferred form for packaging flash memory on cards for nonindustrial applications.

* Interface: The electrical and mechanical interface for PC Card flash cards is defined, and has evolved to accommodate a wider 32 bit PCI-like data bus, often called "CardBus". The software interface between the card and the host system has also been standardized, though sufficient ambiguities remain to prevent universal interchange between all cards and all systems. The actual physical interface between card and host is implemented in a socket contained in a "card drive", sometimes called a card reader/writer. Older card drives were configured to operate with PCMCIA Release 1 specifications, which are not compatible with PCMCIA Release 2 specifications. Consequently, the older card readers must be replaced or reconfigured (if possible) to use any PC Card cards other than memory cards.

  There are many industrial applications for flash memory cards that do not require the full complement of features specified by the PC Card standard. Some card manufacturers are producing lower cost cards that conform to PC Card standards in terms of mechanical and electrical specifications, but with all but the simplest internal logic removed. AMP's FlashLite series is typical of such cards.

* Longevity: Flash memory has a limitation on the number of times a memory cell can be rewritten before its ability to permanently store the data accurately degrades. Most flash cards are currently specified to have at least 100,000 cycle capability, although cards with 10,000 write cycles to 1,000,000 cycles are advertised. Improvements in materials and manufacturing processes are expected to gradually improve this characteristic. In many applications, write cycle limits are not a significant problem, either because the memory does not need to be rewritten often or because wear leveling software is used to rotate write operations across the entire memory on the card, preventing any one cell or block of cells from having an abnormally large number of writes and wearing out early. Since the cycle life of the memory cells statistically follows a bell curve, it is also possible to extend card usability by flagging the memory locations that fail early and removing them from use, thereby extending the usable life of the card at the cost of a small decrease in capacity.

* Compatibility: Differences between voltage and current levels supplied by host sockets and what the memory cards expect can cause interchange incompatibility. Even though PC Card memory may adhere to physical and electrical standards, differences between the way host systems communicate with the cards cause interchange problems. Furthermore, products conforming to PCMCIA Release 2 or the PC Card standard will not operate in host systems configured to support PCMCIA Release 1. PCMCIA has attempted to resolve such difficulties by defining several layers of software executed by the host (Card Services and Socket Services) and by defining a Card Information Structure (CIS), a method for the card to report to the host what type of card it is and how its information is organized. The host computer can then determine how to attach the card's information structure to the host operating environment.

  Newer computers usually have PC Card support software preinstalled as part of the BIOS or operating system, and any operating system drivers required will be capable of operating with PC Card flash cards. The major computer and card suppliers have cooperated to eliminate potential incompatibility problems with PC Cards, but the small form factor cards are all mutually incompatible.

* Insertion integrity: Cards conforming to the PC Card standard must be designed to be removable and insertable with power on and the system running. They must also withstand a considerable number of physical insertions. Most flash cards are specified to withstand at least 10,000 insertion/removal cycles.

* Competing technologies: Other semiconductor technologies compete with flash memory. PC Card models using SRAM with a backup battery to provide nonvolatility are sold by many of the same firms that supply flash cards, but are being displaced by flash technology in applications where fast writes are not required. ROM or EEPROM based cards compete if read-only or write-once characteristics are acceptable. And in the future, ferroelectric memory, which is also inherently nonvolatile and is less restrictive in the number of write/erase cycles allowed, may be a significant competitor, as ferroelectric chips reach 4 megabit densities and above.

PC Card magnetic rigid disk drive technology

Version 2.1 of the PCMCIA specification covers peripheral devices, including rigid disk drives mounted in PC Cards. Because of the limitations imposed by card size, these are all currently 1.8" diameter drives. Although several companies have produced PC Card disk drives during the last few years, Calluna, Momentum Peripherals and Integral Peripherals are currently the disk drive manufacturers active in the market for PC Card rigid disk drives. Much of the commentary in the preceding section concerning PC Card related issues applies as much to rigid disk drive PC Cards as it does to flash cards. Areas of difference are reviewed below, as well as those issues unique to rigid disk drive technology.

Rigid disk drives packaged in PC Card format are well suited for providing primary or secondary storage for full function mobile computers, because of the higher capacities available. Computer users who wish to take their full suite of applications on the road with them will find the 170 megabyte to 514 megabyte capacities of drives now in production to be adequate, though not generous. More capacity is needed, especially for multimedia and graphics applications. Some improvement can be obtained indirectly by using data compression, which can expand drive capacity by a factor of two for an average application and user file mix.

* Areal Density: The most significant aspect of rigid disk drive technology is the trend line of areal density (TPI x BPI) increase. The rigid disk drive industry is currently increasing recording density at an average rate of 60% annually, and this rate is expected to be maintained through this decade. It is this inexorable improvement that will keep the cost per megabyte of rigid disk storage well below the cost of flash memory during the remainder of the decade. The highest areal density announced for a 1.8" drive as of mid-1996 was about 797 megabits per square inch (Integral's 514 megabyte drive), while the industry average remained in the 380 megabits per square inch range, a conservative level allowing for rapid improvements.

  High areal densities are being obtained by using thin film heads and media, coupled with reduced flying height. PRML data channels were incorporated in 1.8" drives during 1995. Magnetoresistive heads are now used in higher capacity 1.8" drives, and heads employing giant magnetoresistance effects will eventually be employed in PC Card drives to extend areal density.

* Packaging: All current rigid disk PC Card drives employ standard Type III PC Card form factors today. A drive in the Type II form factor was announced by Maxtor, but was never shipped before Maxtor withdrew from the PC Card drive market. The major pacing element in establishment of volume production for PC Card Type II disk drives will be availability of adequate quantities of critical new components, such as motors, disks, head assemblies and semiconductors. The small area available in the card for electronics also dictates increased use of higher density semiconductor elements and innovative packaging techniques. It may also be

possible to produce magnetic rigid disk drives which conform to the form factors of the new smaller card standards currently being proposed for flash cards. However, attempts to start new companies to design and manufacture such drives have so far been frustrated by the lack of adequate venture capital investments.

* Power requirements: Rigid drives require more power than semiconductor memories when operating, so power reduction and on-board power management are critical functions and likely to remain so.

* Interface: The PCMCIA-ATA disk drives conform to PCMCIA Release 2 physical specifications and use the PCMCIA 68 pin connector rather than the standard ATA 40 pin connector. The PCMCIA-ATA card also supports extended I/O addressing, necessary for removable drives, and supplies CIS data to the host on request. PCMCIA-ATA drives can support either 8 bit or 16 bit data transfers, as compared to the ATA 8 bit transfer only. Host resident drivers for ATA drives must be revised to account for the removability of the PCMCIA-ATA drives and other features. Such drivers are labeled as "PCMCIA-aware".

* Shock resistance: Because they have moving parts, PC Card rigid disk drives are more vulnerable to mechanical disturbances than their all-electronic counterparts. However, considerable insensitivity to the effects of operating shock has been obtained by incorporating piezoelectric shock sensors into the drive and halting writing operations when an excessive shock is detected, eliminating the possibility of off track or adjacent track writing that can cause unrecoverable errors. Dynamic head loading, used by Integral Peripherals, helps reduce nonoperating shock damage because the heads are parked off the disk when the drive isn't operating. When removed from the host system, a card mounted drive is much more susceptible to shock damage, so nonoperating shock damage elimination is critical for PC Card rigid disk drives.

* Performance: Today's 1.8" drives have average access times in the 18 to 30 millisecond range, substantially inferior to flash memory cards. Startup time is in the 1-2 second range, also slow compared to flash memory. Media data transfer rates are in the 3 to 6 megabytes per second range, with burst rates at 10 megabytes per second. Media data transfer rates will probably increase as linear densities increase.

* Electronics: Drive servos are shifting to use of digital signal processing in servo tracking subsystems as TPI increases put more strain on tracking tolerances. Channel electronics are becoming more complex in order to accommodate the higher data transfer rates associated with higher linear density. While these improvements assist performance and help improve capacity, they also add cost and power consumption, both undesirable for portable systems.

* Motors: It is necessary for drive motor designers to be very creative to accommodate the ever decreasing drive heights. The rate at which the drive producers can introduce PC Card Type II form factor drives is a function of the availability of the very thin spindle motors required. Actuator designs are also being stressed for the same reason, and for some very thin drives, maintaining the expected performance levels will be a challenge.

Magnetic rigid disk cartridge drive technology

Disk cartridge drives are currently available in 5.25", 3.5", and 2.5" form factors. The SyQuest 1.8" drive, which utilized a removable disk, actually fit into a PC Card compatible mounting, but cost, technical problems and the drive's 80 megabyte capacity limited industry acceptance, and the product was withdrawn in early 1996.

All of the factors that apply to rigid disk drives in general pertain to cartridge drives, but the need to accommodate removable cartridges makes it difficult to match the areal densities achieved by drives with sealed head/disk assemblies. Disk cartridge drives must also be designed to deal with dust and airborne chemical pollutants to a degree not required of sealed HDA designs.

Driven by competition from optical disk drives and high capacity flexible disk drives, and able to draw upon basic improvements in magnetic drive technology, rigid disk cartridge drive technology has improved dramatically in the past few years. 5.25" disk cartridge drives currently are available from SyQuest with capacities up to 200 megabytes, but industry direction has shifted to smaller form factors, with a gigabyte now available on Iomega's 3.5" Jaz drive and 1.3 gigabytes available on SyQuest's SyJet, due for shipment in late 1996. Avatar is now producing 2.5" drives with 170 megabytes capacity. Higher capacities for the smaller form factors are expected to become available as areal densities increase. Disk cartridge drives will be able to take advantage of the heads, disks, motors and semiconductors developed for the much larger market provided by fixed disk drives. The special operating environment of removable disk cartridge drives will require improved filtration systems and cartridge protection systems to eliminate airborne pollutants, all attainable refinements of existing technologies.

The primary applications for disk cartridge drives have been data interchange associated with graphics and desktop publishing, plus secure system data storage, where they will compete with PC Card rigid drives, small optical drives, high capacity flexible drives, and, in nongraphics applications, with flash memory as flash capacity increases. Compared to the competition, rigid disk cartridge drives can offer cost advantages, and frequently provide more capacity and convenience of use. The major technology challenge for disk cartridge drives, as always, is to improve reliability, a difficult assignment due to the lack of a completely closed head/disk assembly. Disk cartridge drive reliability is currently regarded as adequate by most users, but it will be necessary to continue to improve, as competition increases from other data storage products.

Small optical disk drive technology

Small form factor optical disk drives offer cartridge removability in the same way as magnetic cartridge disk drives, and compete against both rigid and flexible magnetic cartridge disk drives, largely in the same desktop application niches. However, their larger size and power needs have kept them from playing a significant role in portable system applications. 3.5" optical disk drives in 128, 230 and 640 megabyte capacities are currently on the market, manufactured by a few Japanese companies. Sony introduced a 650 megabyte version in late 1995, but has also announced 640 megabyte media compatible with the industry standard 640 megabyte models. 2.5" drives introduced by Sony have been deemphasized pending redesign to provide higher capacity. 1.8" optical drives have not yet appeared. Although Fujitsu has discussed the possibility of such a future drive, their appearance is unlikely until capacity can be improved.

Optical disk drives and media can demonstrate high areal density exceeding 1000 megabits per square inch for the 640/650 megabyte 3.5" drives, but can address only one side of the disk because only one head is present in the drive. As a result, on-line capacity compares unfavorably with the on-line capacity available from rigid magnetic fixed or cartridge drives of equivalent media size. On the other hand, optical drives do not require the microinch range head-to-disk spacings required by rigid drives and are less subject to head crash or stiction events. Perhaps the greatest obstacle that optical drives must overcome is their high price relative to competing disk technologies, a problem created primarily by the relatively low shipments of drives in this class. Optical drives also suffer in comparison with other removable storage technologies in terms of power requirements, packaging and, sometimes, performance.

Optical drives in 5.25" and larger formats are frequently used in optical libraries (jukeboxes), enabling data stored on multiple disks to be accessed under system control. Because of the small capacities of 3.5" drives, there has been little industry interest in using them in libraries, but 3.5" drives with 600+ megabyte capacities are expected to encourage library use. At present, only one library containing 3.5" drives is available; it holds 22 disks.

Nearly all of the present generation of 3.5" optical drives offers 230 megabytes or 128 megabytes on single sided media, as the 640/650 megabyte drives are still in the beginning of their production ramp. This next generation of 3.5" drives provides 640 megabytes or greater through the use of improved recording techniques and shorter wavelength lasers. Magnetic rigid cartridge disk drives offer serious competition to optical drives in many situations. SyQuest's 3.5" 230 and 270 megabyte removable drives compete with 3.5" 230 and 128 megabyte optical drives in capacity, price and performance, while Iomega's one gigabyte Jaz drive outdistances 3.5" optical drives in capacity and performance. Even high capacity floppy drives, such as the 100 megabyte Zip drive and the 120 megabyte LS-120 compete where price is of primary importance.

While 3.5" optical drives have improved performance to the point where they can provide sub-30 millisecond average seek time, future PC Card magnetic drives already offer sub-20 millisecond average seek times on drives of roughly equivalent capacity.

2.5" optical disk drives are the result of developments by Sony, which created the format originally as a consumer oriented audio recording product. A number of other companies have taken Sony licenses for the technology. In its most recent form, the 2.5" drive offered 140 megabytes of data on single sided magneto-optic media. Because the recording format is borrowed from CD-ROM technology, performance is limited. Although the road map is clear for capacity improvements in 3.5" drives, the situation regarding 2.5" drive capacity improvements is murky. The rate of progress may depend upon technological competition and upon improvements in CD-ROM technology and the success of the audio format drive, which may reduce the costs of the computer version and induce manufacturers to invest in improvements.

All 3.5" optical disk drives currently being manufactured use magneto-optic (MO) media, and although 3.5" drives employing phase change media, which uses a different recording technology and is incompatible with MO media, have been considered by some producers, their appearance is considered unlikely given the already large number of available choices for small removable disk storage. Most drives using MO media cannot directly overwrite previously recorded data. Old data must be erased during one revolution of the disk, which can then record data on the next pass. As a result, the best of the MO drives have read performance approaching that of a magnetic drive, but much inferior write performance. Drives using phase change technology can overwrite data directly, but are subject to a limitation on the number of write/erase cycles that can be performed on a specific location. Direct overwrite on MO media is possible, though more costly, and currently is available only in the 5.25" drives.

The fundamental technology driving improvements in all of optical drives is the technology of the semiconductor lasers used in the optical recording head. Current lasers operate at 780 nanometer (infrared) wavelengths. The spot size the laser makes on the disk is a function of the laser wavelength, and a halving of the wavelength would result in a 4x capacity increase, with proportionate increases at lesser wavelength improvements. The prospects for blue light (400 nanometer) lasers are improving, although the frequency doubling solutions expected in the next few years are costly in both power and money.

Additional improvements in capacity are likely to be obtained from a shift from bit edge encoding to pulse width modulation, improved servo techniques, and the use of unconventional optical elements to increase areal density. Higher laser power will enable higher rotation rates and faster data transfer rates.

High capacity flexible disk drive technology

Flexible disk drives in this group use a variety of technologies to provide capacities above those offered by standard floppy drives, including Iomega's 5.25" Bernoulli principle drives, the 100 megabyte Iomega 3.5" "Zip" drive, and the

3.5" 120 megabyte "floptical drives" initially introduced by Insite Peripherals and now manufactured by Matsushita-Kotobuki Electronics and (soon) by others. Because of the relatively high prices of these drives, compared to standard floppy drives, they compete with rigid magnetic disk drives, optical disk drives and tape drives, for specialized markets which need recording devices with removable media. It is a difficult competitive environment, however, with rapidly dropping prices for the alternative products.

Originally introduced in an 8" diameter format, the Iomega Bernoulli Box transitioned to a 5.25" format and is currently available in capacities up to 230 megabytes. Performance is competitive, with average seek times in the 20-25 millisecond range. The performance of most high capacity 3.5" drives in this group is inferior to that of the Bernoulli drives, but better than that of standard 1.44 or 2.88 megabyte floppy drives. Current 3.5" drives are 1 inch high, but thinner drives figure prominently in the future plans of high capacity floppy manufacturers. Individual design approaches have been used to create high capacity 3.5" flexible drives, generally not compatible with each other. They are reviewed briefly below:

* <u>Rigid drive technology</u>: The Iomega "Zip" drive borrows head and semiconductor technology from the rigid drive industry, obtaining design simplicity, low parts count and reduced costs as a result of being able to use components already being produced in volume for the rigid drive industry. Iomega's success is judged likely to cause other competitors to adopt a similar philosophy in future high capacity drive design efforts.

* <u>Optical tracking</u>: Developed by Insite Peripherals, the original 20 megabyte 'Floptical' drives used optical tracking to provide 1,245 TPI and 1,7 RLL coding to reach almost 24,000 BPI. The barium ferrite media was packaged in a standard 3.5" floppy disk shell. To provide a tracking servo signal, the media was laser branded with a pattern of concentric rings. A multisensor pickup device receives reflected light and generates appropriate tracking data. As manufactured in recent years, track density of the floptical drives was 1,245 TPI, but improved optics, the use of metal powder media and tighter track spacing have increased the available capacity several times. The second generation floptical technology drive with 120 megabyte capacity has 2,490 TPI and 44,880 BPI, also using 1,7 RLL coding. Because it has two heads, the new drive is backward compatible with standard 3.5" floppy drives, but its relatively high production cost (resulting from the need to support dual read/write channels and the optical tracking system) make cost reduction imperative if it is to compete successfully.

* Metal powder media: Using metal powder media and conventional recording techniques, several Japanese firms, including NEC, Matsushita Communication Industrial and Y-E Data introduced 3.5" floppy drives from time to time with capacities up to 20 megabytes (NEC introduced a 10 megabyte version in 1990), but all were withdrawn from the market due to limited acceptance of their limited capacity. Proponents of the metal powder approach have long claimed that it can support floppy drive capacities of 100 megabytes or more using standard form factor flexible disks, and recent history supports this claim. The Iomega "Zip" drive achieves its 100 megabyte capacity with metal powder media, as does the 120 megabyte LS-120 drive and drives from others still in development. Capacities in the 200 megabyte range are expected to become available within the next 6 to 12 months.

* Embedded servo: In 1990, Brier Technology introduced a 20 megabyte floppy drive that used an "embedded servo", a magnetically written servo track colocated with the data track but using a lower frequency than that of the recorded data signals. A track density of 777 TPI was obtained. A frequency sensitive detector scheme was used to provide tracking signals to the head positioner. The barium ferrite disks used had to be preformatted at the factory before use. Brier was unable to win broad acceptance for the drive, which went out of production in 1992. The firm announced, but never made, a 40 megabyte drive.

* Other methods: Various firms have examined the possibility of increasing the capacity of standard floppy drive media by a judicious choice of coding, modulation scheme or compression without changing the fundamental file structure of the drive. While such methods can produce higher capacities, it is questionable if the limited increase in capacity warrants the industry-wide standardization effort required to gain acceptance for any given method or combination of methods.

Low capacity flexible disk drive technology

There has been little recent, significant change in low capacity floppy drive technology. Notebook computers use large numbers of half inch high 3.5" drives, but one inch high 3.5" drives are still the standard for desktop computers. 2.88 megabyte 3.5" drives, once standard on many IBM PS/2 personal computers, are now only an option on IBM's newer personal computers, and have generated limited market response outside of IBM. The most significant technical development efforts are now aimed at high capacity drives.

Low capacity floppy drive development has slowed, but other technologies competing with floppy drives as a universal distribution medium remain too costly, too slow, or are not standardized for universal data interchange. Standard 3.5" flexible disk drives have succeeded because they offer low cost, recordability, random access, interchange standards and media removability. CD-ROM drives, now growing in usage for software distribution, are limited to the distribution role, due to the lack of recording capability. A critical problem for competitors is that any alternate technology must offer significant improvements at a competitive price, and the OEM price for 3.5" floppy drives is below $20 for large quantities.

Ever-smaller form factors, higher capacities, more effective designs, the need to read existing libraries of disks, and lower cost manufacturing methods have sustained floppy drive cost-effectiveness against competitive data storage technologies. Consequently, alternate technologies find only limited success in breaking into floppies' established markets, although some displacement of floppy drives is occurring in notebook and handheld computers where there is insufficient space or power for floppy drives. The most likely successor to the low capacity floppy disk drive is a high capacity floppy disk drive, although prices will have to decline greatly to produce a large scale displacement.

Developments in low capacity floppy technology seem limited to a few areas:

* Form factor: Half inch high 3.5" floppy drives now in production permit designers of notebook computers to reduce weight and system size, and to match the heights of new 2.5" and 1.8" rigid disk drives. The nominal half inch high floppy drives now offered in formats from 11 to 12.7 millimeters in height are widely used in notebook computers and have also found usage in subsystems which combine a 3.5" drive with a 5.25" drive in a single unit designed to be used in a 1.625" high slot in desktop systems.

  Drives ranging from 15 to 19 millimeter height are currently offered as three quarter inch drives. After initial enthusiasm, the computer industry's reaction to three quarter inch floppy drives cooled off, with recent growth in shipments going to one inch high drives -- or to half inch high drives when necessary due to packaging requirements. It currently appears that one inch high drives will remain the desktop computer standard.

  Floppy disk drives have evolved from 8" disk drives through 5.25" disk drives to 3.5" disk drives, but the prospects for further diameter shrinkage in the low capacity category seem unlikely. Attempts to reduce diameter to 2.5" or less go back to the late eighties and a few drives were actually introduced, but the computer industry has not found it economically attractive to go through one more stage of diameter shrinkage.

* Media: The polyester substrate used with flexible disks suffers from limitations in its dimensional stability which derive from the manufacturing process used. As a result, today's mainstream floppy drive products using open loop head positioning systems for low cost are limited to 48 TPI with 8" drives, 96 TPI with 5.25" drives, and 135 TPI with 3.5" drives. The relatively small tonnage of polyester required for diskettes did not inspire plastics manufacturers to invest heavily in research targeted at dimensional stability improvements until the last few years, when the quantities became too large to ignore.

  Some substrate materials do offer high stability and resistance to environmental degradation, but are very expensive relative to polyester films and are unlikely to be widely adopted.

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 or flash card manufacturers use them.

Market classification

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

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

Examples:

* Flash cards sold with a computer by IBM or Fujitsu to computer system end users are considered captive, if internally manufactured.

* Optical disk drives manufactured and sold by Matsushita Electric with a computer system to an end user are considered captive.

Noncaptive: Any public sale or lease by any flash card or disk drive manufacturer, except sales or leases of internally manufactured products 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.

Examples:

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

* Shipments made by Integral Peripherals, SyQuest Technology, SanDisk or Seagate Technology are noncaptive.

PCM/Distributor: Disk drives and flash cards sold in the "aftermarket" -- shipments by disk drive and flash card manufacturers to subsystem producers, value-added resellers, distributors, retail chains, mail-order firms and individual dealers. It includes drives to be connected to systems of all types, including personal computers, minicomputers and mainframes, or products sold as add-on devices by distributors and dealers.

Examples:
* Rigid disk cartridge drives such as those of Iomega or SyQuest.

* Intel flash cards sold through industrial distributors.

OEM/Integrator: Drives and cards 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 flash card manufacturer to a second drive or card manufacturer for resale are included only in shipment totals for the originating manufacturer, except when products are produced on a contract manufacturing basis with a design supplied by the disk drive or flash card manufacturer which finally sells the product to a third party.

Examples:
* Disk drives produced by Integral Peripherals or Calluna for sale to system manufacturers.

* PC Card flash cards sold by Advanced Micro Devices directly to system manufacturers.

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 or card manufacturer to a European system manufacturer is included in worldwide totals, even if the product 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 or card is integrated into a system in Taiwan, regardless of the final destination of systems in which the storage devices 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. Subsidiary corporations are classified according to the geographical location of their parent organization's headquarters.

Example:

* IBM is considered a U.S. manufacturer, even though the company manufactures many of its data storage devices in non-U.S locations.

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 disk drive unit totals are counted in spindles. Flash cards are counted in single card units.

Revenue: Based on sales of disk drives and flash cards alone, as normally sold by individual manufacturers. Controllers sold as separate units are not included in disk drive revenue, nor are spare parts or service. When individual storage device 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. 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 shipments and revenues for current or announced products in new production. Evolutionary improvements within existing disk drive formats are included, but completely new configurations or technologies are not included.

Examples:

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

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

Application classification

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

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

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

Network/midrange computers: Drives and flash cards attached to network file servers and other midrange multiuser systems. Examples: IBM System AS/400, Compaq SystemPro, Hewlett-Packard 3000.

Personal computers: Attached to a portable or desktop personal computer intended primarily for nonconsumer applications. Examples: Dell Dimension, Toshiba Satellite series, Apple Macintosh, Compaq DeskPro.

Workstations: Single user high end workstations used for engineering, graphics, order processing/shipping, document storage and imaging, point-of-sale, medical, CAD/CAM/CAE, factory production control, law enforcement, military and other applications.

Consumer, game and hobby computers: Used in general purpose or dedicated applications systems sold primarily to consumers for nonbusiness purposes. Examples: All personal computers intended primarily for home use and all computer games and home multimedia systems.

Other applications: Any application not included above, including nonconventional uses such as intelligent fax machines, copiers, intelligent personal communication devices, data loggers and industrial equipment.

FLASH CARDS

FLASH CARDS

Coverage

Examples of flash cards in this group include:

Flash disk cards, less than 10 megabytes

Centennial Technologies	FMA05
Cirrus Logic	CL-FD0004
IBM	17JSSFP3MB, 17JSSFP5MB
Kingmax Technology	AJT-004M
SanDisk	SDP3B-4, SDCF-4*
Seiko Epson	ATA202SD11/01, ATA502SD11/01
Toshiba	TH6SS160031AA

Flash memory cards, less than 10 megabytes

ActionTec Electronics	FH002M-BN, FH008M-BN
Advanced Micro Devices	Am MCL004A*, AMC008DFLKA
AMP	Flash 12, FlashLite
Carry Computer	2MB
Centennial Technologies	FL256-15-11131
Fuji Photo Film	RD3001-8
Fujitsu	MB98A8084X, MB98A8133X
Hyundai Electronics	HYCFL001
Intel	iMC004FLSP, iMC004FLSA, iFM002A*
Kingmax Technology	FJN2, FJN8
M-Systems	FlashCard-1M, FlashCard-8M
MagicRAM	FL2MBP100
Matsushita Electric Industrial	BN256HFRE, BN-04MHFRE
Memory Card Technology	F01MX0
Mitsubishi Electric	MF8257-G1EATXX, MF81M1-GCDAT
New Media	NMC00101, NMC00126
SCM Microsystems	FC004MB2
Seiko Epson	HWB257ESX0/40, HWB801S8X0/40
Simple Technology	STI-FL/2A
Smart Modular Technologies	SM9FL512KP3, SM9FL4MP35V
Toshiba	TC5816ADC* (SSFDC)
Transcend	Flash 2 MB
VisionTek	VT12150.0

Flash disk cards, 10 - 25 megabytes

ActionTec	ATA-12
Centennial Technologies	FMA10
Cirrus Logic	CL-FD0020
IBM	17JSSFP10MB, 17JSSFP20MB
Intel	iFD010P2SA
Seiko Epson	ATA112SD11/01, ATA212SD11/01
SanDisk	SDP3B-10, SDCF-10*
Toshiba	THGSS160101AA

Flash memory cards, 10 - 25 megabytes

ActionTec Electronics	FH010M-BN, FH016M-BN
Advanced Micro Devices	AM020DFLKA
AMP	797263-5
Carry Computer	MCBF16384K2
Centennial Technologies	FL16M-20
Fuji Photo Film	RD3001-16
Fujitsu	MB98A8143X
Hyundai Electronics	HYCFL16020
Intel	iMC020FLSP, iMC010FLSA
Kingmax Technology	FJN12, FJN16
M-Systems	FlashCard-10M, FlashCard-20M
MagicRAM	FL10MP100
Matsushita Electric Industrial	BN-16MHF3CE
Memory Card Technology	F14MX0
Mitsubishi Electric	MF810M-G7DATXX, MF820M-G7DATXX
SCM Microsystems	FC020MB2
Seiko Epson	HWB111S8X0/80, HWB161S8X0/80
Simple Technology	STI-FL/16A
Smart Modular Technologies	SM9FL16MP3
Transcend	Flash 16 MB
VisionTek	VT1253.0

Flash disk cards, 25 - 100 megabytes

IBM	17JSSFP30MB, 17JSSFP40MB
MagicRAM	FL20MATA
SanDisk	SDP3B-85
Seiko Epson	ATA412SD12/02
Toshiba	THGSS160402AA

Flash memory cards, 25 - 100 megabytes

Fujitsu	MB98A81573
Intel	iMC040FLSP
M-Systems	FlashCard-40M
MagicRAM	FL40MP100

Flash disk cards, more than 100 megabytes

SanDisk	SDP3B-175

*Smaller than PC Card.

The memory cards discussed in this section include PC Card flash cards and small form factor flash cards such as Compact Flash, Miniature Card and Solid State Floppy Disk Card (SSFDC), organized as either flash disks, which inherently emulate a disk drive, or flash memory (sometimes called linear flash) which requires additional software to provide disk drive emulation. Flash memory can also provide XIP (execution in place) capability, permitting programs to execute from the card as if they were in the host system memory.

Flash cards are ideal mass storage for situations where only a few megabytes of capacity are needed and relatively high price per megabyte is acceptable, and in applications where shock, vibration, humidity, dust and corrosive vapors would preclude the use of disk drives.

Market status

1995 flash card shipments rose 74.6%, reaching 859,100 units, while revenues increased 77.7% to $141.8 million. Shipment growth in some categories was limited by a shortage of chips in the first part of 1995, which helped sustain prices. A modest increase in average capacity also helped revenue growth. However, shipments of larger capacity cards were limited by a small population of portable computers with PC Card slots. Also, there is a preference for nonremovable flash cards in many industrial applications. 75.9% of 1995 card shipments (650,900 units) were in the under 10 megabyte category, while 21.7% (186,600 units) fell into the 10 to 25 megabyte category. 21,500 units exceeded 25 megabytes, a 377.8% gain over 1994. Revenue growth in 1995 showed a similar pattern, with $66.1 million (a 46.6% share) captured by flash cards under 10 megabytes, and $59.1 million (a 41.7% share) by cards between 10 and 25 megabytes. Cards over 25 megabytes garnered $16.6 million for an 11.7% share. Compared to 1994, a significant share of shipments shifted from the lowest capacity range to higher capacities, continuing a trend observed in earlier years.

U.S. manufacturers remain the leading producers of flash cards, retaining 72.4% of total worldwide unit shipments, a slight decrease from 1994. Asian firms are increasing their share. Producers reporting the largest 1995 shipments include Intel, SanDisk, AMD and Fujitsu.

75.4% of the flash cards shipped in 1995 were flash memory cards, with flash disk cards accounting for the remainder. About half of the flash cards over 10 megabytes that shipped in 1995 were flash disk. The material overhead associated with flash disks makes them less attractive at low capacities than flash memory. The relative performance and management advantages of flash disks are advantageous at high capacities.

64.3% of 1995 flash card unit shipments were made through the OEM/Integrator channel, but the share for the PCM/Distributor channel grew moderately, accounting for 35.7%. There were no significant captive shipments, although some flash cards may be shipped on a captive basis in future years.

For flash cards under 10 megabytes in capacity, the price per megabyte averaged approximately $32 to $35 in 1995 (similar to the range observed in 1994), depending upon the distribution channel used and whether the card was flash disk or flash memory. In the 10-25 megabyte class, price per megabyte ranged from about $22 to $23.

The typical flash memory card had a capacity of 2 or 4 megabytes in 1995, while the typical flash disk card had 4-5 megabytes, but the average capacity sold in each product group is slowly increasing each year. The smaller capacity cards (under 10 megabytes) tend to be used in horizontal applications (PDAs, organizers, industrial equipment, etc.), while the higher capacity designs are more likely to be used in vertical applications in service industries such as real estate, finance and insurance. Some companies provide cards with a simplified feature set, but otherwise conforming to PCMCIA/PC Card physical, electrical and environmental specifications, in order to reduce cost by eliminating features required by PCs, but not needed for industrial applications. The AMP FlashLite series is an example. Low capacity cards are usually flash memory cards, as the added costs of the internal controllers in flash disk cards make them poor competitors at the low end of the market.

Application platforms for PC Card flash memory cards tend towards non-personal computer environments, leaning heavily toward industrial equipment, telecommunications products, field survey equipment, data loggers, navigation devices and instrumentation. The more visible PDAs and mobile computers are a minor, yet growing market opportunity. The cards in the higher capacity categories are more likely to be used in mobile general purpose computers and as devices for data transfer between mobile and desktop computers. Small form factor cards, introduced in 1995, are aimed at consumer product markets.

Marketing trends

Shipments of flash cards are expected to grow strongly during the forecast period, with the major portion of that growth resulting from anticipated wide acceptance of small form factor flash cards by consumer industries, notably for camera and personal telecommunications equipment applications. Unit shipments are expected to exceed 10.7 million in 1999, while revenues climb to over $510 million. However, the expected explosion is likely to be generated by the smaller cards. Over 75% of shipments of cards under 10 megabytes capacity will be small form factor cards. The PDA market may get its second wind beginning in 1997, and this should help sales of PC Cards and cards with higher capacities, since many of the newer products are expected to have an Internet orientation and will need to provide some level of local storage in many cases.

Flash cards with capacities less than 10 megabytes are expected to account for 84.4% of unit shipments in 1999, about 9 million units. Cards in the 10 to 25 megabyte category are projected to capture 13% (about 1.4 million units), while the 25 to 100 megabyte category will obtain a 2.6% share, or about 285,000 units. The more than 100 megabyte category is expected to garner a less than 1% share in 1999 due to its relatively high unit cost.

As a result of strong shipments of inexpensive small flash memory cards for cameras, flash memory card shipments are expected to continue to predominate over flash disk shipments throughout the forecast period. However, flash disk is expected to retain a significant share in the higher capacity categories, primarily because of its role as auxiliary storage and data transfer vehicle for mobile general purpose computers and for storage in high end and midrange digital cameras.

Captive shipments, still invisible in 1996, are expected to remain insignificant during the forecast period. Weak sales of PDAs and subnotebook computers will inhibit the PCM/Distributor sales channel from overtaking the OEM/Integrator channel, as aftermarket sales will suffer from the less than anticipated number of mobile systems in use. But increasing sales of digital cameras and other consumer products that use flash cards will help the PCM/Distributor channel grow towards the end of the forecast period.

Technical trends

The most visible product trends anticipated for flash cards involve smaller form factors, and improvements in capacity, performance and cost per megabyte. PC Card standard dimensions are used for cards intended for industrial use, but in applications for consumer equipment, the smaller card form factors will in the majority. There is no direct interchange capability between the competing small form factors.

Capacity: Capacity is primarily a function of chip density. A shift from 8 megabit chips to 16 megabit chips is well under way, with both 32 megabit and 64 megabit chip availability anticipated within the forecast period. Some firms have set 1997 as a goal for introduction of 256 megabit chips. SanDisk has begun shipping flash disks with over 100 megabyte capacities, and several companies have indicated their intention to introduce 32 megabit chips into flash memory cards in the near future. Multilevel flash memory, where each cell can store 2 or more bits, is still in the early stages of development, and while not explicitly assumed to be available during the forecast period, could produce significant reductions in cost per bit for flash memory.

Performance: Performance gains are possible from a wider data transfer bus between the flash card and the host system, plus gains from improved device geometries. However, some techniques that increase capacity, such as multibit storage per memory cell, appear to have associated performance penalties. Performance of flash memory in some applications may be limited by a property of flash file software systems that causes a lengthening of the average seek time after a large number of data rewrites, a characteristic that is avoided in flash disk cards.

Compatibility: Interchange compatibility for PC Card flash memory is still an issue, but is expected to become less significant in the future as the PC Card standard is expanded and clarified and older equipment is retired and replaced. Future systems are also expected to embed drivers for flash memory card support within the BIOS of the host system, providing additional standardization of the interface between card and host system. PC Card flash models capable of operating with multiple voltages will also help eliminate compatibility problems. The industry is on the verge of moving to cards capable of operating with either 5 volt or 3.3 volt power, while 12 volt cards are being phased out.

Power reduction: Intelligent flash card controllers are capable of reducing card power consumption by putting the card into a sleep mode when data is not being transferred. Certain technologies also appear to be inherently less power intensive, and will probably be preferred for mobile computing applications, even at a slight cost premium.

Competing Products: Where small capacities are adequate or use in a hostile environment is necessary, flash memory technology is only weakly challenged by other storage products. SRAM is more expensive and needs a backup battery, DRAM is nonvolatile and becoming less price competitive, and ferroelectric memory is still several product generations away from becoming an effective competitor. Small disk drives remain the main competitors to flash cards, for their low cost per megabyte and rapidly increasing capacities are unlikely to be matched by flash memory in any form during the next decade. The only capacity range in which flash cards and magnetic disks are likely to have any competitive overlap is in capacities under 200 megabytes, an area in which high capacity floppy drives and PC Card rigid disk drives are still active. Ferroelectric memory, with an increased number of write/erase cycles, may also become a serious flash memory competitor by the end of the decade.

Forecasting assumptions

1. Consumer use of small form factor flash cards will rapidly increase beginning in 1997 as a result of their introduction in digital cameras, intelligent pagers and other personal telecommunications equipment.

2. Shipments of flash cards using 64 megabit or larger chips will begin in late 1997.

3. During the forecast period, no technological breakthroughs are anticipated that will drastically alter the ability of flash memory to compete against other products.

TABLE 9

CONSOLIDATED WORLDWIDE REVENUES

FLASH CARDS

REVENUE SUMMARY

	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	27.0	40.0	37.6	58.9	53.1	89.1	57.1	103.5	54.7	105.9
OEM/Integrator	35.3	72.0	51.3	116.6	102.7	201.4	128.1	263.3	131.1	272.3
TOTAL U.S. NONCAPTIVE	62.3	112.0	88.9	175.5	155.8	290.5	185.2	366.8	185.8	378.2
TOTAL U.S. REVENUES	62.3	112.0	88.9	175.5	155.8	290.5	185.2	366.8	185.8	378.2
Non-U.S. Manufacturers										
PCM/Distributor	3.7	4.9	3.9	5.7	5.8	12.5	9.8	22.3	14.7	35.0
OEM/Integrator	8.8	24.9	10.5	37.7	11.6	57.2	13.3	79.1	15.9	97.2
TOTAL NON-U.S. REVENUES	12.5	29.8	14.4	43.4	17.4	69.7	23.1	101.4	30.6	132.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	74.8	141.8	103.3	218.9	173.2	360.2	208.3	468.2	216.4	510.4

TABLE 10

CONSOLIDATED WORLDWIDE SHIPMENTS

FLASH CARDS

SHIPMENT SUMMARY

	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/Reseller	186.1	259.4	296.0	438.3	457.6	730.8	608.7	1,020.6	756.8	1,318.6
OEM/Integrator	210.4	363.2	353.7	730.5	858.8	1,701.5	1,759.0	3,394.9	2,440.6	4,709.3
TOTAL U.S. NONCAPTIVE	396.5	622.6	649.7	1,168.8	1,316.4	2,432.3	2,367.7	4,415.5	3,197.4	6,027.9
TOTAL U.S. SHIPMENTS	396.5	622.6	649.7	1,168.8	1,316.4	2,432.3	2,367.7	4,415.5	3,197.4	6,027.9
Non-U.S. Manufacturers										
PCM/Reseller	34.6	47.4	38.6	61.5	51.9	118.9	80.6	235.8	181.4	581.5
OEM/Integrator	72.5	189.1	98.3	335.7	133.6	760.1	196.2	2,190.6	310.6	4,130.1
TOTAL NON-U.S. SHIPMENTS	107.1	236.5	136.9	397.2	185.5	879.0	276.8	2,426.4	492.0	4,711.6
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	503.6	859.1	786.6	1,566.0	1,501.9	3,311.3	2,644.5	6,841.9	3,689.4	10,739.5

TABLE 11

CONSOLIDATED WORLDWIDE REVENUES
FLASH CARDS
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1995 Revenues $M	1995 Revenues %	Forecast 1996 $M	Forecast 1996 %	Forecast 1997 $M	Forecast 1997 %	Forecast 1998 $M	Forecast 1998 %	Forecast 1999 $M	Forecast 1999 %
FLASH CARDS	66.1	46.6%	105.8	48.3%	162.1	45.0%	216.2	46.2%	221.7	43.4%
LESS THAN 10 MEGABYTES	+48.2%		+60.1%		+53.2%		+33.4%		+2.5%	
FLASH CARDS	59.1	41.7%	76.1	34.8%	121.3	33.7%	145.1	31.0%	152.9	30.0%
10 - 25 MEGABYTES	+89.4%		+28.8%		+59.4%		+19.6%		+5.4%	
FLASH CARDS	16.3	11.5%	34.8	15.9%	69.0	19.2%	91.1	19.5%	106.2	20.8%
25 - 100 MEGABYTES	+307.5%		+113.5%		+98.3%		+32.0%		+16.6%	
FLASH CARDS	.3	.2%	2.2	1.0%	7.8	2.1%	15.8	3.3%	29.6	5.8%
MORE THAN 100 MEGABYTES	--		+633.3%		+254.5%		+102.6%		+87.3%	
Total Worldwide Revenue	141.8	100.0%	218.9	100.0%	360.2	100.0%	468.2	100.0%	510.4	100.0%
	+77.7%		+54.4%		+64.6%		+30.0%		+9.0%	

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

TABLE 12

CONSOLIDATED WORLDWIDE SHIPMENTS
FLASH CARDS
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1995 Shipments Units	1995 %	Forecast 1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %	1999 Units	1999 %
FLASH CARDS LESS THAN 10 MEGABYTES	650.9	75.9%	1,184.2	75.7%	2,515.2	76.1%	5,614.8	82.2%	9,051.9	84.4%
	+61.7%		+81.9%		+112.4%		+123.2%		+61.2%	
FLASH CARDS 10 - 25 MEGABYTES	186.6	21.7%	328.9	21.0%	665.8	20.1%	1,015.0	14.8%	1,391.7	13.0%
	+119.8%		+76.3%		+102.4%		+52.4%		+37.1%	
FLASH CARDS 25 - 100 MEGABYTES	21.5	2.4%	52.3	3.3%	128.0	3.8%	206.9	3.0%	285.1	2.6%
	+377.8%		+143.3%		+144.7%		+61.6%		+37.8%	
FLASH CARDS MORE THAN 100 MEGABYTES	.1	--	.6	--	2.3	--	5.2	--	10.8	--
	--		+500.0%		+283.3%		+126.1%		+107.7%	
Total Worldwide Shipments	859.1	100.0%	1,566.0	100.0%	3,311.3	100.0%	6,841.9	100.0%	10,739.5	100.0%
	+74.6%		+82.3%		+111.4%		+106.6%		+57.0%	
% U.S. Manufacturers	72.4%		74.6%		73.4%		64.5%		56.1%	

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

TABLE 13

FLASH CARDS, LESS THAN 10 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY CARD SIZE (PC CARD/SMALLER THAN PC CARD)

	1995 Shipments		Forecast 1996		Forecast 1997		Forecast 1998		Forecast 1999	
	PC Card	<PC Card	PC Card	<PC Card	PC Card	<PC Card	PC Card	<PC Card	PC Card	<PC Card
U.S. MANUFACTURERS										
PCM/Distributor	204.8	--	347.8	9.1	489.0	82.0	660.0	124.0	834.0	184.0
OEM/Integrator	233.8	.1	480.0	26.9	780.0	481.0	1,101.0	1,706.0	1,455.0	2,570.0
TOTAL U.S. SHIPMENTS	438.6	.1	827.8	36.0	1,269.0	563.0	1,761.0	1,830.0	2,289.0	2,754.0
NON-U.S. MANUFACTURERS										
PCM/Distributor	45.0	--	53.3	7.2	62.0	38.4	82.0	118.0	98.0	424.0
OEM/Integrator	167.2	--	217.7	87.0	280.6	417.0	350.9	1,751.0	420.1	3,613.0
TOTAL NON-U.S. SHIPMENTS	212.2	--	271.0	94.2	342.6	455.4	432.9	1,869.0	518.1	4,037.0
WORLDWIDE RECAP										
PCM/Distributor	249.8	--	401.1	16.3	551.0	120.4	742.0	242.0	932.0	608.0
	+97.6%	--	+60.6%	--	+37.4%	+638.7%	+34.7%	+101.0%	+25.6%	+151.2%
OEM/Integrator	401.0	.1	697.7	113.9	1,060.6	898.0	1,451.9	3,457.0	1,875.1	6,183.0
	+45.2%	--	+74.0%	--	+52.0%	+688.4%	+36.9%	+285.0%	+29.1%	+78.9%
Total Shipments	650.8	.1	1,098.8	130.2	1,611.6	1,018.4	2,193.9	3,699.0	2,807.1	6,791.0
	+61.7%	--	+68.8%	--	+46.7%	+682.2%	+36.1%	+263.2%	+28.0%	+83.6%
ANNUAL SHARE, BY TYPE	100.0%	--	89.5%	10.5%	61.4%	38.6%	37.2%	62.8%	29.2%	70.8%

Note: "<PC Card" means cards smaller than the PC Card form factor.
Examples include Compact Flash, Miniature Card, SSFDC.

TABLE 14

FLASH CARDS, LESS THAN 10 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

PRODUCT TYPE	1995	Forecast 1996	Forecast 1997	Forecast 1998	Forecast 1999
PCM/Distributor					
PC Card	34.64	25.23	17.39	12.13	7.35
Smaller than PC Card	--	--	39.30	19.03	7.98
PCM/Distributor Average	34.64	25.07	20.71	13.83	7.64
OEM/Integrator					
PC Card	31.99	22.07	16.00	11.07	6.72
Smaller than PC Card	--	16.53	14.13	7.93	5.24
OEM/Integrator Average	32.00	21.63	15.37	9.18	5.71

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

"Smaller than PC Card" means cards smaller than the PC Card form factor.

Examples include Compact Flash, Miniature Card, SSFDC.

TABLE 15

FLASH CARDS, 10 - 25 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY CARD SIZE (PC CARD/SMALLER THAN PC CARD)

	1995 Shipments		Forecast 1996		Forecast 1997		Forecast 1998		Forecast 1999	
	PC Card	<PC Card	PC Card	<PC Card	PC Card	<PC Card	PC Card	<PC Card	PC Card	<PC Card
U.S. MANUFACTURERS										
PCM/Distributor	51.6	--	86.8	1.5	145.0	37.5	229.0	71.5	328.0	107.5
OEM/Integrator	116.2	3.5	203.5	14.0	321.0	115.0	399.0	236.0	469.0	361.0
TOTAL U.S. SHIPMENTS	167.8	3.5	290.3	15.5	466.0	152.5	628.0	307.5	797.0	468.5
NON-U.S. MANUFACTURERS										
PCM/Distributor	2.4	--	3.1	--	15.9	2.0	26.3	3.0	42.5	7.0
OEM/Integrator	12.9	--	20.0	--	24.4	5.0	36.2	14.0	48.7	28.0
TOTAL NON-U.S. SHIPMENTS	15.3	--	23.1	--	40.3	7.0	62.5	17.0	91.2	35.0
WORLDWIDE RECAP										
PCM/Distributor	54.0	--	89.9	1.5	160.9	39.5	255.3	74.5	370.5	114.5
	+208.6%	--	+66.5%	--	+79.0%	--	+58.7%	+88.6%	+45.1%	+53.7%
OEM/Integrator	129.1	3.5	223.5	14.0	345.4	120.0	435.2	250.0	517.7	389.0
	+91.5%	--	+73.1%	+300.0%	+54.5%	+757.1%	+26.0%	+108.3%	+19.0%	+55.6%
Total Shipments	183.1	3.5	313.4	15.5	506.3	159.5	690.5	324.5	888.2	503.5
	+115.7%	--	+71.2%	+342.9%	+61.6%	+929.0%	+36.4%	+103.4%	+28.6%	+55.2%
ANNUAL SHARE, BY TYPE	98.2%	1.8%	95.4%	4.6%	76.1%	23.9%	68.1%	31.9%	63.9%	36.1%

Note: "PC Card" means cards smaller than the PC Card form factor.
Examples include Compact Flash, Miniature Card, SSFDC

TABLE 16

FLASH CARDS, 10 - 25 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

PRODUCT TYPE	1995	Forecast 1996	1997	1998	1999
PCM/Distributor					
PC Card	23.38	16.55	13.65	10.86	8.65
Smaller than PC Card	--	19.58	14.53	10.90	8.16
PCM/Distributor Average	23.38	16.59	13.79	10.86	8.55
OEM/Integrator					
PC Card	22.45	14.68	11.83	9.21	7.14
Smaller than PC Card	21.90	18.91	12.48	8.93	5.76
OEM/Integrator Average	22.44	14.88	11.97	9.12	6.63

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

"Smaller than PC Card" means cards smaller than the PC Card form factor.

Examples include Compact Flash, Miniature Card, SSFDC

TABLE 17

FLASH CARDS, 25 - 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY CARD SIZE (PC CARD/SMALLER THAN PC CARD)

	1995 Shipments PC Card	Forecast --1996-- PC Card	Forecast --1997-- PC Card	Forecast --1998-- PC Card	Forecast --1999-- PC Card
U.S. MANUFACTURERS					
PCM/Distributor	3.0	7.2	12.0	19.0	26.0
OEM/Integrator	9.5	25.1	58.0	88.0	128.0
TOTAL U.S. SHIPMENTS	12.5	32.3	70.0	107.0	154.0
NON-U.S. MANUFACTURERS					
PCM/Distributor	--	--	5.0	16.9	29.1
OEM/Integrator	9.0	20.0	53.0	83.0	102.0
TOTAL NON-U.S. SHIPMENTS	9.0	20.0	58.0	99.9	131.1
WORLDWIDE RECAP					
PCM/Distributor	3.0	7.2	17.0	35.9	55.1
	+275.0%	+140.0%	+136.1%	+111.2%	+53.5%
OEM/Integrator	18.5	45.1	111.0	171.0	230.0
	+400.0%	+143.8%	+146.1%	+54.1%	+34.5%
Total Shipments	21.5	52.3	128.0	206.9	285.1
	+377.8%	+143.3%	+144.7%	+61.6%	+37.8%
ANNUAL SHARE, BY TYPE	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 18

FLASH CARDS, 25 - 100 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

PRODUCT TYPE	1995	Forecast 1996	1997	1998	1999
PCM/Distributor					
PC Card	20.22	15.32	13.87	11.80	9.97
Smaller than PC Card	--	--	--	--	--
PCM/Distributor Average	20.22	15.32	13.87	11.80	9.97
OEM/Integrator					
PC Card	21.10	17.43	14.68	11.71	9.50
Smaller than PC Card	--	--	--	--	--
OEM/Integrator Average	21.10	17.43	14.68	11.71	9.50

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 19

FLASH CARDS, MORE THAN 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY CARD SIZE (PC CARD/SMALLER THAN PC CARD)

	1995 Shipments PC Card	Forecast --1996-- PC Card	--1997-- PC Card	--1998-- PC Card	--1999-- PC Card
U.S. MANUFACTURERS					
PCM/Distributor	--	--	.2	.7	1.4
OEM/Integrator	.1	.6	2.1	4.5	9.4
TOTAL U.S. SHIPMENTS	.1	.6	2.3	5.2	10.8
WORLDWIDE RECAP					
PCM/Distributor	--	--	.2	.7	1.4
	--	--	--	+250.0%	+100.0%
OEM/Integrator	.1	.6	2.1	4.5	9.4
	--	+500.0%	+250.0%	+114.3%	+108.9%
Total Shipments	.1	.6	2.3	5.2	10.8
	--	+500.0%	+283.3%	+126.1%	+107.7%
ANNUAL SHARE, BY TYPE	100.0%	100.0%	100.0%	100.0%	100.0%

TABLE 20

FLASH CARDS, MORE THAN 100 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

PRODUCT TYPE	1995	Forecast 1996	1997	1998	1999
PCM/Distributor					
PC Card	--	--	31.62	27.73	24.79
Smaller than PC Card	--	--	--	--	--
PCM/Distributor Average	--	--	31.62	27.73	24.79
OEM/Integrator					
PC Card	29.09	30.43	28.33	24.00	20.76
Smaller than PC Card	--	--	--	--	--
OEM/Integrator Average	29.09	30.43	28.33	24.00	20.76

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 21

FLASH CARDS

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Flash Cards

	1995 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Card Manufacturers	F. Disk	F. Mem.	Total		F. Disk	F. Mem.	Total	
Intel	3.3	192.0	195.3	38.8	4.5	241.0	245.5	28.6
SanDisk	59.3	--	59.3	11.8	182.8	--	182.8	21.3
AMD	1.7	42.0	43.7	8.7	2.5	71.3	73.8	8.6
Fujitsu	--	10.4	10.4	2.1	--	51.4	51.4	6.0
Other U.S.	7.9	90.3	98.2	19.5	17.2	105.0	122.2	14.2
Other Non-U.S.	2.0	94.7	96.7	19.1	4.4	179.0	183.4	21.3
TOTAL	74.2	429.4	503.6	100.0	211.4	647.7	859.1	100.0

Note: "F. Disk" means Flash Disk: "F. Mem" means linear flash memory

PC CARD RIGID DISK DRIVES

PC CARD RIGID DISK DRIVES

Coverage

Examples of disk drives in this group include:

PC Card rigid disk drives, less than 300 megabytes

Calluna Technology	CT-130, CT-170, CT-260
Integral Peripherals	8105PA, 8170PA, PocketFile 260
Momentum Peripherals	130, 170

PCMCIA rigid disk drives, 300 - 500 megabytes

Calluna Technology	CT-390
Integral Peripherals	8340PA

PCMCIA rigid disk drives, 500 megabytes - 1 gigabyte

Calluna Technology	CT-520
Integral Peripherals	8510PA

The 1.8" rigid disk drives included in this section are packaged in removable card form, and all of the drives currently listed conform to the PCMCIA Type III PC Card specification, which defines allowable card dimensions and connectors. The few 1.8" disk drives which do not meet PCMCIA Type III specifications, usually because the PC Card height limitation of 10.5 millimeters is exceeded, or because they are not offered in removable card form, are included in the separate 1996 DISK/TREND Report on rigid disk drives.

The first 1.8" disk drive was shipped by Integral Peripherals in mid-1991, a 21 megabyte drive which was not designed to meet the PCMCIA standard for removable Type III cards. The earliest shipments of PCMCIA Type III rigid disk drives were made in late 1992 by Integral Peripherals. The effective start for volume production of Type III drives was in the second half of 1993 for most manufacturers, including those no longer active. Most of the drives produced to date have been used in Japanese word processors, factory data collection, dedicated application pen-based computers and other specialized applications.

The expected growth in PC Card drive shipments for "personal digital assistants" and notebook computers has proven to be of minor importance so far to the growth of this product group, with the result that several of the drive manufacturers participating in the 1.8" disk drive market during the last few years have dropped out of the contest. MiniStor Peripherals, which had bet heavily on development of a distribution market for 1.8" drives, went out of business, and the firm's Singapore production equipment was purchased through bankruptcy proceedings by Momentum Peripherals, becoming the nucleus of the new company's manufacturing line for 1.8" PC Card drives.

The above drives have been divided into groups, depending on each drive's capacity. The statistical data on drive shipments and sales revenues has also been arranged by the same groups, which correspond to the product groups used in the DISK/TREND Report on rigid disk drives. All drives have been assigned to groups by "native" formatted capacity.

Market status

Worldwide shipments of PC Card rigid disk drives in 1995 were 340,000 units, a modest increase above last year's DISK/TREND forecast for 1995. However, the 1996 unit shipment total is projected at 369,000, an increase of only 8.5%, with total sales revenues estimated at $89.9 million. The limited size of 1996's increase is attributed to reduced utilization of PC Card drives by Hewlett-Packard and IBM for notebook computers and continued delays in development of targeted potential new applications.

The level of sales success achieved by the manufacturers of drives in this product group is significantly below most of the forecasts made in previous years. The largest problem has been that the expected market with subnotebook computers has been much smaller than expected, due to the slow rate of progress computer manufacturers have experienced in reducing the size and weight of notebook computers, combined with the fact that PC Card drives have tended to offer capacities which have not kept up with the levels demanded for new notebook computers. 2.5" drives are used with substantially all of the notebook computers made today, chosen by system manufacturers because 2.5" drive capacities available are higher, and prices are lower, than the capacities and prices available with 1.8" PC Card drives. There is also a less aggressive pattern of reduction in size and weight for notebook computers than was previously expected, minimizing one of the key potential reasons for system manufacturers to move to PC Card disk drives. The drive manufacturers also found a disappointingly small demand for PC Card drives for use with PDA's and portable cellular phone communicators, since the market for both types of devices turned out to be negligible compared to the industry's expectations.

As with all types of rigid disk drives, there has been a race under way by drive manufacturers in the 1990's to increase drive capacities as rapidly as possible. As long as the possibility of substantial markets for 1.8" drives with notebook computers seemed imminent, manufacturers of PC Card drives moved capacities upward as rapidly as possible, reaching 340 megabytes native drive capacity by the end of 1994. Capacities in excess of 500 megabytes were announced in the last year, but there now appears to be less pressure to establish actual production for these drives. The notebook computer market has moved quickly to drive capacities beyond the possible range for 1.8" drives in the near future and the manufacturers of PC Card disk drives are expected to concentrate their product development efforts on products for more immediate market opportunities. The typical capacities of PC Card drives are increasing fast, but drives with capacities below 300 megabytes are expected to provide 63.5% of 1996's unit shipments.

With the departure of Maxtor from the 1.8" disk drive market in 1995, Integral Peripherals resumed its lead in unit shipments, with 78.2% of the worldwide total. MiniStor, which ceased operations in the first half of 1995, earned second place for the year, with 8.8%.

Marketing trends

The continued lack of vigor in the PC Card rigid disk drive market has made necessary another reduction of the DISK/TREND sales forecasts for the product group. Nevertheless, the potential additional applications for these drives still exist and continued growth is expected, even though the timetable incorporates many uncertainties. 1999 worldwide unit shipments are forecasted at 1.1 million drives, representing average annual growth of 45.8% in the 1997-99 period. Total sales revenues are expected to reach $266.9 million in 1999. The forecasting uncertainties involve emerging applications for PC Card drives in such diverse fields as automotive mapping systems, digital cameras and telecommunication equipment. Although it is likely that PC Card disk drives will share the data storage market in each of these fields with other storage technologies, each is potentially large enough to provide a major boost to the current forecasts.

PC Cards with capacities in the 300-500 megabyte range are expected to be leaders in shipment volume by 1997. Drives with capacities over 500 megabytes are getting off to a slow start in 1996, but the disk drive industry's inevitable movement to higher areal densities will also make it possible for PC Card drive manufacturers to obtain the more advanced components required to reduce the cost of higher capacity drive models. By 1999, shipments of PC Card drives are expected to be led by drives in the 500 megabyte to 1 gigabyte range, and by that year PC Card drives with capacities over 1 gigabyte are expected to be in production.

It is not clear whether disk drive manufacturers will again initiate efforts to produce a Type II PC Card, with a thickness of only 5 millimeters. Despite the modest size of the current notebook computer market for PC Card drives, there is an inevitable trend toward smaller and lighter weight notebook computers, as progress in screen and battery technology makes it possible. The first announcement of a Type II disk drive was by Maxtor, but the drive was never delivered. Type II cards are expected to utilize only a single 1.8" disk because of size constraints, and the capacity available will be severely limited. However, the disk drive industry's areal densities are increasing very rapidly, and within a few years, it will be possible to produce Type II PC Card drives with capacities of several hundred megabytes. Current DISK/TREND forecasts do not differentiate between drives in the two card thicknesses, but it is clear that availability of Type II drives could keep overall drive shipments in the lower capacity groups at a higher level than otherwise would be expected, due to a wider market and lower prices than available for Type III drives.

Higher shipments, wider competition and increasing drive capacities will force a continuing decline in average price per megabyte. The overall average OEM/Integrator price/megabyte has already declined sharply with the increasing sales volume, but more is easily predictable as shipments increase and capacities go up. By 1999, the best OEM price/megabyte for PC Card drives is forecasted at 30 cents.

Technical trends

During the rest of this decade it is expected that the rigid disk drive industry will continue to increase areal density by about 60% per year. Critical to this rate of increase is the ability to create smoother disks, recording heads which can utilize narrower tracks, more magnetic flux reversals per linear inch, and development of semiconductors which can process much faster data transfer rates. Although major improvements must be made every year, it appears very likely that the annual 60% improvement will be achieved during the 1995-98 time frame covered by this report. By 1999, leading edge rigid disk drives will be recording data at more than 6 gigabits per square inch, and the drives manufactured at very high production levels, such as the typical 1999 PC Card disk drives in this group, will utilize areal densities above 2.5 gigabits per square inch. Recording densities at that level should make possible the economical production of two disk PC Card drives with capacities of at least 2 gigabytes.

Disk drive manufacturers will face many interesting problems if they choose to establish production of 5 millimeter high PC Card Type II drives, which will typically use one disk and two heads. The mechanical engineering challenges are obviously formidable. However, the biggest short-term problem would probably be to establish volume production for critical new components such as drive and head positioning motors, head assemblies and the special packaging required for semiconductors. None of the engineering problems are impossible and many were already solved by drive manufacturers doing preliminary work on Type II drives. However, establishing high volume manufacturing capability Type II drives would require major new expenses for drive manufacturers and component suppliers, and will not be undertaken unless significant new market opportunities appear imminent.

Forecasting assumptions

1. Shipments of PC Card rigid disk drives with native capacities of more than 500 megabytes will start in 1996, and more than 1 gigabyte in 1999.
2. If shipments of rigid disk drives meeting the PC Card Type II standard, using cards 5 millimeters high, start during the 1997-99 period, the overall shipments of PC Card drives will not be significantly affected.
3. Existing forecasts assume continued growth of current applications, with modest utilization of PC Card drives in new applications.

TABLE 22

CONSOLIDATED WORLDWIDE REVENUES

PC CARD 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										
PCM/Distributor	8.1	10.2	13.3	17.2	13.3	19.9	13.4	19.3	17.3	26.9
OEM/Integrator	39.4	69.3	31.6	58.0	61.4	107.4	89.5	146.1	118.6	186.2
TOTAL U.S. NONCAPTIVE	47.5	79.5	44.9	75.2	74.7	127.3	102.9	165.4	135.9	213.1
TOTAL U.S. REVENUES	47.5	79.5	44.9	75.2	74.7	127.3	102.9	165.4	135.9	213.1
Non-U.S. Manufacturers										
PCM/Distributor	--	3.0	.4	5.2	.7	7.6	2.4	10.1	6.6	17.2
OEM/Integrator	--	.8	1.1	9.5	3.7	15.4	9.3	25.1	13.4	36.6
TOTAL NON-U.S. REVENUES	--	3.8	1.5	14.7	4.4	23.0	11.7	35.2	20.0	53.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	47.5	83.3	46.4	89.9	79.1	150.3	114.6	200.6	155.9	266.9

TABLE 23

CONSOLIDATED WORLDWIDE SHIPMENTS

PC CARD DISK DRIVES

SHIPMENT SUMMARY

	DISK DRIVE SHIPMENTS, BY									
	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/Reseller	32.0	42.0	50.0	65.0	53.0	80.0	55.0	80.0	68.0	105.0
OEM/Integrator	159.0	283.0	130.0	240.0	260.0	455.0	390.0	640.0	505.0	800.0
TOTAL U.S. SHIPMENTS	191.0	325.0	180.0	305.0	313.0	535.0	445.0	720.0	573.0	905.0
Non-U.S. Manufacturers										
PCM/Reseller	--	12.0	2.0	24.0	3.0	30.0	9.0	40.0	25.0	68.0
OEM/Integrator	--	3.0	5.0	40.0	15.0	65.0	38.0	105.0	52.0	147.0
TOTAL NON-U.S. SHIPMENTS	--	15.0	7.0	64.0	18.0	95.0	47.0	145.0	77.0	215.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	191.0	340.0	187.0	369.0	331.0	630.0	492.0	865.0	650.0	1,120.0

TABLE 24

CONSOLIDATED WORLDWIDE REVENUES
PC CARD DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1995 Revenues $M	1995 %	Forecast 1996 $M	1996 %	1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %
PC CARD DISK DRIVES less than 300 Megabytes	75.3 +108.6%	90.5%	51.6 -31.5%	57.5%	40.0 -22.5%	26.6%	21.0 -47.5%	10.5%	12.9 -38.6%	4.8%
PC CARD DISK DRIVES 300 - 500 Megabytes	8.0 --	9.5%	36.5 +356.3%	40.6%	90.3 +147.4%	60.2%	120.3 +33.2%	60.0%	92.9 -22.8%	34.8%
PC CARD DISK DRIVES 500 Megabytes - 1 GB	-- --	--	1.8 --	1.9%	20.0 --	13.2%	59.3 +196.5%	29.5%	120.9 +103.9%	45.3%
PC CARD DISK DRIVES 1 - 2 Gigabytes	-- --	--	-- --	--	-- --	--	-- --	--	40.2 --	15.1%
Total Worldwide Revenue	83.3 +130.7%	100.0%	89.9 +7.9%	100.0%	150.3 +67.2%	100.0%	200.6 +33.5%	100.0%	266.9 +33.1%	100.0%

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

TABLE 25

CONSOLIDATED WORLDWIDE SHIPMENTS
PC CARD DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1995 Shipments		Forecast 1996		Forecast 1997		Forecast 1998		Forecast 1999	
	Units	%	Units	%	Units	%	Units	%	Units	%
PC CARD DISK DRIVES less than 300 Megabytes	314.0 +97.4%	92.5%	234.0 -25.5%	63.5%	195.0 -16.7%	31.0%	110.0 -43.6%	12.7%	70.0 -36.4%	6.3%
PC CARD DISK DRIVES 300 - 500 Megabytes	26.0 --	7.5%	130.0 +400.0%	35.2%	370.0 +184.6%	58.8%	540.0 +45.9%	62.5%	450.0 -16.7%	40.2%
PC CARD DISK DRIVES 500 Megabytes - 1 GB	-- --	--	5.0 --	1.3%	65.0 --	10.2%	215.0 +230.8%	24.8%	480.0 +123.3%	42.9%
PC CARD DISK DRIVES 1 - 2 Gigabytes	-- --	--	-- --	--	-- --	--	-- --	--	120.0 --	10.6%
Total Worldwide Shipments	340.0 +113.7%	100.0%	369.0 +8.5%	100.0%	630.0 +70.7%	100.0%	865.0 +37.3%	100.0%	1,120.0 +29.5%	100.0%
% U.S. Manufacturers	95.5%		82.6%		84.9%		83.2%		80.8%	
Total Capacity (Terabytes)	66.9		105.4		209.9		383.2		742.7	

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

TABLE 26

PC CARD DISK DRIVES, LESS THAN 300 MEGABYTES

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										
PCM/Distributor	29.0	39.0	30.0	40.0	20.0	35.0	10.0	20.0	8.0	15.0
OEM/Integrator	136.0	260.0	70.0	135.0	55.0	105.0	30.0	55.0	15.0	25.0
TOTAL U.S. SHIPMENTS	165.0	299.0	100.0	175.0	75.0	140.0	40.0	75.0	23.0	40.0
Non-U.S. Manufacturers										
PCM/Distributor	--	12.0	2.0	24.0	3.0	20.0	2.0	15.0	2.0	15.0
OEM/Integrator	--	3.0	5.0	35.0	5.0	35.0	3.0	20.0	2.0	15.0
TOTAL NON-U.S. SHIPMENTS	--	15.0	7.0	59.0	8.0	55.0	5.0	35.0	4.0	30.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	165.0	314.0	107.0	234.0	83.0	195.0	45.0	110.0	27.0	70.0
Total Capacity (Terabytes)	30.6	58.1	27.6	58.6	21.5	50.7	11.7	28.6	7.0	18.2
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	318.1	567.4	425.1	801.4	508.1	996.4	553.1	1,106.4	580.1	1,176.4

TABLE 27

PC CARD DISK DRIVES, 300 - 500 MEGABYTES

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										
PCM/Distributor	3.0	3.0	20.0	25.0	30.0	40.0	35.0	45.0	30.0	40.0
OEM/Integrator	23.0	23.0	60.0	105.0	185.0	310.0	265.0	440.0	220.0	365.0
TOTAL U.S. SHIPMENTS	26.0	26.0	80.0	130.0	215.0	350.0	300.0	485.0	250.0	405.0
Non-U.S. Manufacturers										
PCM/Distributor	--	--	--	--	--	5.0	2.0	10.0	3.0	8.0
OEM/Integrator	--	--	--	--	5.0	15.0	20.0	45.0	15.0	37.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	5.0	20.0	22.0	55.0	18.0	45.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	26.0	26.0	80.0	130.0	220.0	370.0	322.0	540.0	268.0	450.0
Total Capacity (Terabytes)	8.8	8.8	27.2	44.2	74.8	125.8	119.1	199.8	109.8	184.5
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	26.0	26.0	106.0	156.0	326.0	526.0	648.0	1,066.0	916.0	1,516.0

TABLE 28

PC CARD DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

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										
PCM/Distributor	--	--	--	--	3.0	5.0	10.0	15.0	20.0	35.0
OEM/Integrator	--	--	--	--	20.0	40.0	95.0	145.0	210.0	325.0
TOTAL U.S. SHIPMENTS	--	--	--	--	23.0	45.0	105.0	160.0	230.0	360.0
Non-U.S. Manufacturers										
PCM/Distributor	--	--	--	--	--	5.0	5.0	15.0	20.0	45.0
OEM/Integrator	--	--	--	5.0	5.0	15.0	15.0	40.0	25.0	75.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	5.0	5.0	20.0	20.0	55.0	45.0	120.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	--	--	--	5.0	28.0	65.0	125.0	215.0	275.0	480.0
Total Capacity (Terabytes)	--	--	--	2.6	14.4	33.4	90.0	154.8	233.7	408.0
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	--	--	--	5.0	28.0	70.0	153.0	285.0	428.0	765.0

TABLE 29

PC CARD DISK DRIVES, 1 - 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										
PCM/Distributor	--	--	--	--	--	--	--	--	10.0	15.0
OEM/Integrator	--	--	--	--	--	--	--	--	60.0	85.0
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	70.0	100.0
Non-U.S. Manufacturers										
PCM/Distributor	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	--	--	--	--	--	--	--	10.0	20.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	--	--	--	--	10.0	20.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	--	--	--	--	--	--	--	--	80.0	120.0
Total Capacity (Terabytes)	--	--	--	--	--	--	--	--	88.0	132.0
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	--	--	--	--	--	--	--	--	80.0	120.0

TABLE 30

PC CARD RIGID DISK DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK CAPACITY	1995	Forecast 1996	1997	1998	1999
Captive					
300 Megabytes or less	--	--	--	--	--
300 - 500 Megabytes	--	--	--	--	--
500 Megabytes - 1 Gigabyte	--	--	--	--	--
1 - 2 Gigabytes	--	--	--	--	--
PCM/Distributor					
300 Megabytes or less	1.52	1.03	.85	.78	.75
300 - 500 Megabytes	.99	.89	.77	.65	.55
500 Megabytes - 1 Gigabyte	--	--	.61	.41	.32
1 - 2 Gigabytes	--	--	--	--	.31
OEM/Integrator					
300 Megabytes or less	1.25	.83	.76	.70	.66
300 - 500 Megabytes	.89	.80	.71	.59	.49
500 Megabytes - 1 Gigabyte	--	.67	.59	.37	.29
1 - 2 Gigabytes	--	--	--	--	.30

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 31

PC CARD 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	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS				
Business and professional, single user	322.4	94.4	924.0	82.5
WORKSTATIONS				
Engineering and office, single user	7.2	2.3	13.4	1.2
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	10.4	3.1	182.6	16.3
Total	340.0	100.0	1120.0	100.0

TABLE 32

PC CARD RIGID 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	1.8"	Total		1.8"	Total	
Integral Peripherals	158.0	158.0	82.7	266.0	266.0	78.2
Ministor	15.0	15.0	7.9	30.0	30.0	8.8
Other U.S.	18.0	18.0	9.4	29.0	29.0	8.5
Other Non-U.S.	--	--	--	15.0	15.0	4.4
TOTAL	191.0	191.0	100.0	340.0	340.0	100.0

RIGID DISK CARTRIDGE DRIVES

1996 DISK/TREND REPORT

RIGID DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

SyQuest Technology	SQ5200C

3.5" disk diameter

Iomega	Jaz
Nomai	MCD-I
SyQuest Technology	EZ135, SQ3270, EZFlyer, SyJET

2.5" disk diameter

Avatar Systems	AR-2170

All types of drives using removable media in the form of rigid disk cartridges have been included in this section, which includes data from the rigid disk cartridge drive product group in the 1996 DISK/TREND Report on rigid disk drives. Until 1995, 5.25" drives provided the majority of shipments in the disk cartridge drive product group. However, SyQuest's 3.5" drives have been available since 1992, with capacities up to 270 megabytes in drives currently in production, and total shipments of 3.5" drives passed up the 5.25" form factor in 1995.

In response to the Iomega initial market success with the Zip 100 megabyte high capacity 3.5" floppy drive, SyQuest introduced in 1995 the "EZ" single head 3.5" rigid disk cartridge drive designed for very low cost, with shipments under way since July, 1995. A 230 megabyte version, the EZFlyer, is planned for mid-1996. Iomega introduced the Jaz 3.5" rigid disk cartridge drive, with first deliveries starting in December, 1995, offering 1 gigabyte capacity using a two disk cartridge. In response, SyQuest has announced the SyJET, a 3.5" drive with a capacity of 1.3 megabytes using a two disk cartridge, with delivery now expected in the third quarter of 1996.

Avatar Systems' 2.5" disk cartridge drives, including models combining removable disk drives with floppy drives, have been available in limited production quantities since 1993, with volume production now under way at the company's new Thailand plant. SyQuest also initiated a 2.5" disk cartridge drive program, with initial shipments in 1993, but has since discontinued the product. In addition, SyQuest placed considerable emphasis on development of an 80 megabyte drive in a PCMCIA Type III PC Card format, using 1.8" disks in a cartridge which could be removed from the removable drive. However, the 1.8" project was dropped in early 1996.

Market status

Total shipments of disk cartridge drives increased 29.4% in 1995, reaching 606,300 units worldwide. Even stronger growth is under way in 1996, with shipments of 1.8 million drives forecasted for the year. 1995 sales revenues totaled $154.8 million, and 1996 is estimated at $448.4 million. The current shipment growth in this product group is entirely derived from 3.5" and 2.5" disk drives, with 5.25" drives expected to provide only 3.6% of 1996 total shipments.

Rigid disk cartridge drives do not exist in an isolated market. They share the market for removable media disk drives with high capacity flexible disk drives and optical disk drives, and frequently compete for the same applications. For years the most aggressive competition for SyQuest's rigid disk cartridge drives was provided by the Iomega 5.25" high capacity Bernoulli floppy disk drive. Iomega's Bernoulli drives also increased in capacity over the years, up to 230 megabytes, with the result that SyQuest and Iomega have competed directly in both the Macintosh and IBM personal computer markets for the same graphics and desktop publishing applications. SyQuest's disk cartridge drives led in these markets, due to a successful strategy of concentrating on the Macintosh market, the leader in desktop publishing. SyQuest's EZ drive series, with 135 and 230 megabytes, is intended for the same markets as Iomega's successful Zip high capacity floppy drive, currently at 100 megabytes with a 200 megabyte version next. This contest illustrates the difficulty in competing against a high capacity floppy drive optimized for low production cost with a rigid disk equivalent, considering Iomega's significantly higher sales totals and SyQuest's major financial losses since mid-1995.

There is also a vigorous contest between 3.5" rigid disk cartridge drives and 3.5" magneto-optic drives, but the 3.5" rigid disk cartridge drives appear to be holding their own in this contest. Both types of drives are experiencing excellent growth in shipments, but rigid disk cartridge drives remain at higher shipment levels, due to lower prices and continuing increases in the disk capacities available. 3.5" MO drives, however, have made progress in displacing 5.25" rigid disk cartridge drives in some professional and business applications, with increasing capacities and more competitive prices.

Although SyQuest's initial growth in disk cartridge drive shipments was built on the company's original 3.9" drives, the 44 megabyte 5.25" model introduced in 1987 became the dominant "prepress" interchange standard, for graphics, typography and other original material used in printing, as projects move from designers, art departments and advertising agencies to typographers and printers. But despite upgrading from 44 megabytes to 88 megabytes in 1991, and 200 megabytes in 1994, the overall market growth for 5.25" disk cartridge drives slowed down, as customers' appetites for even higher capacities became stronger. 5.25" drive shipments started declining in 1995 and in 1996 are projected at only 65,000 drives.

The first 2.5" disk cartridge drive shipments began in 1993. SyQuest's previously announced 2.5" drive was dropped, but Avatar Systems introduced a 2.5" rigid disk cartridge drive, with capacity now up to 170 megabytes, intended for a variety of personal computer and specialized system applications. In the meantime, SyQuest's 1.8" drive in the PCMCIA Type III form factor was one of the most unusual disk drive designs to date. It used a disk cartridge which could be removed from the drive, which, like all drives in a PCMCIA card format, is removable from the host system. SyQuest had hoped that the 1.8" low media cost would be instrumental in applications requiring multiple media units, and make it possible for SyQuest to gradually migrate the "prepress" disk cartridge interchange market from its 5.25" and 3.5" drives to its 1.8" drives, as continuing improvements in the areal density of rigid disk drives made it possible to increase drive capacity. The program was discontinued by SyQuest in early 1996, in light of the modest growth experienced by the industry for 1.8" drives and shifting company priorities.

SyQuest Technology captured 99.3% of the worldwide unit shipments of rigid disk cartridge drives in 1995, with 602,000 drives, with 3.5" drives leading for the first time. In 1995, all disk cartridge drives were shipped in noncaptive market channels, primarily in the PCM/Distributor channel.

Marketing trends

The advent of new applications, new competitors and new products is expected to make major changes in shipment levels for this product group. New growth is projected for both the 100-200 megabyte capacity range and the higher capacity range over 500 megabytes. Very competitive drives in the lower capacity range are destined to high production levels, if SyQuest can resolve the difficult financial problems the company faces in 1996. There is no uncertainty regarding the sales outlook for the higher capacity drives, with models currently announced with up to 1.3 gigabytes capacity. Worldwide shipments for the product group are projected to reach 6.3 million drives in 1999, with sales revenues rising to $1.4 billion.

Due to SyQuest's current difficulty in producing disk drives at a profit, the major vulnerability in the DISK/TREND forecast for 3.5" drives during the next few years is to be found in the drives in the 100-300 megabyte range. The current forecast assumes that SyQuest will be able to establish manufacturing costs low enough to successfully compete in this market, through transition to lower cost product designs. If not, the forecasted totals will probably be lower. There is little doubt that the higher capacity drives in this product group will in fact be available and will achieve rapidly increasing sales. In addition to SyQuest, 3.5" drives from Iomega and Nomai are now in production, with both companies utilizing contract manufacturing sources with proven production capability. Demands for increasing disk cartridge capacity in applications such as graphics and prepress, plus video and multimedia editing, will combine with emerging personal computer markets to create a rapidly increasing market for high-end disk cartridge drives.

The PCM/Distributor sales channel is expected to continue to dominate rigid disk cartridge drive shipments. In recent years, the specialized nature of most applications for disk cartridge drives has meant that the aftermarket has provided most of the sales opportunity. With 3.5" drives, add-on sales are expected to continue to provide most of the shipments to specialized users and to individual personal computer users. However, the majority of 2.5" drives will probably be sold to system manufacturers, the first time in many years that disk cartridge drives have had a major opportunity to achieve significant OEM sales, and some of the planned new high capacity rigid disk cartridge drives may have a similar opportunity to develop specialized OEM markets.

Technical trends

The basic recording technologies now in use for products in this group will continue to predominate for years. The smaller drives in quantity production embody the mechanical design lessons accumulated during years of production of larger removable disk drives, and will be able to exploit the rapid advances in recording technology from other segments of the disk drive industry. The 3.5" and 2.5" disk cartridge drives now available may be expected to increase continually in capacity during the coming years, following closely the rapid improvements in areal density expected with fixed disk drives.

Iomega's Jaz drive provides an illustration of the benefits which accrue to this product group from the much higher production levels now achieved with fixed disk drives manufactured for the desktop personal computer market. The current Jaz drive uses two 540 megabyte disks in each cartridge -- the same type of disks which were manufactured for the highest volume drives produced in the last year. As recording capacities increase at the expected 60% per year, disks, heads and semiconductors manufactured for the industry's highest volume fixed disk drives will become available to the manufacturers of disk cartridge drives at low costs. With these components available, it is to be expected that capacities available in 3.5" disk cartridge drives will track the same upward trend, probably following fixed disk drives by about a year.

Forecasting assumptions

1. Significant shipment increases of 3.5" and 2.5" disk cartridge drives will continue, with further increases in drive capacity available, with successful sales to both system manufacturers and the aftermarket.
2. Production for 5.25" disk cartridge drives will decline after an increase in 1997 stimulated by availability of increased disk capacity.

TABLE 33

RIGID DISK CARTRIDGE 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										
PCM/Distributor	98.1	150.1	232.9	318.0	480.8	686.1	634.8	905.1	723.5	1,030.8
OEM/Integrator	2.2	3.5	26.8	77.9	74.4	140.4	110.5	201.6	139.0	246.4
TOTAL U.S. REVENUES	100.3	153.6	259.7	395.9	555.2	826.5	745.3	1,106.7	862.5	1,277.2
Non-U.S. Manufacturers										
PCM/Distributor	--	1.2	21.0	52.5	20.9	70.8	36.8	102.9	44.7	127.4
OEM/Integrator	--	--	--	--	--	6.3	1.4	11.3	3.8	16.4
TOTAL NON-U.S. REVENUES	--	1.2	21.0	52.5	20.9	77.1	38.2	114.2	48.5	143.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	100.3	154.8	280.7	448.4	576.1	903.6	783.5	1,220.9	911.0	1,421.0
OEM Average Price ($000)		.291		.230		.232		.219		.202

TABLE 34

RIGID DISK CARTRIDGE 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										
PCM/Distributor	387.2	592.3	975.0	1,355.0	1,760.0	2,510.0	2,540.0	3,620.0	3,195.0	4,550.0
OEM/Integrator	7.5	12.0	115.0	338.0	310.0	610.0	490.0	930.0	675.0	1,235.0
TOTAL U.S. SHIPMENTS	394.7	604.3	1,090.0	1,693.0	2,070.0	3,120.0	3,030.0	4,550.0	3,870.0	5,785.0
Non-U.S. Manufacturers										
PCM/Distributor	--	2.0	50.0	125.0	65.0	220.0	125.0	350.0	165.0	470.0
OEM/Integrator	--	--	--	--	--	20.0	5.0	40.0	15.0	65.0
TOTAL NON-U.S. SHIPMENTS	--	2.0	50.0	125.0	65.0	240.0	130.0	390.0	180.0	535.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	394.7	606.3	1,140.0	1,818.0	2,135.0	3,360.0	3,160.0	4,940.0	4,050.0	6,320.0
Total Capacity (Terabytes)	67.8	104.8	719.8	1,002.0	1,535.3	2,303.8	3,438.7	5,134.5	5,996.7	9,035.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	2.5	4.1	3.7	5.9	5.8	9.3	9.0	14.2	13.0	20.5

TABLE 35

RIGID DISK CARTRIDGE DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues			Forecast 1996			1997			1998			1999		
	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"
U.S. MANUFACTURERS															
PCM/Distributor	70.0	80.1	--	16.3	301.7	--	39.4	641.3	5.4	34.6	859.5	11.0	13.7	1,001.2	15.9
OEM/Integrator	--	2.8	.7	--	12.3	65.6	8.8	39.8	91.8	12.0	74.1	115.5	5.7	112.2	128.5
TOTAL U.S. REVENUES	70.0	82.9	.7	16.3	314.0	65.6	48.2	681.1	97.2	46.6	933.6	126.5	19.4	1,113.4	144.4
NON-U.S. MANUFACTURERS															
PCM/Distributor	--	1.2	--	--	52.5	--	--	70.8	--	--	102.9	--	--	127.4	--
OEM/Integrator	--	--	--	--	--	--	--	6.3	--	--	11.3	--	--	16.4	--
TOTAL NON-U.S. REVENUES	--	1.2	--	--	52.5	--	--	77.1	--	--	114.2	--	--	143.8	--
WORLDWIDE RECAP															
PCM/Distributor	70.0	81.3	--	16.3	354.2	--	39.4	712.1	5.4	34.6	962.4	11.0	13.7	1,128.6	15.9
	+14.9%	+66.6%	--	-76.7%	+335.7%	--	+141.7%	+101.0%	--	-12.2%	+35.1%	+103.7%	-60.4%	+17.3%	+44.5%
OEM/Integrator	--	2.8	.7	--	12.3	65.6	8.8	46.1	91.8	12.0	85.4	115.5	5.7	128.6	128.5
	--	+100.0%	+133.3%	--	+339.3%	--	--	+274.8%	+39.9%	+36.4%	+85.2%	+25.8%	-52.5%	+50.6%	+11.3%
Total Revenues	70.0	84.1	.7	16.3	366.5	65.6	48.2	758.2	97.2	46.6	1,047.8	126.5	19.4	1,257.2	144.4
	+14.0%	+67.5%	+133.3%	-76.7%	+335.8%	--	+195.7%	+106.9%	+48.2%	-3.3%	+38.2%	+30.1%	-58.4%	+20.0%	+14.2%
ANNUAL SHARE, BY DIAMETER	45.3%	54.3%	.4%	3.6%	81.8%	14.6%	5.3%	84.0%	10.7%	3.8%	85.9%	10.3%	1.4%	88.6%	10.0%

Note: "<=" indicates "less than or equal to".

TABLE 36

RIGID DISK CARTRIDGE DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments			Forecast 1996			1997			1998			1999		
	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"
U.S. MANUFACTURERS															
PCM/Distributor	264.0	328.3	--	65.0	1,290.0	--	110.0	2,375.0	25.0	85.0	3,480.0	55.0	35.0	4,430.0	85.0
OEM/Integrator	--	10.0	2.0	--	53.0	285.0	25.0	150.0	435.0	30.0	305.0	595.0	15.0	510.0	710.0
TOTAL U.S. SHIPMENTS	264.0	338.3	2.0	65.0	1,343.0	285.0	135.0	2,525.0	460.0	115.0	3,785.0	650.0	50.0	4,940.0	795.0
NON-U.S. MANUFACTURERS															
PCM/Distributor	--	2.0	--	--	125.0	--	--	220.0	--	--	350.0	--	--	470.0	--
OEM/Integrator	--	--	--	--	--	--	--	20.0	--	--	40.0	--	--	65.0	--
TOTAL NON-U.S. SHIPMENTS	--	2.0	--	--	125.0	--	--	240.0	--	--	390.0	--	--	535.0	--
WORLDWIDE RECAP															
PCM/Distributor	264.0	330.3	--	65.0	1,415.0	--	110.0	2,595.0	25.0	85.0	3,830.0	55.0	35.0	4,900.0	85.0
	-4.7%	+78.5%	--	-75.4%	+328.4%	--	+69.2%	+83.4%	--	-22.7%	+47.6%	+120.0%	-58.8%	+27.9%	+54.5%
OEM/Integrator	--	10.0	2.0	--	53.0	285.0	25.0	170.0	435.0	30.0	345.0	595.0	15.0	575.0	710.0
	--	+100.0%	+100.0%	--	+430.0%	--	--	+220.8%	+52.6%	+20.0%	+102.9%	+36.8%	-50.0%	+66.7%	+19.3%
Total Shipments	264.0	340.3	2.0	65.0	1,468.0	285.0	135.0	2,765.0	460.0	115.0	4,175.0	650.0	50.0	5,475.0	795.0
	-4.8%	+79.1%	+100.0%	-75.4%	+331.4%	--	+107.7%	+88.4%	+61.4%	-14.8%	+51.0%	+41.3%	-56.5%	+31.1%	+22.3%
ANNUAL SHARE, BY DIAMETER	43.6%	56.1%	.3%	3.6%	80.8%	15.6%	4.0%	82.4%	13.6%	2.3%	84.6%	13.1%	.8%	86.7%	12.5%
TOTAL CAPACITY (Terabytes)	42.2	62.2	.4	12.4	941.1	48.5	39.3	2,149.6	115.0	53.0	4,854.0	227.5	24.3	8,653.0	357.8

Note: "<=" indicates "less than or equal to".

TABLE 37

RIGID DISK CARTRIDGE DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1995	Forecast 1996	1997	1998	1999
PCM/Distributor					
5.25"	1.65	1.31	1.19	.81	.78
3.5"	1.34	.39	.35	.21	.14
2.5" or less	--	--	.86	.57	.41
PCM/Distributor Average	1.47	.40	.36	.22	.14
OEM/Integrator					
5.25"	--	--	1.40	1.13	.85
3.5"	1.55	.33	.35	.21	.14
2.5" or less	1.50	1.35	.84	.55	.40
OEM/Integrator Average	1.54	.91	.59	.34	.21

Note: Price per megabyte calculations represent estimated total sales revenues for each product type divided by the total yearly shipped capacity of all drives of that type.

TABLE 38

RIGID DISK CARTRIDGE 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	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	406.5	67.1	5,245.6	83.0
WORKSTATIONS Engineering and office, single user	199.0	32.8	1,061.8	16.8
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.6	.1	12.6	.2
Total	606.3	99.9	6,320.0	100.0

TABLE 39

RIGID DISK CARTRIDGE DRIVES

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	
SyQuest Technology	172.0	221.0	--	393.0	99.6	264.0	338.0	--	602.0	99.3
Other U.S.	--	.2	1.5	1.7	.4	--	.3	2.0	2.3	.4
Other Non-U.S.	--	--	--	--	--	--	2.0	--	2.0	.3
TOTAL	172.0	221.2	1.5	394.7	100.0	264.0	340.3	2.0	606.3	100.0

SMALL OPTICAL DISK DRIVES

1996 DISK/TREND REPORT

SMALL OPTICAL DISK DRIVES

Coverage

Examples of optical disk drives in this group include:

2.5" disk diameter

Sony	MDH-10

3.5" disk diameter

Fujitsu	M2511A, M2541B, M2513A
Konica	OMD-7060
Matsushita Electric Industrial	LF-3100, LF-3294
Mountain Optech	SE-250 R/W
Olympus	230MO Plus, MOS330E, SYS-230
Seiko Epson	OMD 6020
Sony	RMO-S330, HS-D650

The drives included in this group are 2.5" and 3.5" optical disk drives with removable media. At the present time, all of these drives use one sided disks and are equipped with one read/write head. All use magneto-optic (MO) recording technology, although other recording methods such as phase change technology may be used in the future.

The read/write drives discussed in this section are typically used with personal computers and workstations. Small automated libraries (jukeboxes, in industry parlance) used in departmental mass storage subsystems are usually equipped with 5.25" read/write drives, but are expected to also use 3.5" drives, as drive capacities increase above 600 megabytes.

Market status

1995 3.5" optical disk drive shipments rose to nearly 518,000 units, a 7.5% gain. As in previous years, the majority of the 3.5" drives shipped were consumed in the Japanese domestic market. Growth was sustained as a result of Fujitsu's aggressive pricing strategy, which has stimulated the increase of the total market while improving Fujitsu's market share. However, further growth is being impacted by the availability of drives using competing technologies, notably magnetic rigid disk cartridge drives, high capacity floppies and writable CD format drives. Sony began shipments of a 2.5" drive in 1994, but shipped few units, and the product has been de-emphasized pending redesign.

3.5" optical disk drive shipments have been helped by declining prices, plus the fact that computer networks have seen limited usage in Japan, compared to the United States and European markets, providing an incentive to exchange data using 3.5" optical disks. However, with the current increase in network installation now under way in Japan, it is likely that reliance on data exchange via optical disk cartridge will diminish.

In the U.S., demand remains relatively weak as the result of severe competition from magnetic rigid disk cartridge drives, high capacity floppies and the heavy usage of networks, permitting data transfer by wire. OEM demand for 3.5" optical disk drives remains small, with integrators and resellers moving most of the drives shipped. The Apple Macintosh add-on market, where there is less price sensitivity, has been the strongest 3.5" market segment in the U.S., but 3.5" MO drive sales have been impacted by 3.5" magnetic disk cartridge drives, which offer higher capacity, lower prices and superior performance.

Fujitsu and Olympus were the leading 3.5" optical disk drive producers in 1995, capturing a combined share of nearly 90% of the market. Despite the growth in unit shipments, the 3.5" optical disk drive business has proven disappointing to some manufacturers, and several suppliers have left the market, including IBM, Laserbyte, TEAC and MOST.

Worldwide sales revenues for 3.5" drives shrank in 1995 as a result of reduced prices, declining to $253.1 million. 2.5" drive revenues were about $400,000. U.S. firms accounted for 27.8% of 1995 revenues for small optical drives, but this share will drop drastically as a result of IBM's withdrawal from the 3.5" drive market. The U.S. market share rose modestly to 26% of 1995 worldwide sales revenues, reflecting a weak U.S. market for 3.5" drives and higher non-U.S. prices for 3.5" drives, compared to prices in the United States.

While Sony's 140 megabyte 2.5" drive requires no erase pass before writing, a feature that can be expected in other MO drives in the future, the drive's performance is much like that of a compact disk drive. Because of size, power, price, and performance constraints, the 2.5" MO drive has not been well accepted by the OEM community and it seems likely that significant product redesign will be needed to launch a successful OEM version of the drive. Sony's announcement of a 650 megabyte 3.5" drive has also met a lukewarm reception, because the media is not interchangeable with media from the 640 megabyte drives introduced by Fujitsu and several other competitors.

Marketing trends

The optical disk drive industry still lags the rigid magnetic disk drive industry in expanding the areal density of stored data. Optical drive manufacturers can't match the average 60% per year areal density growth rate of magnetic disk drives, and this lag is expected to weaken the prospects for optical drive sales relative to magnetic disk cartridge drive.

Although 3.5" optical disk drives with 640 and 650 megabyte capacities are now shipping, they must compete with the one gigabyte Iomega Jaz drive now, and with higher capacity versions of the Jaz expected in the future. The new MO drives must also compete against the 650 megabyte PD drive, the increasingly less expensive CD-R drives (and CD-E drives later in 1996), and 2.6 gigabyte DVD-RAM drives expected to ship in quantity in 1998. While modest shipment growth is projected during the forecast period, it assumes a steady reduction in drive prices and a fast expansion of capacity to match competition from drives using other technologies.

Annual shipments of nearly 1.3 million 3.5" optical disk drives are anticipated for 1999. While 2.5" drive shipments may resume, timing is uncertain, so no shipments have been explicitly forecast. Several U.S. startup companies are developing advanced high capacity small optical drives, but introduction dates are at least two years in the future.

Because of steadily declining prices, sales revenues for this product group are expected to grow to only $292 million in 1999. However, if new very high capacity drives are introduced as anticipated, late in the forecast period, revenues for this product group could be substantially higher. The U.S. portion of worldwide revenues is expected to remain in the 25 to 30 percent range during the forecast period.

Applications

3.5" optical disk drives are used to provide project oriented storage on a single disk, and are often used in desktop publishing to transfer large amounts of data needed for prepress processing. They are also used for file transfer applications with video editing systems. The drives have established a role as add-on devices to Apple Macintosh systems, which are frequently used for desktop publishing. In Japan and other countries where networking has not been as widely used, they have had a significant role as intersystem data exchange devices. Toward the end of the forecast period, higher capacity 3.5" drives may acquire a role as a nearline storage device in optical libraries attached to file servers in small networks. As they match or exceed current CD-ROM capacity and performance (and have prospects for matching or exceeding 2.6 gigabyte DVD-RAM), they have an opportunity to establish a role as a multipurpose device that can provide data distribution services, selective backup capability, and other secondary mass storage tasks. While 3.5" optical disk drives are unlikely to exceed DVD-RAM drives in capacity in the short run, they will probably provide superior performance compared to DVD drives, but at higher cost.

2.5" drives were targeted at the secondary storage market for portable and mobile computer systems. If available at a low enough price and in thin form factors, 2.5" drives could also acquire the role of a data exchange device, especially in portable systems, but no clear role for the drive in this application has yet emerged. 2.5" drives may develop usage in consumer and hobby systems and, to some extent, with personal computers if their current deficiencies in power consumption and package size are overcome.

Media with both a read-only section and a writable section, when available, can serve as a vehicle for software and data base distribution, providing that cost of the media is low. The writability feature permits timely update of a previously installed data base. Furthermore, the ability to write gives the data base publisher certain security and antipiracy options not readily available on read-only media, in that individual disks or sections of disks can be serialized or encrypted for use on a specific system or group of systems at nominal cost. However, the low market penetration of optical drives and high media costs have discouraged this application.

Technical trends

Optical disk drive technology is advancing. The key areas of change are reviewed below.

Capacity: The average capacity of small optical disk drives in this product group is expected to increase. 3.5" drive capacities are expected to reach 1.3 gigabytes in 1998 and have prospects for growth to well over 2 gigabytes in the 1998-1999 time frame. Fujitsu and several other firms introduced backward compatible 640 megabyte 3.5" MO drives in late 1995. Sony has also introduced a 650 megabyte 3.5" drive. Although it is not backward compatible with earlier drives, Sony claims their approach is more amenable to future capacity and performance improvements. Capacity growth for 2.5" drives is more problematic. Because a number of the existing drives' characteristics, such as CLV rotation speed control and file format are derived from CD-ROM technology, capacity gains may be tied to DVD-RAM technology or advanced MO technology.

Capacity can be increased by several techniques, including improved optics and shorter laser wavelength permitting smaller spots and higher BPI and TPI, reduction of track pitch, the adoption of pulse width modulation, zoned recording, improved optics providing higher numerical aperture, land and groove recording, and variable track pitch. Changes in encoding methods can also improve capacity.

It is unlikely that all of these possibilities will be implemented on any one drive in the near term, but many are expected to be standard features of future drives. Some capacity improvement techniques, such as zoned recording, are used on optical drives currently in production. Increased capacity will expand the applications for 3.5" drives, enabling them to move into some niches currently occupied by 5.25" optical drives and to better compete with magnetic disk cartridge drives.

Performance: The optical disk drives in this group won't provide the average access times and data transfer rates of magnetic disk drives or flash memory. While performance is expected to improve, it is not expected to match that of magnetic rigid disk drives within the forecast period, even if direct overwrite techniques are used. 26-28 millisecond average seek times and 7.1 millisecond average latency represent the best performance of 1996 production drives, as was also the case in 1995.

The current generation of 3.5" magneto-optical drives have an additional latency for writing operations caused by the need to erase each sector before writing. This lack of overwrite capability requires that an additional complete rotation be performed before the drive is ready to write in the selected sector. Some 5.25" drives already eliminate the need for an erase pass, and it is likely that future generations of small MO drives will not require a separate erase pass. But the overwrite solution will come at the expense of performance or of additional complexity in the drive, media or both, so there will be a trade-off of performance for cost, as in the case of the Sony 2.5" MD-DATA drive.

Data transfer rate: Specified internal drive maximum data transfer rates are in the 2 megabyte per second range for 3.5" drives, and are expected to increase to the 5 megabyte per second range as bit density and spin rate increase. The average data transfer rate will be lower, since bit density varies from track to track.

Competing products: The SyQuest 3.5" EZFlyer 230 megabyte magnetic rigid disk cartridge drive is strong competition for 3.5", 230 megabyte MO drives, and priced substantially under current prices for 3.5" MO drives. The Iomega Zip drive, although it currently offers only 100 megabytes, also competes by virtue of its under $200 list price. The 640 megabyte 3.5" MO drive must compete against the Iomega gigabyte magnetic disk cartridge drive, as well as the PD drive and the CD-E drives expected to become available late in 1996.

While tape drives do not offer the performance of optical disk drives, especially when reading data, they do offer inexpensive offline storage. Newer small cartridge drives using the "Travan" format developed by 3M can compete against 3.5" MO drives where save/restore and data transfer are primary applications and performance is not a major issue.

Multigigabyte 5.25" and 3.5" magnetic rigid disk drives from Seagate, Quantum and others are also negatively impacting optical drive sales in those stand-alone applications where a removable disk cartridge drive is not mandatory. A typical 3.5" 1 gigabyte magnetic disk drive sells for half the price of a 230 megabyte 3.5" optical disk drive, has four times the capacity and three times better performance.

Forecasting assumptions

1. 640/650 megabyte 3.5" drives will be shipping in large quantities in late 1996. 1.3 gigabyte drives will begin shipping in late 1998.
2. Rewritable media of appropriate capacity will be available in adequate production quantities throughout the forecast period.
3. 3.5" drive and media prices will continue to decline in 1996 and thereafter as a result of improving economies of scale and competition from other technologies.
4. Magnetic cartridge drives will continue to improve capacity at a faster rate than magneto-optical drives throughout the forecast period.

TABLE 40

SMALL 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	18.0	48.0	--	--	--	--	--	--	--	--
PCM/Distributor	3.5	10.1	--	--	--	--	--	--	--	--
OEM/Integrator	1.4	7.4	--	--	--	--	--	--	--	--
TOTAL U.S. REVENUES	22.9	65.5	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	10.0	--	20.3	--	21.2	--	22.0	--	21.6
PCM/Distributor	37.3	158.1	65.3	216.5	66.6	219.5	66.2	220.3	65.1	215.1
OEM/Integrator	5.8	19.9	6.2	40.7	10.6	49.8	10.7	55.3	11.0	55.0
TOTAL NON-U.S. REVENUES	43.1	188.0	71.5	277.5	77.2	290.5	76.9	297.6	76.1	291.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	66.0	253.5	71.5	277.5	77.2	290.5	76.9	297.6	76.1	291.7
OEM Average Price ($000)		.478		.309		.279		.250		.220

TABLE 41

SMALL 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										
Captive	12.0	32.0	--	--	--	--	--	--	--	--
PCM/Distributor	5.0	14.4	--	--	--	--	--	--	--	--
OEM/Integrator	2.4	12.4	--	--	--	--	--	--	--	--
TOTAL U.S. SHIPMENTS	19.4	58.8	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	20.0	--	40.0	--	50.0	--	55.0	--	60.0
PCM/Distributor	103.5	395.1	215.6	693.8	256.0	844.0	276.0	918.0	296.0	978.0
OEM/Integrator	13.3	44.6	20.5	131.5	38.0	178.0	42.6	221.0	50.0	250.0
TOTAL NON-U.S. SHIPMENTS	116.8	459.7	236.1	865.3	294.0	1,072.0	318.6	1,194.0	346.0	1,288.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	136.2	518.5	236.1	865.3	294.0	1,072.0	318.6	1,194.0	346.0	1,288.0
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	389.0	1,434.3	625.1	2,299.6	919.1	3,371.6	1,237.7	4,565.6	1,583.7	5,853.6

TABLE 42

SMALL OPTICAL DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues 3.5"	1995 Revenues 2.5"	Forecast 1996 3.5"	Forecast 1997 3.5"	Forecast 1998 3.5"	Forecast 1999 3.5"
U.S. MANUFACTURERS						
Other U.S. Captive	48.0	--	--	--	--	--
PCM/Distributor	10.1	--	--	--	--	--
OEM/Integrator	7.4	--	--	--	--	--
TOTAL U.S. REVENUES	65.5	--	--	--	--	--
NON-U.S. MANUFACTURERS						
Captive	10.0	--	20.3	21.2	22.0	21.6
PCM/Distributor	158.1	--	216.5	219.5	220.3	215.1
OEM/Integrator	19.5	.4	40.7	49.8	55.3	55.0
TOTAL NON-U.S. REVENUES	187.6	.4	277.5	290.5	297.6	291.7
WORLDWIDE RECAP						
Captive	58.0	--	20.3	21.2	22.0	21.6
	+142.7%	--	-65.0%	+4.4%	+3.8%	-1.8%
PCM/Distributor	168.2	--	216.5	219.5	220.3	215.1
	-31.2%	--	+28.7%	+1.4%	+.4%	-2.4%
OEM/Integrator	26.9	.4	40.7	49.8	55.3	55.0
	-54.0%	-42.9%	+51.3%	+22.4%	+11.0%	-.5%
Total Revenues	253.1	.4	277.5	290.5	297.6	291.7
	-22.6%	-42.9%	+9.6%	+4.7%	+2.4%	-2.0%
ANNUAL SHARE, BY DIAMETER	99.9%	.1%	100.0%	100.0%	100.0%	100.0%

TABLE 43

SMALL OPTICAL DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments 3.5"	1995 Shipments 2.5"	Forecast 1996 3.5"	Forecast 1997 3.5"	Forecast 1998 3.5"	Forecast 1999 3.5"
U.S. MANUFACTURERS						
Other U.S. Captive	32.0	--	--	--	--	--
PCM/Distributor	14.4	--	--	--	--	--
OEM/Integrator	12.4	--	--	--	--	--
TOTAL U.S. SHIPMENTS	58.8	--	--	--	--	--
NON-U.S. MANUFACTURERS						
Captive	20.0	--	40.0	50.0	55.0	60.0
PCM/Distributor	395.1	--	693.8	844.0	918.0	978.0
OEM/Integrator	44.0	.6	131.5	178.0	221.0	250.0
TOTAL NON-U.S. SHIPMENTS	459.1	.6	865.3	1,072.0	1,194.0	1,288.0
WORLDWIDE RECAP						
Captive	52.0	--	40.0	50.0	55.0	60.0
	+227.0%	--	-23.1%	+25.0%	+10.0%	+9.1%
PCM/Distributor	409.5	--	693.8	844.0	918.0	978.0
	+11.8%	--	+69.4%	+21.6%	+8.8%	+6.5%
OEM/Integrator	56.4	.6	131.5	178.0	221.0	250.0
	-43.4%	-45.5%	+133.2%	+35.4%	+24.2%	+13.1%
Total Shipments	517.9	.6	865.3	1,072.0	1,194.0	1,288.0
	+7.5%	-45.5%	+67.1%	+23.9%	+11.4%	+7.9%
ANNUAL SHARE, BY DIAMETER	100.0%	--	100.0%	100.0%	100.0%	100.0%

TABLE 44

SMALL 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	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	8.0	1.6	41.2	3.2
PERSONAL COMPUTERS				
Business and professional, single user	416.1	80.2	700.7	54.4
WORKSTATIONS				
Engineering and office, single user	81.4	15.7	490.7	38.1
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	19.3	1.5
OTHER APPLICATIONS	13.0	2.5	36.1	2.8
Total	518.5	100.0	1,288.0	100.0

TABLE 45

SMALL 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	3.5"	2.5"	Total		3.5"	2.5"	Total	
Fujitsu	100.0	--	100.0	80.5	342.0	--	342.0	73.3
Olympus Optical	12.8	--	12.8	10.3	77.0	--	77.0	16.5
Other U.S.	7.4	--	7.4	6.0	26.8	--	26.8	5.7
Other Non-U.S.	4.0	--	4.0	3.2	20.1	.6	20.7	4.5
TOTAL	124.2	--	124.2	100.0	465.9	.6	466.5	100.0

HIGH CAPACITY FLEXIBLE DISK DRIVES

1996 DISK/TREND REPORT

HIGH CAPACITY FLEXIBLE DISK DRIVES

Coverage

Examples of flexible disk drives in this group include:

5.25" Bernoulli principle drives

Iomega	Bernoulli 150, 230

3.5" flexible disk drives

Iomega	Zip 100
Matsushita-Kotobuki Electronics	LS-120
O.R. Technology	FD-3120A
Seiko Epson	EZ 110/111
Swan Instruments	UHC 3260

All types of floppy drives with capacities over 5 megabytes have been consolidated into this section. The functional and physical characteristics of these products are varied, and are individually discussed below. Unfortunately, there has been no general industry agreement on media interchange standards, and most of the high capacity floppy drives announced to date are incapable of interchanging diskettes with drives of other manufacturers, except for the downward compatibility with lower capacity standard floppy drives claimed by some manufacturers of 3.5" drives.

Iomega Bernoulli principle drives: Iomega's existing 5.25" disk drives use the Bernoulli effect to control head/disk spacing. These are high performance drives, using flexible disks in a removable cartridge, and a sophisticated internal air flow system to maintain the proper position of the flexible disk relative to the recording head. A rotary voice coil magnetic head positioning system, in conjunction with an embedded servo, provides average seek times equivalent to those of many rigid disk drives.

Iomega started deliveries of the original 8" 10 megabyte Alpha-10 in September, 1982, followed by other 8" models, all of which have since been discontinued. A 5 megabyte full size 5.25" drive was introduced in 1983, followed by a 21 megabyte half high model in 1986, a 44 megabyte version in 1989, a 90 megabyte model in 1991, a 150 megabyte model in 1992, and the current 230 megabyte model in late 1994.

Iomega Zip drives: A significant new entry in the 3.5" high capacity floppy drive market appeared in 1994 with the Iomega announcement of the "Zip" 100 megabyte drive. After participating in the 21 megabyte floptical drive market and in the Optics Research joint program to develop a higher capacity version of the drive, Iomega undertook its own development program with the objective to develop a 3.5" high capacity floppy with the lowest possible cost. The Zip drive dispensed with backward compatibility, and started shipments in March, 1995, providing 100 megabyte capacity at an end user price less than $200, supplemented in mid-1996 with a $50 consumer rebate. Iomega is manufacturing the Zip drive at its factory in Roy, Utah, supplemented by a contract manufacturing arrangement with Seiko Epson, which also sells the drives under its own label.

Floptical drives: Insite Peripherals achieved quick fame in the industry by announcing its trademarked "floptical" technology, a combination of optical tracking methods with conventional magnetic recording. Floptical drives use a reflective servo pattern applied to the surface of 3.5" diskettes to achieve high track density. The original floptical drive introduced in 1989 had a 21 megabyte capacity in a one inch high form factor, with downward read/write compatibility for .7 and 1.44 megabyte diskettes.

In 1992, Insite engaged Matsushita-Kotobuki Electronics to manufacture the drive on a contract basis, and also licensed the floptical technology to Iomega, which introduced drives compatible with Insite's in 1992, using Chinon as a contract manufacturing source. Iomega phased out of the floptical drive market in 1994, after finding a limited market for the product. In November, 1993, O.R. Computer System Pte. Ltd., a major Singapore distributor of personal computers and peripherals, acquired control of Insite Peripherals, changed the name to O.R. Technology in 1995, and continued to sell floptical 21 megabyte drives produced by MKE until phasing them out in 1996.

In 1995, a joint program for the LS-120, a 120 megabyte version of the 3.5" floptical disk drive developed by Optics Research, Inc., in Boulder, Colorado, was announced by three companies. MKE will manufacture the drives, 3M (now Imation) will manufacture the metal powder diskettes to be used, and Compaq Computer will use the drives in personal computers. LS-120 drives are backward compatible with 720 kilobyte, 1.2 megabyte and 1.44 megabyte floppies, and conform to the standard form factor for one inch high 3.5" floppy drives, with thinner models expected. The sponsors have also licensed Mitsubishi Electric to make the LS-120, but a specific Mitsubishi model has not yet been announced. O.R. Technology will also sell the drive.

Other flexible disk drives: For several years the technology required for production of higher capacity floppy drives using conventional recording techniques has been available, and numerous companies have offered floppy drives ranging in capacity from 6 to 21 megabytes, none of which were successful in the market. Swan Instruments, a California manufacturer of test equipment for the disk drive industry, announced a combination fixed/removable floppy drive with capacities over 100 megabytes in 1994, using technology licensed from Antek Peripherals. Swan's management intends to utilize a manufacturing partner, but no definitive plans have yet been announced for a production start-up. Mitsumi Electric announced a 128 megabyte 3.5" floppy drive utilizing the Antek technology at the 1995 Fall Comdex show, but production plans have been delayed by legal proceedings between Mitsumi, Swan and Antek, in a dispute over licensing terms.

Market status

With the advent in 1995 of 3.5" floppy drives with 100 megabyte capacities, the outlook for the high capacity floppy drive market changed drastically. In place of the declining market for Iomega's 5.25" Bernoulli principle drives, the computer industry has demonstrated a big appetite for 3.5" high capacity floppy drives.

67,700 Bernoulli 5.25" drives were shipped worldwide in 1995, and the 32,000 units forecasted for 1996 are expected to be the end of the Bernoulli drive program. 760,000 high capacity 3.5" floppy drives were shipped in 1995, a mixture of 21 megabyte floptical drives manufactured by MKE and 100 megabyte Zip drives produced by Iomega. The DISK/TREND 3.5" drive forecast for 1996 exceeds 5 million units, reflecting the outstanding growth in Zip drive shipments, supplemented by end-of-life shipments of 20 megabyte floptical drives and initial shipments of MKE's LS-120 drives. Total 1996 sales revenues for the suddenly prosperous high capacity flexible disk drive product group are estimated at $421.8 million, up from the previous year's $122.6 million.

Iomega was founded in 1980 to manufacture 8" drives using Bernoulli technology, after the founders terminated their IBM careers over discouragement with IBM's failure to utilize the technology they had developed. Production of the original 8" drives ended five years ago, but shipments of the firm's 5.25" Bernoulli drives continued to grow until 1993. Iomega's Bernoulli drives have competed primarily with removable rigid disk cartridge drives and small erasable optical disk drives, rather than with low capacity flexible disk drives available in the past, due to their capacity, performance, and pricing.

Because of the unique characteristics of its Bernoulli drives and lack of effective second sources, Iomega achieved most of its sales successes through its program to sell Bernoulli Box subsystems in the personal computer add-on market with distribution through dealers. For years, Iomega's main difficulty in selling to major system manufacturers on an OEM basis was lack of alternate sources for the company's drives. The products are unique, and system manufacturers, as always, are reluctant to take a chance on a sole-sourced disk drive of a unique design. Attempts to establish token alternate sources in Japan and the U.S. were abortive.

5.25" Bernoulli drive shipments declined slightly in 1993 and 1994, but stayed just over the 100,000 unit level, until 1995. Despite 1995 availability of the 230 megabyte model, unit shipments started down sharply, and Iomega will close out the product line in 1996. Despite sharp price reductions for Bernoulli drives, competition from Iomega's own newer high capacity floppy drives has proven much more lethal than the traditional competitors, rigid disk cartridge drives and optical disk drives.

Major changes are under way in the market for high capacity 3.5" flexible disk drives. After a flat sales year in 1994, with shipments static at the 103,000 drive level, total 3.5" drive shipments are forecasted to reach a total almost fifty times higher, only two years later. The new factor is the availability of 3.5" floppy drives in the 100+ megabyte range, caused initially by shipments of the Iomega Zip drive starting early in 1995, followed by expected availability of the MKE LS-120 in the second half of 1996.

3.5" 21 megabyte "floptical" drives became available in volume, after numerous delays, from Insite in the first half of 1992 and from Iomega late in that year.

Total 3.5" drive shipments were only 25,600 units in 1992, but the combined marketing activity of Insite and Iomega boosted 1993 shipments to 103,400 drives, concentrated in distribution markets. Although the 21 megabyte floptical drive found a market in a variety of specialized applications, broader sales throughout the computer industry were held down due to price levels perceived as too high by both system manufacturers and most end users.

During 1995, sales momentum for 3.5" high capacity floppy drives shifted to the Iomega Zip drive, which attracted widespread attention in the computer industry by combining a capacity large enough to perform several useful functions with a price low enough to be attractive to a wide market. The combination of 100 megabytes capacity and an end user price less than $200 have turned out to be the right combination for many buyers. The Zip drive has received more coverage in the computer and general business press than any disk drive in years, and generated a sales backlog of many more drives than Iomega could manufacture during 1995. Iomega established Seiko Epson as an additional contract manufacturing source for the Zip drive, providing a better balance between supply and demand during most of 1996.

Personal computers for business applications dominated shipments in 1995, with 89.5% of overall unit shipments for the product group. Workstations for engineering and office usage held 4.6% of shipments, and consumer, game and hobby computers grew to 4.7%. By 1999, with shipments dominated by relatively inexpensive 3.5" drive models, personal computers are forecasted to retain 88.0% of all shipments, with workstations down to 4.0%, and consumer computers growing to 7.2%.

In 1995, Iomega held the lead in noncaptive unit shipments with 88.5% of the worldwide total, with the company's total consisting of both 5.25" and 3.5" drives. O.R. Technology, selling drives manufactured by MKE held 11.5% of the total, all 3.5" floptical drives.

Marketing trends

DISK/TREND forecasts for high capacity flexible disk drives have been increased sharply since last year, in light of the extent of the favorable market reaction to the products now available. 1999 worldwide shipments are projected at 25.5 million drives, an average annual increase of 75.3% during the 1997-99 period. Total sales revenues are forecasted at $1.3 billion for 1999, more than three times larger than the 1996 revenue total.

The market response to the new generation of 3.5" high capacity floppy drives will be adequate to carry shipments for this product group to much higher levels than those achieved in previous years. Several computer industry trends have combined to create this response. The continuous increase in capacities for the fixed rigid disk drives used as the basic disk for all of today's personal computers has made many users nervous about their risks in failing to preserve their data by backing it up.

For many of these users in both home and business applications, the high capacity floppy now provides an inexpensive alternative to buying a tape drive, and preserves the random access capability of the disk drive. Many other users now have the functional need to keep individual projects offline to free space on their system's fixed disk drive, a pattern previously available only to users of high-end personal computers or workstations, at much higher cost. The widespread usage of graphics and desktop publishing software, CD-ROM applications, games, and downloads from the Internet have inspired many additional computer users to seek affordable removable data storage devices which are suitable to keep individual projects on individual disks, ready to be loaded when needed.

High capacity 3.5" floppy drives are expected to capture a major part of the available market created by the above trends, while coexisting in a competitive marketplace alongside rigid disk cartridge drives, small optical disk drives and tape cartridge drives. During this forecast period, it is expected that the 3.5" 100 megabyte Zip drives and the 120 megabyte LS-120 drives will be increased in capacity, initially to at least 200 megabytes, then probably doubled again, and that prices will be significantly reduced as sales increase.

By 1997, the product mix for high capacity flexible disk drives will be entirely 3.5" models, all with capacities over 100 megabytes. There is less certainty as to which of the competing formats will prevail, if indeed whether any of the current high capacity floppy drive manufacturers will emerge the winner by 1999. At the moment, the key competitors are locked in a struggle for sales momentum, with

LS-120 advocates contending that backward compatibility is essential to market dominance, and Iomega saying "Not so!".

Other things being equal, it is logical to expect personal computer manufacturers to choose a backward compatible high capacity floppy drive if used as a standard feature in a PC. However, in this contest the Zip drive has more than a year's head start, growing sales as an aftermarket add-on product, and several OEM adoptions for specialized systems. Although the high capacity floppy drive field has already become a classic electronics industry standards war, the battlefield may become even more complex if the Mitsumi Electric/Swan Instruments licensing problems are resolved, with two more entrants in the contest.

Drive prices will probably be the largest influence on the future size of the high capacity floppy drive market. Sales for high capacity 3.5" floppy drives are now predominantly through distribution, and the average prices in that marketing channel are expected to continue a pattern of rapid decline, even as drives with high capacities enter the market. Each of the manufacturers developing this drive market intend to sell a major share of their production to personal computer manufacturers, with the result that significant OEM shipments will necessarily force overall average prices down even faster. By 1999, the average OEM price for 3.5" high capacity floppy drives is projected at $47, with PCM/Distributor prices a few dollars higher. Also by 1999, OEM/Integrator shipments are expected to equal those in the PCM/Distributor channel.

Technology trends

The 3.5" form factor for floppy drives in this product group is clearly destined to prevail, and the development task will be to increase capacities beyond the 100-120 megabytes now available, and to achieve the design simplification required for low manufacturing cost.

The floptical optical tracking method is perhaps the most innovative approach, with obvious potential for greater capacity and low manufacturing costs. The reflective servo pattern is imprinted on the diskette as part of the media manufacturing process, and should increase the media manufacturing cost only slightly when high shipment levels are achieved. The overwhelming challenge for the engineers working with the floptical design will be to reduce the manufacturing cost of the drive, no small challenge when the requirements of the optical tracking method and backward compatibility are considered, both of which contribute to an increased parts count.

None of the interesting technical developments in this field will see wide application unless producible at low cost. This is not going to be easy, since these drives will require sophisticated head positioning systems, multifunction heads, high density encoding schemes, error correction capability, high reliability and embedded controllers. Furthermore, the media must be priced low enough to avoid buyer resistance, while still offering long life, adequate durability and easy handling. It's definitely a difficult development task, but without low costs these drives will occupy only a small market niche.

At this point, it appears that Iomega's Zip drive design has intrinsic cost advantages, when compared with the floptical design. Both types of drives will be able to utilize components designed for rigid disk drives produced at very high production volumes, and therefore available at attractive costs. And as the rigid disk drive industry continues to advance rapidly in storage capacity, high capacity floppy drives will probably benefit from being able to utilize low cost components originally developed for magnetic rigid disk drives. But, all things being equal, it is hard to see how the floptical drives, with more internal functions to be performed, with more parts, can avoid higher manufacturing costs, if production volumes are comparable to those of competitors.

Forecasting assumptions

1. Adequate production of 3.5" high capacity floppy drives will be available in the 1997-99 period to satisfy demand, which will grow to exceed 25 million drives per year by 1999.

2. Although the higher production levels for 3.5" high capacity floppy drives projected for future years will lower the pricing differential compared to 1.44 megabyte 3.5" drives, high capacity 3.5" drives will still be priced 3 to 4 times higher at the OEM level than 1.44 megabyte drives in 1999, and will not be able to replace them as the basic floppy drive used with the majority of personal computers.

3. Shipments of 5.25" Bernoulli drives will end in 1996.

TABLE 46

HIGH CAPACITY FLEXIBLE 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										
PCM/Distributor	80.5	105.8	241.7	320.7	276.9	395.5	280.0	430.7	221.0	368.2
OEM/Integrator	1.7	2.0	6.6	7.5	16.0	20.1	42.3	56.7	54.6	79.5
TOTAL U.S. REVENUES	82.2	107.8	248.3	328.2	292.9	415.6	322.3	487.4	275.6	447.7
Non-U.S. Manufacturers										
Captive	--	--	--	17.1	3.2	27.2	6.2	33.1	8.4	34.2
PCM/Distributor	4.1	6.5	19.4	32.4	44.8	85.6	79.1	171.5	100.2	250.2
OEM/Integrator	5.3	8.3	42.0	44.1	211.4	264.6	320.4	427.8	368.0	527.3
TOTAL NON-U.S. REVENUES	9.4	14.8	61.4	93.6	259.4	377.4	405.7	632.4	476.6	811.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	91.6	122.6	309.7	421.8	552.3	793.0	728.0	1,119.8	752.2	1,259.4
OEM Average Price ($000)		.168		.099		.068		.057		.047

TABLE 47

HIGH CAPACITY FLEXIBLE 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										
PCM/Distributor	542.5	726.7	3,134.0	4,173.0	4,260.0	6,085.0	5,090.0	7,830.0	4,910.0	8,180.0
OEM/Integrator	5.0	6.0	88.5	99.0	290.0	365.0	940.0	1,260.0	1,560.0	2,270.0
TOTAL U.S. SHIPMENTS	547.5	732.7	3,222.5	4,272.0	4,550.0	6,450.0	6,030.0	9,090.0	6,470.0	10,450.0
Non-U.S. Manufacturers										
Captive	--	--	--	90.0	20.0	170.0	45.0	240.0	75.0	305.0
PCM/Distributor	25.0	40.0	180.0	320.0	560.0	1,070.0	1,130.0	2,450.0	1,670.0	4,170.0
OEM/Integrator	35.0	55.0	400.0	420.0	3,020.0	3,780.0	5,340.0	7,130.0	7,360.0	10,545.0
TOTAL NON-U.S. SHIPMENTS	60.0	95.0	580.0	830.0	3,600.0	5,020.0	6,515.0	9,820.0	9,105.0	15,020.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	607.5	827.7	3,802.5	5,102.0	8,150.0	11,470.0	12,545.0	18,910.0	15,575.0	25,470.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	1.6	2.1	5.4	7.2	13.6	18.7	26.1	37.6	41.7	63.1

TABLE 48

HIGH CAPACITY FLEXIBLE DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues		Forecast 1996		Forecast 1997	Forecast 1998	Forecast 1999
	5.25"	3.5"	5.25"	3.5"	3.5"	3.5"	3.5"
U.S. MANUFACTURERS							
PCM/Distributor	22.6	83.2	9.8	310.9	395.5	430.7	368.2
OEM/Integrator	2.0	--	1.3	6.2	20.1	56.7	79.5
TOTAL U.S. REVENUES	24.6	83.2	11.1	317.1	415.6	487.4	447.7
NON-U.S. MANUFACTURERS							
Captive	--	--	--	17.1	27.2	33.1	34.2
PCM/Distributor	--	6.5	--	32.4	85.6	171.5	250.2
OEM/Integrator	--	8.3	--	44.1	264.6	427.8	527.3
TOTAL NON-U.S. REVENUES	--	14.8	--	93.6	377.4	632.4	811.7
WORLDWIDE RECAP							
Captive	--	--	--	17.1	27.2	33.1	34.2
	--	--	--	--	+59.1%	+21.7%	+3.3%
PCM/Distributor	22.6	89.7	9.8	343.3	481.1	602.2	618.4
	-40.8%	+875.0%	-56.6%	+282.7%	+40.1%	+25.2%	+2.7%
OEM/Integrator	2.0	8.3	1.3	50.3	284.7	484.5	606.8
	-4.8%	-18.6%	-35.0%	+506.0%	+466.0%	+70.2%	+25.2%
Total Revenues	24.6	98.0	11.1	410.7	793.0	1,119.8	1,259.4
	-39.0%	+405.2%	-54.9%	+319.1%	+93.1%	+41.2%	+12.5%
ANNUAL SHARE, BY DIAMETER	20.1%	79.9%	2.6%	97.4%	100.0%	100.0%	100.0%

TABLE 49

HIGH CAPACITY FLEXIBLE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments		Forecast 1996		Forecast 1997	Forecast 1998	Forecast 1999
	5.25"	3.5"	5.25"	3.5"	3.5"	3.5"	3.5"
U.S. MANUFACTURERS							
PCM/Distributor	61.7	665.0	28.0	4,145.0	6,085.0	7,830.0	8,180.0
OEM/Integrator	6.0	--	4.0	95.0	365.0	1,260.0	2,270.0
TOTAL U.S. SHIPMENTS	67.7	665.0	32.0	4,240.0	6,450.0	9,090.0	10,450.0
NON-U.S. MANUFACTURERS							
Captive	--	--	--	90.0	170.0	240.0	305.0
PCM/Distributor	--	40.0	--	320.0	1,070.0	2,450.0	4,170.0
OEM/Integrator	--	55.0	--	420.0	3,780.0	7,130.0	10,545.0
TOTAL NON-U.S. SHIPMENTS	--	95.0	--	830.0	5,020.0	9,820.0	15,020.0
WORLDWIDE RECAP							
Captive	--	--	--	90.0	170.0	240.0	305.0
	--	--	--	--	+88.9%	+41.2%	+27.1%
PCM/Distributor	61.7	705.0	28.0	4,465.0	7,155.0	10,280.0	12,350.0
	-35.1%	--	-54.6%	+533.3%	+60.2%	+43.7%	+20.1%
OEM/Integrator	6.0	55.0	4.0	515.0	4,145.0	8,390.0	12,815.0
	+9.1%	-5.2%	-33.3%	+836.4%	+704.9%	+102.4%	+52.7%
Total Shipments	67.7	760.0	32.0	5,070.0	11,470.0	18,910.0	25,470.0
	-32.6%	+637.9%	-52.7%	+567.1%	+126.2%	+64.9%	+34.7%
ANNUAL SHARE, BY DIAMETER	8.2%	91.8%	.6%	99.4%	100.0%	100.0%	100.0%

TABLE 50

HIGH CAPACITY FLEXIBLE 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	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	740.8	89.5	22,413.6	88.0
WORKSTATIONS Engineering and office, single user	38.2	4.6	1,018.8	4.0
CONSUMER, GAME AND HOBBY COMPUTERS	38.6	4.7	1,833.8	7.2
OTHER APPLICATIONS	10.2	1.2	203.8	.8
Total	827.8	100.0	25,470.0	100.0

TABLE 51

HIGH CAPACITY FLEXIBLE 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	5.25"	3.5"	Total		5.25"	3.5"	Total	
Iomega	57.5	490.0	547.5	90.1	67.7	665.0	732.7	88.5
O.R. Technology	--	60.0	60.0	9.9	--	95.0	95.0	11.5
Other U.S.	--	--	--	--	--	--	--	--
Other Non-U.S.	--	--	--	--	--	--	--	--
TOTAL	57.5	550.0	607.5	100.0	67.7	760.0	827.7	100.0

LOW CAPACITY FLEXIBLE DISK DRIVES

LOW CAPACITY FLEXIBLE DISK DRIVES

Coverage

Examples of low capacity flexible disk drives in this group include:

8" disk diameter

Y-E Data	YD-180

5.25" disk diameter: .360 megabyte

TEAC	FD-55BR

5.25" disk diameter: .7 megabyte

TEAC	FD-55FR

5.25" disk diameter: 1.2 megabytes

Matsushita Communication Ind.	JU-475
Samsung Electronics	SFD-560D
Tae-Il Media	TFD-510
TEAC	FD-55GFR, FD-155GF
Y-E Data	YD-380B

5.25" disk diameter: 2.4 megabytes

Y-E Data	YD-801

3.5" disk diameter: .7 megabyte

Matsushita Electronic Comp.	EME-213
Mitsumi Electric	D357T5

3.5" disk diameter: 1.2 megabytes

Citizen	OSDB, W1DB*
Mitsumi Electric	D358F2*
NEC	FD 1139C
TEAC	FD-235GF, FD-05GF*
Y-E Data	YD-686C

3.5" disk diameter: 1.44 megabytes

Alps Electric	DF 334H
Chinon	FG-357
Citizen	OSDA, W1DA*
Matsushita Communication Ind.	JU-257A, JU-227A*
Matsushita Electronic Comp.	EME-219
Mitsubishi Electric	MF 355F, MF 355H*
Mitsumi Electric	D 359T5, D 359G*

3.5" disk diameter: 1.44 megabytes (continued)

NEC	FD 1231H, FD 1239H*
Samsung Electronics	SFD-321D
Seiko Epson	SMD-1340
S.F.R.	DS-34AC
Sony	MPF520, MPF720*
Tai-Il Media	TFD-310
TEAC	FD-235HF, FD-05HF*
Y-E Data	YD-701B, YD-702J*

3.5" disk diameter: 2.88 megabytes

Alps Electric	DF 328N
Mitsubishi Electric	MF 356F

*12.7 millimeters height, or less

All flexible disk drives with capacities less than 5 megabytes are included in this product group. The first commercial floppy drive, used only to load microcode for a mainframe disk drive controller, was an 8" drive shipped by IBM in 1971. However, IBM's 33FD 8" drive first shipped in 1973 established an industry de facto standard, setting off a rush of companies vying to establish floppy drive production. After a 23 year product life, only one manufacturer is still producing 8" floppy drives.

The basic standards for physical size and recording format for 5.25" floppy drives were created by Shugart Associates' 1976 introduction of the SA 400, the original minifloppy. Early growth in small microcomputer systems inspired several innovative one sided 5.25" drives, but two sided 5.25" floppy drives became a reality in 1978. The current industry recording format was established in 1982, when 1.2 megabyte two sided 5.25" drives were first shipped by Y-E Data, designed to a standard coordinated by Nippon Telephone and Telegraph. IBM's 1984 introduction of the PC AT, using Y-E Data's 1.2 megabyte drive, stampeded the market into rapid worldwide usage of the 1.2 megabyte 5.25" format, which for several years accounted for most of the industry's shipments of 5.25" floppy drives.

The only type of microfloppy currently remaining in the low capacity floppy drive product group is the 3.5" format, which has evolved into the industry standard. All of the other microfloppy formats in the 2" to 4" diameter range which were introduced during the last 14 years have been phased out. All 3.5" drives are derived from the Sony microfloppy first shipped in 1982, with modifications to achieve logical file organization similar to the larger diskette drives which preceded it in the market.

The few remaining drives with capacities of one megabyte or less use 6,250 bytes per track, the same track capacity as "double density" 5.25" diskettes, and also use 40 or 80 tracks per side to maintain file compatibility with 5.25" diskettes. 1.2 and 1.44 megabyte 3.5" drives were announced in 1985, and are intended for use with the high density media originally proposed by Sony, which operates at up to 17,434 BPI, and uses the 135 TPI standard of today's production drives. All current 1.2 and 1.44 megabyte drives claim "downward compatibility", the ability to read and write on lower capacity diskettes. 1.2 megabyte 3.5" drives are compatible with NEC drives used with personal computers in the domestic Japanese market. After the adoption of 1.44 megabyte drives by IBM in April, 1987, for the PS/2 systems, most major manufacturers of microfloppy drives added drives with the same capacity.

Manufacturers of 3.5" floppy drives have also made the transition from the earlier 41.3 millimeter high drives ("half high", in 5.25" drive terms) to the 25.4 millimeter (one inch) high drives pioneered by Citizen in 1984. Citizen's floppy drive packaging innovations prompted many companies to follow the firm's introduction of thinner drives in the 17-19 millimeter (3/4 inch) high range in 1989 and 15 millimeters in 1991. This trend culminated in TEAC's introduction of 12.7 millimeter (one half inch) high drives for shipment later in 1991 -- which, in turn, prompted many other drive manufacturers to join the movement to half inch high floppy drives. Citizen did not match the 12.7 millimeter height, but lowered the height on its later models to 10.9 millimeters.

In addition to the substantial notebook computer market for thin 3.5" floppy drives, their availability has made it possible for manufacturers to offer the drives in combination packages with other products, initially with 5.25" floppy drives. In 1994, TEAC announced a 3.5" floppy/CD-ROM drive combination with 41.3 millimeter height, and 3.5" floppy/PCMCIA card slot combinations with 25.4 millimeter heights were announced by Mitsumi Electric and others.

The 3" microfloppy format which was produced in quantity for several years has lost all of its original adherents including the last holdout, Matsushita Electronic Components, and is now out of production. 2" drives, in a data recording version of a video camera floppy, were produced during recent years by Sony, but found a limited market. Initial shipments of 2" drives with notebook computers encountered resistance from buyers who did not want to bother with interchange problems, and there were not enough applications in home computers, electronic typewriters and games to maintain growth for the 2" format. While there may eventually be a future for a 2" or smaller floppy format, most of the drive manufacturers do not appear to be interested.

Market status

Although 5.25" floppy drive shipments have been declining rapidly, demand from the strong personal computer market has been high enough to maintain overall growth in total shipments of flexible disk drives. 82.2 million floppy drives were shipped in 1995 and the total for 1996 is estimated at 89.7 million, up 9.1%. It is a different story, however, for total sales revenues, which suffer from a continuing decline resulting from ever-lower average unit prices and the phaseout of 5.25" models. The 1996 revenue total is estimated at $1.888 billion, the latest annual reduction from 1992's $2.6 billion.

After more than a decade of high volume unit shipments, 5.25" floppy drives started a pattern of decline in 1993. 3.5" floppy drives passed up 5.25" drives in shipments in 1988, but 5.25" models continued in high demand for several more years, driven by the need for owners of new personal computers with 3.5" floppy drives to interchange data with older systems. However, the personal computer industry's movement to newer processors and improved software has stimulated the rapid replacement of older systems in recent years, and the percentage of personal computer buyers who need 5.25" floppy drives for interchange is dropping rapidly. Worldwide unit shipments of 5.25" floppy drives declined 45.5% in 1995, and the reduction in unit shipments for 1996 is estimated at 78.8%, to 1.1 million drives, only 1.3% of the total for all floppy disk drives.

One inch high (25.4 millimeter) 3.5" floppy drives became the dominant form factor several years ago, and have shown continuing strength in the face of competition from new drives in thinner physical formats. Intense competition has come from drives with smaller heights -- initially 19 millimeters, then 17 millimeters, 15 millimeters, then in late 1991 12.7 millimeters, and more recently down to 10.9 millimeters. 3.5" drives in packages 12.7 millimeters thick now constitute most of the 3.5" drive shipments for models less than one inch high, which collectively provided 13.6% of the 1995 3.5" overall total.

The average unit price for 3.5" floppy drives continues to fall. The reasons for the continuing price decline are pressure from system manufacturers for the lowest possible price, extensive product redesign for cost reduction, and the movement of most Japanese floppy drive manufacturing to offshore production sites with lower costs. The average OEM price for all 3.5" floppy drives was $59 in 1988, $51 in 1989, $46 in 1990, $42 in 1991, $38 in 1992, $34 in 1993, $27 in 1994 and $22 in 1995. In 1996 the overall OEM average unit price for 3.5" floppy drives is expected to be $19, with the standard one inch high models a dollar or two lower.

1995 shipments of 1.2/1.44 megabyte drives provided 99.3% of the total of all 3.5" floppy drive formats, and the 1996 share for these drives is expected to reach 98.6% of the worldwide total for low capacity flexible disk drives. The 1.44 megabyte 3.5" models which originated in 1985 and are now offered by nearly all major floppy drive manufacturers have become the industry's major products, originally stimulated by IBM's 1987 adoption of 1.44 megabyte drives for PS/2 personal computers. The similar 1.2 megabyte drives are used mostly in Japan, primarily by NEC and with computers designed to be compatible with NEC's personal computer product line.

IBM's adoption of the 2.88 megabyte microfloppy format in 1991 for numerous PS/2 personal computer models inspired a flurry of product introductions, but the 2.88 megabyte format has proven to be a failure. Most floppy drive manufacturers had expected 2.88 megabyte drives to become an important part of the industry, but shipments peaked at only 1.6 million drives in 1993, and have declined rapidly. The major negative influence holding down wider usage was the 2.88 megabyte drives' higher selling price, combined with low awareness of the drives' higher capacity among computer users. Since personal computer system manufacturers did not notice significant demand for 2.88 megabyte floppy drives, few manufacturers included them in new PC systems, and those that offered 2.88 megabyte drives classified them as options, not standard equipment.

Business personal computer applications continue to dominate unit shipments of low capacity floppy drives, with 93% of the worldwide total in 1995. However, business personal computer applications are expected to take a somewhat smaller share of 1999's total shipments, declining to 85%, as consumer and hobby applications rise to 13% of the 1999 total of low capacity floppy drive shipments.

TEAC continued to lead in noncaptive floppy drive shipments in 1995, based on strong shipments in both 3.5" and 5.25" formats, with 16.3 million drives, 20.2% of the worldwide total. Mitsumi Electric retained second place with 15.2 million drives, also a combination of 3.5" and 5.25" models, 18.8% of the total. Sony held third place with 11.7 million drives, all 3.5", for 14.5%.

Marketing trends

While the decline of 5.25" drives has imposed limits on overall floppy drive shipment totals in recent years, growth in annual shipments of 3.5" drives has remained strong, following the increasing size of the personal computer market. However, this pattern is expected to change. Declining utilization of floppy drives in lightweight notebook computers and competitive inroads by high capacity floppy drives in both notebook and desktop personal computers will impact the growth rate for 3.5" low capacity floppy drives. Following several years of annual shipment increases in the 20% range, 3.5" drives grew 17.0% in 1995 and the 1996 increase is estimated at 15.3%. By 1999, an annual shipment increase of only 2.6% is projected for 3.5" low capacity floppy drives.

Total sales revenues for low capacity floppy drives are forecasted to decline to $1.7 billion in 1999, depressed by declining shipments of higher priced drive models, and especially by continued reductions in the noncaptive average unit price for mainstream one inch high 3.5" drives. Noncaptive drive price levels are expected to continue the long-term trend to lower levels, as the result of intense competition between leading Japanese floppy drive manufacturers and the lower costs these manufacturers are achieving as they fine-tune the manufacturing facilities established during recent years in the Philippines, Malaysia, Thailand, and China. The overall average unit OEM price for 3.5" floppy drives is forecasted to be only $14 in 1999.

There is a trend for some notebook computers to be designed without internal floppy drives, relying on other methods of interchange, such as direct or infrared connections to networks. Although the increasing population of CD-ROM drives in the personal computer and workstation markets will absorb a portion of the software distribution role traditionally held by floppies, CD-ROM penetration of these markets by itself is not expected to have a significant impact on shipments of floppy drives, which provide a unique low cost interchange medium. However, many of the high capacity 3.5" floppy drives in the 100+ megabyte range now entering the market will displace low capacity 3.5" floppy drives. Some of the announced high capacity 3.5" floppy drives will be available in packages less than one inch thick and will offer backward compatibility to low capacity diskettes, and when used will clearly be installed in lieu of a low capacity 3.5" floppy drive.

The future for drives with heights less than one inch is a mixed picture. Most floppy drive manufacturers have discontinued drives in the 15-19 millimeter height range. Demand for 10.9-12.7 millimeter high floppy drives is driven mostly by the continuing expansion of the notebook computer market, which now employs floppies limited to this height range. However, in addition to the direct network connections now used with selected notebook computers, some others are being packaged in ever-smaller form factors, accelerating the tendency to eliminate the floppy drive in the smaller implementations, relying for interchange on network connections or on externally attached floppy drives. Growth in total shipments of drives less than one inch high is expected to decline in the 1997-99 period.

The movement to smaller, lower weight notebook computers has been slow, due to the existing limitations of screens and batteries, but the expected improvements in these components will eventually make lighter weight systems feasible, strengthening the movement to eliminate the internal floppy drive from notebook computers by the end of this forecast period. The smaller market for packaging thin floppy drives in combination units with CD-ROM drives, PCMCIA card slots and other devices is not expected to provide enough momentum to sustain the current unit shipment growth rate for 3.5" floppy disk drives less than one inch high.

Technical trends

As attempts to upgrade the standard floppy disk drive configurations with increased capacity have failed, the product development targets for all remaining manufacturers of low capacity floppy drives have become cost reduction. Intense activity has resulted in lower costs through reduction of electronic and mechanical parts counts, and through substitution of alternate materials.

The industry's failure to reduce costs fast enough for the 2.88 megabyte 3.5" drive prevented it from becoming a mainstream product. The biggest problem was the greater complexity and higher costs associated with the multifunction head required to provide downward compatibility with .7 and 1.44 megabyte drives. The result was 2.88 megabyte drives with selling prices twice those of standard 1.44 megabyte 3.5" floppy drives -- and a distinct lack of enthusiasm by most manufacturers of personal computers.

The next challenges for most manufacturers of 3.5" drives are packaging problems in reducing the height of the drive to meet the demand for half inch high drives -- and to hold down costs at the same time. It has been very expensive and technically difficult for most manufacturers to match competition with continually smaller drive configurations. Nevertheless, the changes have been achievable, once production of smaller motors and other key components became available. The thinner drive configurations made possible the initial announcements in 1994 of combination packages of 3.5" floppy drive/CD-ROM drive and 3.5" floppy drive/PCMCIA card slot combinations. However, the floppy drive manufacturers' attempts to retain as much of a market with manufacturers of notebook computers as possible will provide a continuing incentive to reduce the production costs of floppy drives 12.7 millimeters or less in thickness to levels much closer to those one inch high drives.

Many manufacturers have found it convenient to use belt drive arrangements instead of the direct drive motors common with most of today's floppy drives and preferred by the majority of system manufacturers. Several small format drives using direct drive motors have been announced, but considerable effort will probably be expended to explore various mechanical designs before an industry consensus on this point is reached.

Forecasting assumptions

1. Shipments of 3.5" drives with heights less than one inch will decline after 1997, and 1.44 megabyte drives will maintain shipment dominance through 1999.

2. No major personal computer manufacturer will utilize 2.88 megabyte drives as a standard for its product lines.

3. 1998 will be the last year of production for 8" and 5.25" floppy drives.

4. A positive growth rate for personal computers will continue through 1999.

5. The dollar/yen exchange rate will stay in the current range, and prices for noncaptive 3.5" drives will continue to decline at the forecasted rate.

TABLE 52

LOW CAPACITY FLEXIBLE 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										
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	153.6	--	221.5	19.9	205.0	27.8	190.2	33.5	170.9
PCM/Distributor	227.3	466.6	204.4	422.8	179.9	418.7	172.2	409.8	158.7	387.1
OEM/Integrator	485.4	1,362.5	423.1	1,243.8	411.7	1,228.9	403.6	1,210.0	384.5	1,154.0
TOTAL NON-U.S. REVENUES	712.7	1,982.7	627.5	1,888.1	611.5	1,852.6	603.6	1,810.0	576.7	1,712.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	712.7	1,982.7	627.5	1,888.1	611.5	1,852.6	603.6	1,810.0	576.7	1,712.0
OEM Average Price ($000)		.022		.019		.017		.016		.014

TABLE 53

LOW CAPACITY FLEXIBLE 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	--	1,520.0	--	2,921.0	310.0	3,180.0	470.0	3,210.0	625.0	3,170.0
PCM/Distributor	9,779.0	20,125.0	11,095.0	22,795.0	10,555.0	24,555.0	10,745.0	25,585.0	10,575.0	25,800.0
OEM/Integrator	21,995.0	60,580.0	22,153.0	64,012.0	23,881.0	70,334.0	25,302.0	74,753.0	26,105.0	77,230.0
TOTAL NON-U.S. SHIPMENTS	31,774.0	82,225.0	33,248.0	89,728.0	34,746.0	98,069.0	36,517.0	103,548.0	37,305.0	106,200.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	31,774.0	82,225.0	33,248.0	89,728.0	34,746.0	98,069.0	36,517.0	103,548.0	37,305.0	106,200.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	250.4	563.0	283.7	652.7	318.4	750.8	355.0	854.3	392.3	960.5

TABLE 54

LOW CAPACITY FLEXIBLE DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues			Forecast 1996			Forecast 1997			Forecast 1998			Forecast 1999
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	3.5"
U.S. MANUFACTURERS													
TOTAL U.S. REVENUES	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS													
Captive	1.0	3.5	149.1	.3	.9	220.3	--	--	205.0	--	--	190.2	170.9
PCM/Distributor	--	101.7	364.9	--	19.2	403.6	--	2.9	415.8	--	.6	409.2	387.1
OEM/Integrator	4.7	72.5	1,285.3	3.3	13.8	1,226.7	2.2	2.9	1,223.8	.9	.5	1,208.6	1,154.0
TOTAL NON-U.S. REVENUES	5.7	177.7	1,799.3	3.6	33.9	1,850.6	2.2	5.8	1,844.6	.9	1.1	1,808.0	1,712.0
WORLDWIDE RECAP													
Captive	1.0	3.5	149.1	.3	.9	220.3	--	--	205.0	--	--	190.2	170.9
	-63.0%	-69.0%	-24.6%	-70.0%	-74.3%	+47.8%	--	--	-6.9%	--	--	-7.2%	-10.1%
PCM/Distributor	--	101.7	364.9	--	19.2	403.6	--	2.9	415.8	--	.6	409.2	387.1
	--	-12.1%	+18.6%	--	-81.1%	+10.6%	--	-84.9%	+3.0%	--	-79.3%	-1.6%	-5.4%
OEM/Integrator	4.7	72.5	1,285.3	3.3	13.8	1,226.7	2.2	2.9	1,223.8	.9	.5	1,208.6	1,154.0
	+9.3%	-69.9%	-9.2%	-29.8%	-81.0%	-4.6%	-33.3%	-79.0%	-.2%	-59.1%	-82.8%	-1.2%	-4.5%
Total Revenues	5.7	177.7	1,799.3	3.6	33.9	1,850.6	2.2	5.8	1,844.6	.9	1.1	1,808.0	1,712.0
	-18.6%	-51.7%	-6.3%	-36.8%	-80.9%	+2.9%	-38.9%	-82.9%	-.3%	-59.1%	-81.0%	-2.0%	-5.3%
ANNUAL SHARE, BY DIAMETER	.3%	9.0%	90.7%	.2%	1.8%	98.0%	.1%	.3%	99.6%	--	.1%	99.9%	100.0%

TABLE 55

LOW CAPACITY FLEXIBLE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments			Forecast 1996			Forecast 1997			Forecast 1998			Forecast 1999
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	3.5"
U.S. MANUFACTURERS													
TOTAL U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--	--	--	--
NON-U.S. MANUFACTURERS													
Captive	3.0	37.0	1,480.0	1.0	10.0	2,910.0	--	--	3,180.0	--	--	3,210.0	3,170.0
PCM/Distributor	--	3,112.0	17,013.0	--	700.0	22,095.0	--	115.0	24,440.0	--	25.0	25,560.0	25,800.0
OEM/Integrator	18.0	2,199.0	58,363.0	12.0	425.0	63,575.0	8.0	96.0	70,230.0	3.0	20.0	74,730.0	77,230.0
TOTAL NON-U.S. SHIPMENTS	21.0	5,348.0	76,856.0	13.0	1,135.0	88,580.0	8.0	211.0	97,850.0	3.0	45.0	103,500.0	106,200.0
WORLDWIDE RECAP													
Captive	3.0	37.0	1,480.0	1.0	10.0	2,910.0	--	--	3,180.0	--	--	3,210.0	3,170.0
	-57.1%	-63.4%	-27.5%	-66.7%	-73.0%	+96.6%	--	--	+9.3%	--	--	+.9%	-1.2%
PCM/Distributor	--	3,112.0	17,013.0	--	700.0	22,095.0	--	115.0	24,440.0	--	25.0	25,560.0	25,800.0
	--	+.3%	+47.1%	--	-77.5%	+29.9%	--	-83.6%	+10.6%	--	-78.3%	+4.6%	+.9%
OEM/Integrator	18.0	2,199.0	58,363.0	12.0	425.0	63,575.0	8.0	96.0	70,230.0	3.0	20.0	74,730.0	77,230.0
	-5.3%	-66.7%	+12.1%	-33.3%	-80.7%	+8.9%	-33.3%	-77.4%	+10.5%	-62.5%	-79.2%	+6.4%	+3.3%
Total Shipments	21.0	5,348.0	76,856.0	13.0	1,135.0	88,580.0	8.0	211.0	97,850.0	3.0	45.0	103,500.0	106,200.0
	-19.2%	-45.5%	+17.0%	-38.1%	-78.8%	+15.3%	-38.5%	-81.4%	+10.5%	-62.5%	-78.7%	+5.8%	+2.6%
ANNUAL SHARE, BY DIAMETER	--	6.5%	93.5%	--	1.3%	98.7%	--	.2%	99.8%	--	--	100.0%	100.0%

TABLE 56

LOW CAPACITY 3.5" FLEXIBLE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

DRIVE HEIGHT ANALYSIS

	1995 Shipments Units	1995 %	Forecast 1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %	1999 Units	1999 %
U.S. MANUFACTURERS										
Total U.S.	--		--		--		--		--	
NON-U.S. MANUFACTURERS										
Captive Total	1,480.0		2,910.0		3,180.0		3,210.0		3,170.0	
Less than 1 inch	905.0	61.1%	890.0	30.6%	910.0	28.6%	830.0	25.9%	620.0	19.6%
1 inch	575.0	38.9%	2,020.0	69.4%	2,270.0	71.4%	2,380.0	74.1%	2,550.0	80.4%
Noncaptive Total	75,376.0		85,670.0		94,670.0		100,290.0		103,030.0	
Less than 1 inch	9,533.0	12.6%	11,010.0	12.9%	12,250.0	12.9%	11,790.0	11.8%	10,885.0	10.6%
1 inch	65,843.0	87.4%	74,660.0	87.1%	82,420.0	87.1%	88,500.0	88.2%	92,145.0	89.4%
Total Non-U.S.	76,856.0		88,580.0		97,850.0		103,500.0		106,200.0	
Less than 1 inch	10,438.0	13.6%	11,900.0	13.4%	13,160.0	13.4%	12,620.0	12.2%	11,505.0	10.8%
1 inch	66,418.0	86.4%	76,680.0	86.6%	84,690.0	86.6%	90,880.0	87.8%	94,695.0	89.2%
WORLDWIDE SHIPMENTS										
Total Worldwide Shipments	76,856.0		88,580.0		97,850.0		103,500.0		106,200.0	
	+17.0%		+15.3%		+10.5%		+5.8%		+2.6%	
Less than 1 inch	10,438.0	13.6%	11,900.0	13.4%	13,160.0	13.4%	12,620.0	12.2%	11,505.0	10.8%
	-8.7%		+14.0%		+10.6%		-4.0%		-8.7%	
1 inch	66,418.0	86.4%	76,680.0	86.6%	84,690.0	86.6%	90,880.0	87.8%	94,695.0	89.2%
	+22.5%		+15.5%		+10.4%		+7.3%		+4.2%	

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

TABLE 57

LOW CAPACITY 3.5" FLEXIBLE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

DRIVE CAPACITY ANALYSIS

	1995 --Shipments--		Forecast -----1996-----		-----1997-----		-----1998-----		-----1999-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
U.S. MANUFACTURERS										
Total U.S.	--		--		--		--		--	
NON-U.S. MANUFACTURERS										
Captive Total	1,480.0		2,910.0		3,180.0		3,210.0		3,170.0	
1.2/1.44 Megabytes	1,480.0	100.0%	2,910.0	100.0%	3,180.0	100.0%	3,210.0	100.0%	3,170.0	100.0%
Noncaptive Total	75,376.0		85,670.0		94,670.0		100,290.0		103,030.0	
.7 Megabyte or less	270.0	.4%	45.0	.1%	10.0	--	--	--	--	--
1.2/1.44 Megabytes	74,841.0	99.2%	85,530.0	99.8%	94,660.0	100.0%	100,290.0	100.0%	103,030.0	100.0%
2.88 Megabytes	265.0	.4%	95.0	.1%	--	--	--	--	--	--
Total Non-U.S.	76,856.0		88,580.0		97,850.0		103,500.0		106,200.0	
.7 Megabyte or less	270.0	.4%	45.0	.1%	10.0	--	--	--	--	--
1.2/1.44 Megabytes	76,321.0	99.3%	88,440.0	99.8%	97,840.0	100.0%	103,500.0	100.0%	106,200.0	100.0%
2.88 Megabytes	265.0	.3%	95.0	.1%	--	--	--	--	--	--
WORLDWIDE SHIPMENTS										
Total Worldwide Shipments	76,856.0		88,580.0		97,850.0		103,500.0		106,200.0	
	+17.0%		+15.3%		+10.5%		+5.8%		+2.6%	
.7 Megabyte or less	270.0	.4%	45.0	.1%	10.0	--	--	--	--	--
	-65.5%		-83.2%		-77.7%		--		--	
1.2/1.44 Megabytes	76,321.0	99.3%	88,440.0	99.8%	97,840.0	100.0%	103,500.0	100.0%	106,200.0	100.0%
	+19.2%		+15.9%		+10.6%		+5.8%		+2.6%	
2.88 Megabytes	265.0	.3%	95.0	.1%	--	--	--	--	--	--
	-69.6%		-64.1%		--		--		--	

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

TABLE 58

LOW CAPACITY FLEXIBLE 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	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS Midrange systems and network servers	707.1	.9	318.6	.3
PERSONAL COMPUTERS Business and professional, single user	76,526.8	93.0	90,270.0	85.0
WORKSTATIONS Engineering and office, single user	1,677.4	2.0	1,593.0	1.5
CONSUMER, GAME AND HOBBY COMPUTERS	2,935.4	3.6	13,806.0	13.0
OTHER APPLICATIONS	378.3	.5	212.4	.2
Total	82,225.0	100.0	106,200.0	100.0

TABLE 59

LOW CAPACITY FLEXIBLE 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	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
TEAC	--	510.0	6550.0	7060.0	22.2	--	1735.0	14574.0	16309.0	20.2
Mitsumi Electric	--	383.0	3625.0	4008.0	12.6	--	871.0	14289.0	15160.0	18.8
Sony	--	--	6070.0	6070.0	19.1	--	--	11710.0	11710.0	14.5
Seiko Epson	--	575.0	3040.0	3615.0	11.4	--	1040.0	7135.0	8175.0	10.1
Matsushita Comm Ind.	--	66.0	1475.0	1541.0	4.8	--	682.0	6665.0	7347.0	9.1
Alps Electric	--	--	1855.0	1855.0	5.8	--	--	3935.0	3935.0	4.9
Citizen	--	--	715.0	715.0	2.3	--	--	3180.0	3180.0	3.9
Y-E Data	13.0	45.0	1140.0	1198.0	3.8	18.0	90.0	3030.0	3138.0	3.9
Matsushita Elec. Ind.	--	--	917.0	917.0	2.9	--	--	1965.0	1965.0	2.4
Chinon	--	210.0	1090.0	1300.0	4.1	--	300.0	1530.0	1830.0	2.3
NEC	--	160.0	570.0	730.0	2.3	--	218.0	1455.0	1673.0	2.1
Other U.S.	--	--	--	--	--	--	--	--	--	--
Other Non-U.S.	--	55.0	2710.0	2765.0	8.7	--	375.0	5908.0	6283.0	2.0
TOTAL	13.0	2004.0	29757.0	31774.0	100.0	18.0	5311.0	75376.0	80705.0	100.0

FLASH CARD SPECIFICATIONS

FLASH CARD SPECIFICATIONS

Coverage

This product specification section of the Removable Data Storage report includes flash cards packaged in PC Card format and the new smaller formats, all of which are now in production or announced, arranged alphabetically by manufacturer.

Specifications of flash card models sold by computer system manufacturers but purchased on an OEM basis from others may be included in a few cases for clarity. Not listed in most cases are captive cards which are similar to OEM models made by the same manufacturer. In some cases, cards made by one card manufacturer and resold by another card manufacturer may be included for identification purposes.

Generic product type

Flash memory cards are categorized as "Flash disk" if organized as a disk drive, and "Flash memory" otherwise. The flash memory category is often called "Linear flash memory".

Chip density and chip count

Chip density is the number of bits contained on each of the several memory chips included in the flash card, expressed in mega<u>bits</u>. Chip count is the number of memory chips on the card.

Chip logic

Chip logic describes the basic logical architecture of the memory chip, typically NAND or NOR. Minor variations are assigned to the basic architecture.

Chip organization

This parameter describes how the chip is addressed by its controller. In the case of flash memory, it is by word width and the number of words on the chip, e.g. 1 x 8 is 1 million 8 bit words, .512 x 16 is 512,000 16 bit words, etc. Some flash memory cards can operate in more than one mode. In the case of flash disks, three parameters are given that are equivalent to heads, sectors and cylinders on an equivalent disk drive.

Package

Package refers to the PC Card standard form factor used for the card or to a sub-PC Card packaging format such as Compact Flash, SSFDC or Miniature Card.

Interface

Interfaces are defined according to the PCMCIA definition. Flash disk cards are designated as PCMCIA-ATA. Flash memory is designated with the PCMCIA revision level specified by each of the manufacturers. If the card does not conform to PCMCIA interface specifications, it is designated by the width of the data transfer path, (in bits, if given by the manufacturer) or as "Proprietary".

XIP

XIP (execute in place) is a capability of most flash memory cards that enables the card to appear as additional main memory to the host system.

Erasable block size

The erasable block size given is for individual chips except where noted. Card manufacturers may provide for simultaneous erasure of chips in pairs or other multiple units.

Capacity

Formatted capacities for flash disk cards have been shown in order to be consistent with the disk drive industry's trend in recent years to identify all drives by formatted capacities. Flash memory capacity is given in unformatted form, since formatting applies only when a flash memory card is used with flash file system software.

Sector endurance, spare sectors and wearout leveling

A flash memory segment or sector can be erased and rewritten a limited number of times. As specified by the manufacturer, this is a minimum specification, and most cards will exceed the specification. In order to extend the life of the memory, writes are spread across the entire memory, minimizing the accumulation of write/erase events at any one location. This is called wearout leveling, and is functionally embedded in some flash cards. Cards without this feature must have wearout leveling provided by host driver software. Flash disk cards may have spare sectors supplied to accommodate a sector failure.

Average access time

In a flash card, the time between the issuance of a read command and the transmission of data to the host system. As used in this report, it is assumed that the card is not in a powered down or sleep mode when the command is given.

Internal data read rate

The rate at which data is transferred from the card memory chips to the card control logic.

Internal data write rate

Except as noted, internal write rates given are for individual chips and assumed the chip has already been erased. Card manufacturers may provide for simultaneous writes of multiple chips.

External transfer rate

This is the maximum rate at which data can be transferred between the on-card controller and the host system.

Block erase time

Flash memory must be erased one block at a time, and it must be erased before it can be written. This parameter is the time required to erase the smallest erasable block.

Accuracy

All information has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries were necessary. Your corrections will be most welcome and will be included in the next edition.

DISK/TREND product groups

In most cases the product groups used for individual flash memory cards are clear, but a few arbitrary decisions have been made. Note that all cards with capacities over 100 megabytes have been placed in the highest capacity group.

1996 DISK/TREND product groups for flash cards included in the Removable Data Storage report

Group number	Cards included
40.	Flash cards, less than 10 megabytes
41.	Flash cards, 10 - 25 megabytes
42.	Flash cards, 25 - 100 megabytes
43.	Flash cards, more than 100 megabytes

MANUFACTURER	ACTIONTEC	ACTIONTEC	ACTIONTEC	ACTIONTEC	ACTIONTEC
MODEL	ATA-4	ATA-8	FH002M-BN	FH004M-BN	FH008M-BN
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NAND	NAND	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA ATA		PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No		Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	Yes		None	None	None
CAPACITY: Total capacity (Mbytes)	4	8	2	4	8
SECTOR ENDURANCE: (Kcycles)			100	100	100
Spare sectors			--	--	--
Wearout leveling			--	--	--
PERFORMANCE: Avg. access time (ns)			70 (read)	70 (read)	70 (read)
Media read rate (MB/Sec)	8		10	10	10
Media write rate (MB/Sec)			.85	.85	.85
Burst transfer rate (MB/Sec)	20		10 (read)	10 (read)	10 (read)
Block erase time (ms)			300	300	300
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V, 3.3 V 12 V option	5 V, 3.3 V 12 V option	5 V, 3.3 V 12 V option
FIRST CUSTOMER SHIPMENT	3Q96	3Q96	1994	1994	1994
COMMENTS			Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 2 chips.

MANUFACTURER	ACTIONTEC	ACTIONTEC	ACTIONTEC	ACTIONTEC	ACTIONTEC
MODEL	FH0256K-BN	FH0512K-BN	ATA-12	ATA-16	ATA-20
DISK/TREND GROUP	40	40	41	41	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NAND	NAND	NAND
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type II	PC Card Type II
Interface	PCMCIA 2.1	PCMCIA 2.1			
XIP	No	No			
Erasable block size (KB)					
Internal ECC	None	None			
CAPACITY: Total capacity (Mbytes)	.256	.512	12	16	20
SECTOR ENDURANCE: (Kcycles)	100	100			
Spare sectors	--	--			
Wearout leveling	--	--			
PERFORMANCE: Avg. access time (ns)	200	200			
Media read rate (MB/Sec)	5	5			
Media write rate (MB/Sec)	.125	.125			
Burst transfer rate (MB/Sec)	5	5			
Block erase time (ms)	2000	2000			
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1994	1994	3Q96	3Q96	3Q96
COMMENTS	Intel Series 1 chips.	Intel Series 1 chips.			

MANUFACTURER	ACTIONTEC	ACTIONTEC	ACTIONTEC	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES
MODEL	FH010M-BN	FH016M-BN	FH024M-BN	Am MC002A	Am MC004A
DISK/TREND GROUP	41	41	41	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)				8	16
Chip count per card				2	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization				1 x 8	2 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	Miniature Card	Miniature Card
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	Minicard 1.1	Minicard 1.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)				64	64
Internal ECC	None	None	None	--	--
CAPACITY: Total capacity (Mbytes)	10	16	24	2	4
SECTOR ENDURANCE: (Kcycles)	100	1000	1000	1000*	1000*
Spare sectors	--	--		--	--
Wearout leveling	--	--		--	--
PERFORMANCE: Avg. access time (ns)	70 (read)	150 (read)	150 (read)	150	150
Media read rate (MB/Sec)	10	10		13.3	13.3
Media write rate (MB/Sec)	.85	.85		.25	.25
Burst transfer rate (MB/Sec)	10 (read)	10 (read)			
Block erase time (ms)	300	300	300	1000	1000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6	3.5 x 38 x 33	3.5 x 38 x 33
OPERATING VOLTAGE:	5 V, 3.3 V 12 V option	5 V, 3.3 V 12 V option	5 V, 3.3 V 12 V option	5 V	5 V
FIRST CUSTOMER SHIPMENT	1994	1994	4Q95	4Q96	4Q96
COMMENTS	Intel Series 2 chips.	Intel Series 2+ chips.	Intel Series 2+ chips.	*100K minimum guaranteed.	*100K minimum guaranteed.

MANUFACTURER	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES
MODEL	Am MC008A	Am MCL002A	Am MCL004A	AMC001CFLKA	AMC002CFLKA
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM	OEM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	16	8	8	4	4
Chip count per card	4	2	4	2	4
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2 x 8	1 x 8	1 x 8	.512 x 8	.512 x 8
FEATURES: Package	Miniature Card	Miniature Card	Miniature Card	PC Card Type I	PC Card Type I
Interface	Minicard 1.1	Minicard 1.1	Minicard 1.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	64	64	64	64	64
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	8	2	4	1	2
SECTOR ENDURANCE: (Kcycles)	1000*	1000*	1000*	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	Software	Software
PERFORMANCE: Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)	13.3	13.3	13.3	13.3	13.3
Media write rate (MB/Sec)	.25	.25	.25	.125	.125
Burst transfer rate (MB/Sec)				--	--
Block erase time (ms)	1000	1000	1000	1500	1500
SIZE: (mm: H x W x D)	3.5 x 38 x 33	3.5 x 38 x 33	3.5 x 38 x 33	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	3 V	3 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96	5/94	5/94
COMMENTS	*100K minimum guaranteed.	*100K minimum guaranteed.	*100K minimum guaranteed.		

MANUFACTURER	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES	ADVANCED MICRO DEVICES
MODEL	AMC004CFLKA	AMC004DFLKA	AMC008DFLKA	AMC010CFLKA	AM020DFLKA
DISK/TREND GROUP	40	40	40	41	41
MARKET	OEM	OEM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	4	16	16	4	16
Chip count per card	8	2	4	20	10
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	.512 x 8	2 x 8	2 x 8	.512 x 8	2 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	64	64	64	64	64
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	4	4	8	10	20
SECTOR ENDURANCE: (Kcycles)	100	1000	1000	100	1000
Spare sectors	--	--	--	--	--
Wearout leveling	Software	Software	Software	Software	Software
PERFORMANCE: Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)	13.3	13.3	13.3	13.3	13.3
Media write rate (MB/Sec)	.125	.25	.25	.125	.25
Burst transfer rate (MB/Sec)	--	--	--	--	--
Block erase time (ms)	1500	1000	1000	1500	1000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	5/94	7/95	7/95	5/94	7/95
COMMENTS					

MANUFACTURER	AMP	AMP	AMP	AMP	AMP
MODEL	1-797459-1* 1-797459-2 FlashLite	1-797459-3* 1-797459-4 FlashLite	2-797132-5* 797132-1 Flash 5	2-797132-6* 797132-2 Flash 5	2-797132-7* 797132-3 Flash 5
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	16	1	1	1
Chip count per card	1	1	2	4	8
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization			8x.256/16x.128	8x.512/16x.256	8 x 1/16 x .512
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	8 bit	8 bit	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No	No	No
Erasable block size (KB)	128	64	.128/.512	.128/.512	.128/.512
Internal ECC	No		--	--	--
CAPACITY: Total capacity (Mbytes)	.128	2	.256	.512	1
SECTOR ENDURANCE: (Kcycles)	10	100			
Spare sectors	--	--	--	--	--
Wearout leveling	No	No	--	--	--
PERFORMANCE: Avg. access time (ns)	200	150	200	200	200
Media read rate (MB/Sec)			5	5	5
Media write rate (MB/Sec)			--	--	--
Burst transfer rate (MB/Sec)			--	--	--
Block erase time (ms)			--	--	--
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT			1Q94	1Q94	1Q94
COMMENTS	*Without AMP label. Atmel chips.	*Without AMP label. AMD chips.	*Without AMP label. Atmel chips.	*Without AMP label. Atmel chips.	*Without AMP label. Atmel chips.

MANUFACTURER	AMP	AMP	AMP	AMP	AMP
MODEL	2-797132-8* 797132-4 Flash 5	2-797262-5* 797262-1 Flash 5C	2-797262-6* 797262-2 Flash 5C	2-797262-7* 797262-3 Flash 5C	2-797262-8* 797262-4 Flash 5C
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	4	4	4	4
Chip count per card	16	2	4	8	16
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	8 x 2/16 x 1	8 x 1/16 x .512	8 x 2/16 x 1	8 x 4/16 x 2	8 x 8/16 x 4
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No	No	No
Erasable block size (KB)	.128/.512	.128/.512	.128/.512	.128/.512	.128/.512
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	2	1	2	4	8
SECTOR ENDURANCE: (Kcycles)					
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	200	200	200	200	200
Media read rate (MB/Sec)	5	5	5	5	5
Media write rate (MB/Sec)	--	--	--	--	--
Burst transfer rate (MB/Sec)	--	--	--	--	--
Block erase time (ms)	--	--	--	--	--
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	1Q94	1Q94	1Q94
COMMENTS	*Without AMP label. Atmel chips.	*Without AMP label. AMD chips.	*Without AMP label. AMD chips.	*Without AMP label. AMD chips.	*Without AMP label. AMD chips.

MANUFACTURER	AMP	AMP	AMP	AMP	AMP
MODEL	3-797078-7* 1-797078-1 Flash 12	3-797078-8* 1-797078-2 Flash 12	3-797078-9* 1-797078-3 Flash 12	3-797263-1* 797263-1 Flash 12HC	3-797263-2* 797263-2 Flash 12HC
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	2	2	2	8	8
Chip count per card	2	4	8	2	4
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	8 x 1/16 x .512	8 x 2/16 x 1	8x.512/16x.256		
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No		
Erasable block size (KB)	8	8	8		
Internal ECC	--	--	--	No	No
CAPACITY: Total capacity (Mbytes)	.512	1	2	2	4
SECTOR ENDURANCE: (Kcycles)	10	10	10		
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	No	No
PERFORMANCE: Avg. access time (ns)	200	200	200	200	200
Media read rate (MB/Sec)	5	5	5		
Media write rate (MB/Sec)	.065	.065	.065		
Burst transfer rate (MB/Sec)	--	--	--		
Block erase time (ms)	2000	2000	2000		
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	1Q94		
COMMENTS	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.

MANUFACTURER	AMP	AMP	AMP	AMP	AMP
MODEL	3-797263-3* 797263-3 Flash 12HC	3-797263-4* 797263-4 Flash 12HC	3-797441-1* 2-797441-1	3-797441-2* 2-797441-2	3-797441-3* 2-797441-3 FlashLite
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	8	1	4	4
Chip count per card	8	10	2	2	1
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	16 bit	16 bit	16 bit
XIP			No	No	No
Erasable block size (KB)			128	256/512	64
Internal ECC	No	No	No	No	
CAPACITY: Total capacity (Mbytes)	8	10	.256	1	.256
SECTOR ENDURANCE: (Kcycles)			10	10	100
Spare sectors	--	--	--	--	--
Wearout leveling	No	No	No	No	No
PERFORMANCE: Avg. access time (ns)	200	200	200	200	150
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT					
COMMENTS	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Atmel chips.	*Without AMP label. Atmel chips.	*Without AMP label. AMD chips.

MANUFACTURER	AMP	AMP	AMP	AMP	AMP
MODEL	3-797441-4* 2-797441-4 FlashLite	3-797441-5* 2-797441-5 FlashLite	3-797441-6* 2-797441-6 FlashLite	3-797441-7* 2-797441-7 FlashLite	3-797441-8* 2-797441-8 FlashLite
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	4	16	16	1	2
Chip count per card	4	2	4	1	1
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	16 bit	16 bit	16 bit	16 bit	16 bit
XIP	No	No	No	No	No
Erasable block size (KB)	64	64	64	128	256
Internal ECC	No	No	No	No	No
CAPACITY: Total capacity (Mbytes)	1	4	8	.256	.512
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	No	No	No	No	No
PERFORMANCE: Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)				2000	2000
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT					
COMMENTS	*Without AMP label. AMD chips.	*Without AMP label. AMD chips.	*Without AMP label. AMD chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.

MANUFACTURER	AMP	AMP	AMP	AMP	AMP
MODEL	3-797441-9* 2-797441-9 FlashLite	4-797078-0* 1-797078-5 Flash 12	4-797441-0* 3-797441-0 FlashLite	797459-1* 797459-6 FlashLite	797459-2* 797459-7 FlashLite
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	2	8	4	4
Chip count per card	2	16	4	1	1
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization		8 x 2/16 x 2			
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	16 bit	PCMCIA 2.1	16 bit	8 bit	8 bit
XIP	No	No	No	No	No
Erasable block size (KB)	64	8	64	256/512	64
Internal ECC	No	--	No	No	
CAPACITY: Total capacity (Mbytes)	2	4	4	.512	.512
SECTOR ENDURANCE: (Kcycles)	100	10	100	10	100
Spare sectors	--	--	--	--	--
Wearout leveling	No	--	No	No	No
PERFORMANCE: Avg. access time (ns)	150	200	150	200	150
Media read rate (MB/Sec)		5			
Media write rate (MB/Sec)		.065			
Burst transfer rate (MB/Sec)		--			
Block erase time (ms)	1600	2000	1600		
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3.3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V	5 V
FIRST CUSTOMER SHIPMENT					
COMMENTS	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Atmel chips.	*Without AMP label. AMD chips.

MANUFACTURER	AMP	AMP	AMP	AMP	CARRY COMPUTER
MODEL	797459-3* 797459-8 FlashLite	797459-4* 797459-9 FlashLite	797459-5* 1-797459-0 FlashLite	3-797263-5* 797263-5 Flash 12HC	2MB
DISK/TREND GROUP	40	40	40	41	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	2	8	8	8
Chip count per card	1	1	1	16	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					1 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	8 bit	8 bit	8 bit	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No		Yes
Erasable block size (KB)	128	256	64		128*
Internal ECC	No	No	No	No	None
CAPACITY: Total capacity (Mbytes)	.128	.256	1	16	2
SECTOR ENDURANCE: (Kcycles)	100	100	100		100
Spare sectors	--	--	--	--	None
Wearout leveling	No	No	No	No	--
PERFORMANCE: Avg. access time (ns)	150	150	150	200	200
Media read rate (MB/Sec)					5
Media write rate (MB/Sec)					.2*
Burst transfer rate (MB/Sec)					5
Block erase time (ms)	2000	2000	1600		1600
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT					1994
COMMENTS	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	*Without AMP label. Intel chips.	Intel Series 2 chips. *Chip pair.

MANUFACTURER	CARRY COMPUTER	CARRY COMPUTER	CARRY COMPUTER	CARRY COMPUTER	CARRY COMPUTER
MODEL	4MB	8MB	MCBF2048K2	MCBF4096K2	MCBF8192K2
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	8	1	1	1
Chip count per card	4	8	2	4	8
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	1 x 8	1 x 8	1 x 8	1 x 8	1 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes			
Erasable block size (KB)	128*	128*			
Internal ECC	None	None			
CAPACITY: Total capacity (Mbytes)	4	8	2	4	8
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	None	None			
Wearout leveling	--	--			
PERFORMANCE: Avg. access time (ns)	200	200	200	200	200
Media read rate (MB/Sec)	5	5			
Media write rate (MB/Sec)	.2*	.2*			
Burst transfer rate (MB/Sec)	5	5			
Block erase time (ms)	1600	1600			
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V			
FIRST CUSTOMER SHIPMENT	1994	1994			
COMMENTS	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 2 chips.

MANUFACTURER	CARRY COMPUTER	CARRY COMPUTER	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES
MODEL	16MB	MCBF16384K2	FL01M-15-111-31 Series 1	FL02M-15-111-31 Series 1	FL02M-20-111-81 Series 2
DISK/TREND GROUP	41	41	40	40	40
MARKET	OEM, PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	1	4	8	8
Chip count per card	16	16	8	8	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	1 x 8	1 x 8	8 x 1/16 x .512	8 x 2/8 x 1	
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes		No	No	Yes
Erasable block size (KB)	128*				
Internal ECC	None		--	--	--
CAPACITY: Total capacity (Mbytes)	16	16	1	2	2
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	None		--	--	--
Wearout leveling	--		--	--	--
PERFORMANCE: Avg. access time (ns)	200	200	150	150	150
Media read rate (MB/Sec)	5				
Media write rate (MB/Sec)	.2*				
Burst transfer rate (MB/Sec)	5				
Block erase time (ms)	1600		2000	2000	1600
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V		5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1994		1993	1993	1994
COMMENTS	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips.			

MANUFACTURER	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES
MODEL	FL04M-20-111-31 Series 1	FL04M-20-111-81 Series 2	FL08M-20-111-81 Series 2	FL256-15-111-31 Series 1	FL512-15-111-31 Series 1
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	8	8	1	2
Chip count per card	16	4	8	2	4
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	8 x 2/8 x 1			8x.256/16x.128	8x.512/16x.256
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	Yes	Yes	No	No
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	4	4	8	.256	.512
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)	2000	1600	1600	2000	2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1994	1994	1994	1993	1993
COMMENTS					

MANUFACTURER	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES	CENTENNIAL TECHNOLOGIES
MODEL	FMA05	FL16M-20-111-81 Series 2	FL20M-20-111-81 Series 2	FMA10	FMA20
DISK/TREND GROUP	40	41	41	41	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Memory	Flash Memory	Flash Disk	Flash Disk
Chip density (Mb)		16	16		
Chip count per card		8	10		
Chip logic type		NOR	NOR		
Chip organization					
FEATURES: Package	PC Card Type II	PC Card Type I	PC Card Type I	PC Card Type II	PC Card Type II
Interface	PCMCIA-ATA	PCMCIA 2.1	PCMCIA 2.1	PCMCIA-ATA	PCMCIA-ATA
XIP	No	Yes	Yes	No	No
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	5	16	20	10	20
SECTOR ENDURANCE: (Kcycles)		100	100		
Spare sectors		--	--		
Wearout leveling		--	--		
PERFORMANCE: Avg. access time (ns)					
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)		1600	1600		
SIZE: (mm: H x W x D)		3.3 x 54 x 85.6	3.3 x 54 x 85.6		
OPERATING VOLTAGE:		5 V, 12 V	5 V, 12 V		
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	CENTENNIAL TECHNOLOGIES	CIRRUS LOGIC	CIRRUS LOGIC	CIRRUS LOGIC	CIRRUS LOGIC
MODEL	FMA40	CL-FD0004	CL-FD0008	CL-FD0012	CL-FD0016
DISK/TREND GROUP	42	40	40	41	41
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)		16	16	16	16
Chip count per card		2	4	6	8
Chip logic type		NAND	NAND	NAND	NAND
Chip organization		1 x 256	1 x 256	1 x 256	1 x 256
FEATURES: Package	PC Card Type II	PC Card Type II	PC Card Type II	PC Card Type II	PC Card Type II
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)		16	16	16	16
Internal ECC	--	Yes	Yes	Yes	Yes
CAPACITY: Total capacity (Mbytes)	40	4	8	12	16
SECTOR ENDURANCE: (Kcycles)		250	250	250	250
Spare sectors		Yes	Yes	Yes	Yes
Wearout leveling		Yes	Yes	Yes	Yes
PERFORMANCE: Avg. access time (ns)		200	200	200	200
Media read rate (MB/Sec)		8	8	8	8
Media write rate (MB/Sec)		8	8	8	8
Burst transfer rate (MB/Sec)		16.6*	16.6*	16.6*	16.6*
Block erase time (ms)		5-10	5-10	5-10	5-10
SIZE: (mm: H x W x D)		5 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:		5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT		3Q95	3Q95	3Q95	3Q95
COMMENTS		Samsung chips. *PIO Mode 4. *DMA Mode 3.	Samsung chips. *PIO Mode 4. *DMA Mode 3.	Samsung chips. *PIO Mode 4. *DMA Mode 3.	Samsung chips. *PIO Mode 4. *DMA Mode 3.

MANUFACTURER	CIRRUS LOGIC	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM
MODEL	CL-FD0020	RD1001-2MS	RD1001-4MS	RD1001-8MS	RD1001-8MV
DISK/TREND GROUP	41	40	40	40	40
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	16				
Chip count per card	10				
Chip logic type	NAND	NAND	NAND	NAND	NAND
Chip organization	1 x 256				
FEATURES: Package	PC Card Type II	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA-ATA	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No				
Erasable block size (KB)	16	4	4	4	16
Internal ECC	Yes				
CAPACITY: Total capacity (Mbytes)	20	2	4	8	8
SECTOR ENDURANCE: (Kcycles)	250	250	250	250	250
Spare sectors	Yes				
Wearout leveling	Yes				
PERFORMANCE: Avg. access time (ns)	200	200	200	200	200
Media read rate (MB/Sec)	8	2.2	2.2	2.2	2.7
Media write rate (MB/Sec)	8	.5	.5	.5	2.7
Burst transfer rate (MB/Sec)	16.6*				
Block erase time (ms)	5-10				
SIZE: (mm: H x W x D)	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	3Q95	1994	1994	1994	1994
COMMENTS	Samsung chips. *PIO Mode 4. *DMA Mode 3.				

MANUFACTURER	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM
MODEL	RD3001-2	RD3001-4	RD3001-8	RD4001-1	RD4001-2
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Disk	Flash Disk
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA-ATA	PCMCIA-ATA
XIP					
Erasable block size (KB)					
Internal ECC					
CAPACITY: Total capacity (Mbytes)	2	4	8	1	2
SECTOR ENDURANCE: (Kcycles)	1000	1000	1000	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)					
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6	3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1995	1995	1995	1995	1995
COMMENTS	Atmel chips.	Atmel chips.	Atmel chips.	Atmel chips.	Atmel chips.

MANUFACTURER	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM
MODEL	RD4001-4	RD4001-8	RD1001-10MS	RD1001-16MS	RD1001-16MV
DISK/TREND GROUP	40	40	41	41	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NAND	NAND	NAND
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)			4	4	16
Internal ECC					
CAPACITY: Total capacity (Mbytes)	4	8	10	16	16
SECTOR ENDURANCE: (Kcycles)	100	100	250	250	250
Spare sectors	--	--			
Wearout leveling	--	--			
PERFORMANCE: Avg. access time (ns)			200	200	200
Media read rate (MB/Sec)			2.2	2.2	2.7
Media write rate (MB/Sec)			.5	.5	2.7
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3 x 54 x 85.6	3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1995	1995	1994	1994	1994
COMMENTS	Atmel chips.	Atmel chips.			

MANUFACTURER	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJI PHOTO FILM	FUJITSU
MODEL	RD1001-20MS	RD1001-24MS	RD1001-24MV	RD3001-16	MB98A8084X
DISK/TREND GROUP	41	41	41	41	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					1
Chip count per card					2
Chip logic type	NAND	NAND	NAND	NOR	NOR
Chip organization					8x.256/16x.128
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					No
Erasable block size (KB)	4	4	16		
Internal ECC					--
CAPACITY: Total capacity (Mbytes)	20	24	24	16	.256
SECTOR ENDURANCE: (Kcycles)	250	250	250	1000	10
Spare sectors				--	--
Wearout leveling				--	--
PERFORMANCE: Avg. access time (ns)	200	200	200		200
Media read rate (MB/Sec)	2.2	2.2	2.7		5
Media write rate (MB/Sec)	.5	.5	2.7		.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)					2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1994	1994	1994	1995	4Q92
COMMENTS				Atmel chips.	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
MODEL	MB98A8091X	MB98A8092X	MB98A8094X	MB98A8101X	MB98A8102X
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	2	1	1	2
Chip count per card	4	2	4	8	4
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	8x.512/16x.256	8x.512/16x.256	8x.512/16x.256	8 x 1/16 x .512	8 x 1/16 x .512
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No	No	No
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	.512	.512	.512	1	1
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	200	250	250
Media read rate (MB/Sec)	5	4	5	5	4
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)	2000	2000	2000	2000	2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	2Q92	1Q92	4Q93	4Q93	2Q93
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
MODEL	MB98A8104X	MB98A8111X	MB98A8112X	MB98A8113X	MB98A8114X
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	2	1	1
Chip count per card	8	16	16	2	16
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	8 x 1/16 x .512	8 x 2/16 x 1	8 x 2/16 x 1	8 x 2/16 x 1	8 x 2/16 x 1
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No		
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY:					
Total capacity (Mbytes)	1	2	2	2	2
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE:					
Avg. access time (ns)	200	200	250	200	200
Media read rate (MB/Sec)	5	5	4	5	5
Media write rate (MB/Sec)	.0625	.0625	.0625		.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)	2000	2000	2000	2000	2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	4Q93	4Q93	4Q93	1Q94	4Q93
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
MODEL	MB98A81183	MB98A8122X	MB98A8123X	MB98A81273	MB98A8133X
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	2	1	16	1
Chip count per card	8	16	4	16	8
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization		8 x 4/16 x 2	8 x 4/16 x 2		8 x 8/16 x 4
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes			Yes	
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	2	4	4	4	8
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	200	250	200
Media read rate (MB/Sec)	5	4	5	5	5
Media write rate (MB/Sec)	0.625	.0625	.0625	0.625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)	2000	2000	2000	2000	2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	4Q95	1Q94	1Q94	4Q95	1Q94
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	HYUNDAI
MODEL	MB98A81372	MB98A8143X	MB98A81471	MB98A81573	HYCFL001
DISK/TREND GROUP	40	41	41	42	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	16	8	16	16	4
Chip count per card	16	16	16	16	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization		8 x 16/16 x 8			.512 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	No	Yes	Yes	
Erasable block size (KB)					64
Internal ECC	--	--	--	--	No
CAPACITY:					
Total capacity (Mbytes)	8	16	16	32	1
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE:					
Avg. access time (ns)	250	200	250	250	150
Media read rate (MB/Sec)	5	5	5	5	6
Media write rate (MB/Sec)	0.625	.0625	0.625	0.625	.125
Burst transfer rate (MB/Sec)					
Block erase time (ms)	2000	2000	2000	2000	1000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	5V
FIRST CUSTOMER SHIPMENT	4Q95	1Q94	4Q95	3Q95	4Q96
COMMENTS				Not sold in US and Europe, except UK.	

MANUFACTURER	HYUNDAI	HYUNDAI	HYUNDAI	HYUNDAI	IBM MICRO-ELECTRONICS
MODEL	HYCFL002	HYCFLF16004	HYCFLF16008	HYCFLF16020	17JSSFB3MB
DISK/TREND GROUP	40	40	40	41	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	Captive,OEM,PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Disk
Chip density (Mb)	4	16	16	16	32
Chip count per card	4	2	4	10	1
Chip logic type	NOR	NOR	NOR	NOR	NAND
Chip organization	.512 x 8	2 x 8	2 x 8	2 x 8	
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type II
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA-ATA/IDE
XIP					No
Erasable block size (KB)	64	64	64	64	4
Internal ECC	No	No	No	No	Yes
CAPACITY:					
Total capacity (Mbytes)	2	4	8	20	3.5
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	250
Spare sectors	--	--	--	--	Yes
Wearout leveling	--	--	--	--	Yes
PERFORMANCE:					
Avg. access time (ns)	150	150	150	150	.8 ms
Media read rate (MB/Sec)	6	6	6	6	7
Media write rate (MB/Sec)	.125	.125	.125	.125	1.2
Burst transfer rate (MB/Sec)					9/4.5*
Block erase time (ms)	1000	1000	1000	1000	
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	5V	5V	5V	5V	3.3 V, 5 V
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96	4Q96	3Q96
COMMENTS					*At reduced power.

MANUFACTURER	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS
MODEL	17JSSFB7MB	17JSSFP2MB	17JSSFP3MB	17JSSFP5MB	17JSSFB10MB
DISK/TREND GROUP	40	40	40	40	41
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	16	16	16	32
Chip count per card	2	2	2	3	3
Chip logic type	NAND	NAND	NAND	NAND	NAND
Chip organization		32, 4, 32	48, 4, 32	80, 4, 32	
FEATURES: Package	PC Card Type II	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type II
Interface	PCMCIA-ATA/IDE	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA/IDE
XIP	No	No	No	No	No
Erasable block size (KB)	4	4	4	4	4
Internal ECC	Yes	Yes	Yes	Yes	Yes
CAPACITY: Total capacity (Mbytes)	7	2	3	5	10
SECTOR ENDURANCE: (Kcycles)	250	250	250	250	250
Spare sectors	Yes	Yes	Yes	Yes	Yes
Wearout leveling	Yes	Yes	Yes	Yes	Yes
PERFORMANCE: Avg. access time (ns)	.8 ms	.8 ms	.8 ms	.8 ms	.8 ms
Media read rate (MB/Sec)		7/4.3*/2.5**	7/4.3*/2.5**	7/4.3*/2.5**	
Media write rate (MB/Sec)		1.2/1*/.8*	1.2/1*/.8**	1.2/1*/.8**	
Burst transfer rate (MB/Sec)		8/4*/2**	8/4*/2**	8/4*/2**	
Block erase time (ms)		6	6	6	
SIZE: (mm: H x W x D)		3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	
OPERATING VOLTAGE:	3.3 V, 5 V	5 V	5 V	5 V	3.3 V, 5 V
FIRST CUSTOMER SHIPMENT	3Q96	5/94	5/94	5/94	3Q96
COMMENTS		Toshiba chips. *At reduced power. **At low power.	Toshiba chips. *At reduced power. **At low power.	Toshiba chips. *At reduced power. **At low power.	

MANUFACTURER	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS
MODEL	17JSSFB20MB	17JSSFI10MB	17JSSFI20MB	17JSSFP10MB	17JSSFP20MB
DISK/TREND GROUP	41	41	41	41	41
MARKET	Captive,OEM,PCM	OEM, PCM	OEM, PCM	Captive,OEM,PCM	Captive,OEM,PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	16	16	16	16
Chip count per card	5	5	10	6	11
Chip logic type	NAND	NAND	NAND	NAND	NAND
Chip organization				160, 4, 32	320, 4, 32
FEATURES: Package	PC Card Type II	1.3" IDE	1.3" IDE	PC Card Type I	PC Card Type I
Interface	PCMCIA-ATA/IDE	IDE	IDE	PCMCIA-ATA	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)	4	4	4	4	4
Internal ECC	Yes	Yes	Yes	Yes	Yes
CAPACITY: Total capacity (Mbytes)	20	10	20	10	20
SECTOR ENDURANCE: (Kcycles)	250	250	250	250	250
Spare sectors	Yes	Yes	Yes	Yes	Yes
Wearout leveling	Yes	Yes	Yes	Yes	Yes
PERFORMANCE: Avg. access time (ns)	.8 ms	.8 ms	.8 ms	.8 ms	.8 ms
Media read rate (MB/Sec)		7	7	7/4.3*/2.5**	7/4.3*/2.5**
Media write rate (MB/Sec)		1.2	1.2	1.2/1*/.8*	1.2/1*/.8**
Burst transfer rate (MB/Sec)		8	8	8/4*/2**	8/4*/2**
Block erase time (ms)		6	6	6	6
SIZE: (mm: H x W x D)		10.5 x 50.8 x 43.5	10.5 x 50.8 x 43.5	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	3.3 V, 5 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	3Q96			5/94	5/94
COMMENTS				Toshiba chips. *At reduced power. **At low power.	Toshiba chips. *At reduced power. **At low power.

MANUFACTURER	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS	IBM MICRO-ELECTRONICS
MODEL	17JSSFB40MB	17JSSFB60MB	17JSSFB80MB	17JSSFI36MB	17JSSFP30MB
DISK/TREND GROUP	42	42	42	42	42
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	Captive,OEM,PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	32	32	16	16
Chip count per card	11	15	20	18	16
Chip logic type	NAND	NAND	NAND	NAND	NAND
Chip organization					464, 4, 32
FEATURES: Package	PC Card Type II	PC Card II	PC Card II	1.3" IDE	PC Card Type II
Interface	PCMCIA-ATA/IDE	PCMCIA-ATA/IDE	PCMCIA-ATA/IDE	IDE	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)	4	4	4	4	4
Internal ECC	Yes	Yes	Yes	Yes	Yes
CAPACITY: Total capacity (Mbytes)	40	60	80	36	30
SECTOR ENDURANCE: (Kcycles)	250	250	250	250	250
Spare sectors	Yes	Yes	Yes	Yes	Yes
Wearout leveling	Yes	Yes	Yes	Yes	Yes
PERFORMANCE: Avg. access time (ns)	.8 ms	.8 ms	.8 ms	.8 ms	.8 ms
Media read rate (MB/Sec)		7	7	7	7/4.3*/2.5**
Media write rate (MB/Sec)		1.2	1.2	1.2	1.2/1*/.8*
Burst transfer rate (MB/Sec)		9/4.5*	9/4.5*	8	8/4*/2**
Block erase time (ms)				6	6
SIZE: (mm: H x W x D)		5 x 54 x 85.6	5 x 54 x 85.6	10.5 x 50.8 x 43.5	5 x 54 x 85.6
OPERATING VOLTAGE:	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	3Q96	3Q96	3Q96		5/94
COMMENTS		*At reduced power.	*At reduced power.		Toshiba chips. *At reduced power. **At low power.

MANUFACTURER	IBM MICRO-ELECTRONICS	INTEL	INTEL	INTEL	INTEL
MODEL	17JSSFP40MB	iFM002A	iFM004A	iMC002FLSC Value Series 100	iMC004FLSC Value Series 100
DISK/TREND GROUP	42	40	40	40	40
MARKET	Captive,OEM,PCM	OEM	OEM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	16	8	8	8	8
Chip count per card	21	2	4	2	4
Chip logic type	NAND	NOR	NOR	NOR	NOR
Chip organization	624, 4, 32	2 x 8*	2 x 8*	2 x 8	2 x 8
FEATURES: Package	PC Card Type II	Miniature Card	Miniature Card	PC Card Type I	PC Card Type I
Interface	PCMCIA-ATA	Minicard 1.1	Minicard 1.1	PCMCIA 1.0	PCMCIA 1.0
XIP	No	Yes	Yes	Yes	Yes
Erasable block size (KB)	4	64	64	64	64
Internal ECC	Yes	No	No	None	None
CAPACITY: Total capacity (Mbytes)	40	2	4	2	4
SECTOR ENDURANCE: (Kcycles)	250	100	100	100	100
Spare sectors	Yes	No	No	None	None
Wearout leveling	Yes	--	--	--	--
PERFORMANCE: Avg. access time (ns)	.8 ms	100/150	100/150	100	100
Media read rate (MB/Sec)	7/4.3*/2.5**	20/13**	20/13**	20	20
Media write rate (MB/Sec)	1.2/1*/.8*	.25/.12**	.25/.12**	0.33	0.33
Burst transfer rate (MB/Sec)	8/4*/2**	--	--	20	20
Block erase time (ms)	6	1.1/1.8**	1.1/1.8**	600	600
SIZE: (mm: H x W x D)	5 x 54 x 85.6	3.5 x 38 x 33	3.5 x 38 x 33	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5, 3.3*	5, 3.3*	5 V	5 V
FIRST CUSTOMER SHIPMENT	5/94	1996	1996	4Q95	4Q95
COMMENTS	Toshiba chips. *At reduced power. **At low power.	Write protect switch. *Chip pair. **5 V/3.3 V.	Write protect switch. *Chip pair. **5 V/3.3 V.		

MANUFACTURER	INTEL	INTEL	INTEL	INTEL	INTEL
MODEL	iMC008FLSC Value Series 100	iMC001FLKA Series 1	iMC002FLKA Series 1	iMC002FLSA Series 2	iMC004FLKA Series 1
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	1	2	8	2
Chip count per card	8	4	8	2	16
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2 x 8	2 x 8*	2 x 8*	2 x 8*	2 x 8*
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 1.0	PCMCIA 1.0	PCMCIA 1.0	PCMCIA 2.01	PCMCIA 1.0
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	64	512*	512*	64	N/A
Internal ECC	None	None	None	None	None
CAPACITY: Total capacity (Mbytes)	8	1	2	2	4
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	None	None	None	None	None
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	100	200	200	150	200
Media read rate (MB/Sec)	20	5	5	5	5
Media write rate (MB/Sec)	0.33	.1250*	.1250*	.2*	.1250*
Burst transfer rate (MB/Sec)	20	5	5	5	5
Block erase time (ms)	600	2000	2000	1600	2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	4Q95	1990	1990	2Q92	1990
COMMENTS		*Chip pair.	*Chip pair.	*Chip pair.	*Chip pair.

MANUFACTURER	INTEL	INTEL	INTEL	INTEL	INTEL
MODEL	iMC004FLSA Series 2	iMC004FLSP Series 2+	iMC010FLSA Series 2	iMC020FLSA Series 2	iMC020FLSP Series 2+
DISK/TREND GROUP	40	40	41	41	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	16	8	8	16
Chip count per card	4	2	10	20	10
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2 x 8*	2 x 8*	2 x 8*	2 x 8*	2 x 8*
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	64	64	64	64	64
Internal ECC	None	None	--	--	--
CAPACITY:					
Total capacity (Mbytes)	4	4	10	20	20
SECTOR ENDURANCE: (Kcycles)	100	1000	100	100	1000
Spare sectors	None	None	None	None	--
Wearout leveling	--	--	--	--	--
PERFORMANCE:					
Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)	5	13	5	5	13
Media write rate (MB/Sec)	.2*	.85	.2*	.2*	.85
Burst transfer rate (MB/Sec)	5	10 (Read)	5	5	13 (Read)
Block erase time (ms)	1600	300	1600	1600	300
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 or 3.3 V 12 V option	5 V, 12 V	5 V, 12 V	5 or 3.3 V 12 V option
FIRST CUSTOMER SHIPMENT	2Q92	1Q94	2Q92	2Q92	1Q94
COMMENTS	*Chip pair.	*Chip pair.	*Chip pair.	*Chip pair.	*Chip pair.

MANUFACTURER	INTEL	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY
MODEL	iMC040FLSP Series 2+	AJT-004M	AJT-008M	FJN2	FJN4
DISK/TREND GROUP	42	40	40	40	40
MARKET	OEM, PCM	PCM	PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Disk	Flash Disk	Flash Memory	Flash Memory
Chip density (Mb)	32				
Chip count per card	10				
Chip logic type	NOR			NOR	NOR
Chip organization	2 x 8*				
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.01	PCMCIA ATA/IDE	PCMCIA ATA/IDE	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	No	No	Yes	Yes
Erasable block size (KB)	64				
Internal ECC	--	Yes	Yes		
CAPACITY: Total capacity (Mbytes)	40	4	8	2	4
SECTOR ENDURANCE: (Kcycles)	1000			100	100
Spare sectors	--	Yes	Yes		
Wearout leveling	--	Yes	Yes		
PERFORMANCE: Avg. access time (ns)	150			250	250
Media read rate (MB/Sec)	13				
Media write rate (MB/Sec)	.85				
Burst transfer rate (MB/Sec)	13 (Read)				
Block erase time (ms)	300				
SIZE: (mm: H x W x D)	3.3 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 or 3.3 V 12 V option	5 V	5 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1Q94	1996	1996	1994	1994
COMMENTS	*Chip pair.				

MANUFACTURER	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY
MODEL	FJN8	FJP4	JV0124	JV0512	AJT-012M
DISK/TREND GROUP	40	40	40	40	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Disk
Chip density (Mb)		16			
Chip count per card		2			
Chip logic type	NOR	NOR	NOR	NOR	
Chip organization		2 x 8			
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA ATA/IDE
XIP	Yes	Yes	Yes	Yes	No
Erasable block size (KB)		64			
Internal ECC		--			Yes
CAPACITY: Total capacity (Mbytes)	8	4	1	.512	12
SECTOR ENDURANCE: (Kcycles)	100	1000			
Spare sectors		--			Yes
Wearout leveling		--			Yes
PERFORMANCE: Avg. access time (ns)	250	150		200	
Media read rate (MB/Sec)		.13			
Media write rate (MB/Sec)		.85			
Burst transfer rate (MB/Sec)		10 (Read)			
Block erase time (ms)		300			
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1994	1994	1994	1994	1996
COMMENTS					

MANUFACTURER	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY
MODEL	AJT-016M	AJT-020M	FJN10	FJN12	FJN16
DISK/TREND GROUP	41	41	41	41	41
MARKET	PCM	PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type			NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA ATA/IDE	PCMCIA ATA/IDE	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	Yes	Yes			
CAPACITY: Total capacity (Mbytes)	16	20	10	12	16
SECTOR ENDURANCE: (Kcycles)			100	100	100
Spare sectors	Yes	Yes			
Wearout leveling	Yes	Yes			
PERFORMANCE: Avg. access time (ns)			250	250	250
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	5 x 54 x 85.6	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1996	1996	1994	1994	1994
COMMENTS					

MANUFACTURER	KINGMAX TECHNOLOGY	KINGMAX TECHNOLOGY	M-SYSTEMS	M-SYSTEMS	M-SYSTEMS
MODEL	FJP20	FJP24	FlashCard-1M	FlashCard-2M	FlashCard-4M
DISK/TREND GROUP	41	41	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	16	16	8	8	8
Chip count per card			1	2	4
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2 x 8	2 x 8	1 x 8	1 x 8	1 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	64	64	128	128	128
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	20	24	1	2	4
SECTOR ENDURANCE: (Kcycles)	1000	1000	100	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)	13	13	12.5	12.5	12.5
Media write rate (MB/Sec)	.85	.85	.4	.4	.4
Burst transfer rate (MB/Sec)	13 (Read)	13 (Read)			
Block erase time (ms)	300	300	1600	1600	1600
SIZE: (mm: H x W x D)	5 x 54 x 85.6	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	3.3 to 5 V	3.3 to 5 V	3.3 to 5 V
FIRST CUSTOMER SHIPMENT	1994	1994			
COMMENTS					

MANUFACTURER	M-SYSTEMS	M-SYSTEMS	M-SYSTEMS	M-SYSTEMS	MAGICRAM
MODEL	FlashCard-8M	FlashCard-10M	FlashCard-20M	FlashCard-40M	FL2MBP100
DISK/TREND GROUP	40	41	41	42	40
MARKET	OEM	OEM	OEM	OEM	
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	8	8	8	8
Chip count per card	8	10	20	40	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	1 x 8	1 x 8	1 x 8	1 x 8	1 x 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	128	128	128	128	128*
Internal ECC	--	--	--	--	None
CAPACITY: Total capacity (Mbytes)	8	10	20	40	2
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	--	--	--	--	None
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	150	150	150	150	200
Media read rate (MB/Sec)	12.5	12.5	12.5	12.5	5
Media write rate (MB/Sec)	.4	.4	.4	.4	.2*
Burst transfer rate (MB/Sec)					5
Block erase time (ms)	1600	1600	1600	1600	1600
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	3.3 to 5 V	3.3 to 5 V	3.3 to 5 V	3.3 to 5 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT				3Q95	1992
COMMENTS					Intel Series 2 chips. *Chip pair.

MANUFACTURER	MAGICRAM	MAGICRAM	MAGICRAM	MAGICRAM	MAGICRAM
MODEL	FL4MBP100	FL8MBP100	FL10MP100	FL16MP100	FL20MP100
DISK/TREND GROUP	40	40	41	41	41
MARKET	PCM	PCM	PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8	8	8	8	8
Chip count per card	4	8	10	16	
Chip logic type	NOR	NOR	NOR	NOR	
Chip organization	1 x 8	1 x 8	1 x 8	1 x 8	
FEATURES: Package	PC Card I	PC Card I	PC Card I	PC Card I	PC Card I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)	128*	128*	128*	128*	128*
Internal ECC	None	None	None	None	None
CAPACITY: Total capacity (Mbytes)	4	8	10	16	20
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	None				
Wearout leveling	--				
PERFORMANCE: Avg. access time (ns)	200	200	200	200	200
Media read rate (MB/Sec)	5	5	5	5	5
Media write rate (MB/Sec)	.2*	.2*	.2*	.2*	.2*
Burst transfer rate (MB/Sec)	5	5	5	5	5
Block erase time (ms)	1600	1600	1600	1600	1600
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1992	1992	1992	1992	1992
COMMENTS	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips. *Chip pair.	Intel Series 2 chips. *Chip pair.

MANUFACTURER	MAGICRAM	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
MODEL	FL40MP100	BN-002AA-L	BN-004AA-L	BN-011HFRE	BN-01MHFRE
DISK/TREND GROUP	42	40	40	40	40
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Disk	Flash Disk	Flash Memory	Flash Memory
Chip density (Mb)	8			1	2
Chip count per card				8	4
Chip logic type				NOR	NOR
Chip organization		125, 4, 8	250, 4, 8	.256x8/.128x16	1 x 8/.512 x 16
FEATURES: Package	PC Card I	PC Card Type II	PC Card Type II	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA ATA	PCMCIA ATA	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	No	No	Yes	Yes
Erasable block size (KB)	128*			128	256
Internal ECC	None	Yes	Yes	--	--
CAPACITY: Total capacity (Mbytes)	40	2	4	1	1
SECTOR ENDURANCE: (Kcycles)	100	1000	1000	100	100
Spare sectors				--	--
Wearout leveling				--	--
PERFORMANCE: Avg. access time (ns)		1.2	1.2	250	250
Media read rate (MB/Sec)		3.5	3.5	5	5
Media write rate (MB/Sec)		.46	.46	.0625	.0625
Burst transfer rate (MB/Sec)		8	8	--	--
Block erase time (ms)				1000	2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V	5 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT		1996	1996	1994	1994
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
MODEL	BN-021HFRE	BN-02MHF3CE	BN-02MHFRE	BN-04MHF3CE	BN-04MHFRE
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	8	2	8	2
Chip count per card	16	2	8	4	16
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	.512x8/.256x16	16 x 8/8 x 16	2 x 8/1 x 16	16 x 8/8 x 16	4 x 8/2 x 16
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes		Yes		Yes
Erasable block size (KB)	128	128	256	128	256
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	2	2	2	4	4
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	--	No	--	No	--
Wearout leveling	--	No	--	No	--
PERFORMANCE: Avg. access time (ns)	250	250	250	250	250
Media read rate (MB/Sec)	5		5		5
Media write rate (MB/Sec)	.0625	.1	.0625	.100	.0625
Burst transfer rate (MB/Sec)	--		--		--
Block erase time (ms)	1000		2000		2000
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1994		1994		1994
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL
MODEL	BN-08MHF3CE	BN-256HFRE	BN-511HFRE	BN-512HFRE	BN-010AA-L
DISK/TREND GROUP	40	40	40	40	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Disk
Chip density (Mb)	8	1	1	2	
Chip count per card	8	2	4	2	
Chip logic type	NOR	NOR	NOR	NOR	
Chip organization	16 x 8/8 x 16	1 x 8/.512 x 16	2 x 8/1 x 16	.512x8/.256x16	625, 4, 8
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type II
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA ATA
XIP		Yes	Yes	Yes	No
Erasable block size (KB)	128	128	128	256	
Internal ECC	--	--	--	--	Yes
CAPACITY:					
Total capacity (Mbytes)	8	.256	.512	.512	10
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	1000
Spare sectors	No	--	--	--	
Wearout leveling	No	--	--	--	
PERFORMANCE:					
Avg. access time (ns)	250	250	250	250	1.2
Media read rate (MB/Sec)		5	5	5	3.5
Media write rate (MB/Sec)	.100	.0625	.0625	.0625	.46
Burst transfer rate (MB/Sec)		--	--	--	8
Block erase time (ms)		1000	1000	2000	
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V
FIRST CUSTOMER SHIPMENT		1994	1994	1994	1996
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MEMORY CARD TECHNOLOGY
MODEL	BN-020AA-L	BN-10MHF3CE	BN-16MHF3CE	BN-040AA-L	F01MX0
DISK/TREND GROUP	41	41	41	42	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Memory	Flash Memory	Flash Disk	Flash Memory
Chip density (Mb)		8	8		
Chip count per card		10	16		
Chip logic type		NOR	NOR		NOR
Chip organization	625, 4, 16	16 x 8/8 x 16	16 x 8/8 x 16	625, 4, 32	
FEATURES: Package	PC Card Type II	PC Card Type I	PC Card Type I	PC Card Type II	PC Card Type I
Interface	PCMCIA ATA	PCMCIA 2.1	PCMCIA 2.1	PCMCIA ATA	PCMCIA 2.1
XIP	No			No	
Erasable block size (KB)		128	128		
Internal ECC	Yes	--	--	Yes	
CAPACITY: Total capacity (Mbytes)	20	10	16	40	1
SECTOR ENDURANCE: (Kcycles)	1000	100	100	1000	10
Spare sectors		No	No		
Wearout leveling		No	No		
PERFORMANCE: Avg. access time (ns)	1.2	250	250	1.2	250
Media read rate (MB/Sec)	3.5			3.5	
Media write rate (MB/Sec)	.46	.100	.100	.46	
Burst transfer rate (MB/Sec)	8			8	
Block erase time (ms)					
SIZE: (mm: H x W x D)	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	5 x 54 x 85.6	
OPERATING VOLTAGE:	5 V	5 V, 12 V	5 V, 12 V	5 V	+5V, +12V
FIRST CUSTOMER SHIPMENT	1996			1996	
COMMENTS					Intel Series 1 chips.

MANUFACTURER	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY
MODEL	F02MXO	F04MXO	F06MXO	F08MXO	F256XO
DISK/TREND GROUP	40	40	40	40	40
MARKET	PCM	PCM	PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)					
Internal ECC					
CAPACITY: Total capacity (Mbytes)	2	4	6	8	.256
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	10
Spare sectors					
Wearout leveling					
PERFORMANCE: Avg. access time (ns)	200	200	200	200	250
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)					
OPERATING VOLTAGE:	+5V, +12V	+5V, +12V	+5V, +12V	+5V, +12V	+5V, +12V
FIRST CUSTOMER SHIPMENT					
COMMENTS	Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 1 chips.

MANUFACTURER	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY	MEMORY CARD TECHNOLOGY
MODEL	F512XO	F10MXO	F12MXO	F14MXO	F16MXO
DISK/TREND GROUP	40	41	41	41	41
MARKET	PCM	PCM	PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)					
Internal ECC					
CAPACITY: Total capacity (Mbytes)	.512	10	12	14	16
SECTOR ENDURANCE: (Kcycles)	10	100	100	100	100
Spare sectors					
Wearout leveling					
PERFORMANCE: Avg. access time (ns)	250	200	200	200	200
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)					
OPERATING VOLTAGE:	+5V, +12V	+5V, +12V	+5V, +12V	+5V, +12V	+5V, +12V
FIRST CUSTOMER SHIPMENT					
COMMENTS	Intel Series 1 chips.	Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 2 chips.	Intel Series 2 chips.

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF81M1-G4EATXX	MF81M1-G5EATXX	MF81M1-GBDAT	MF81M1-GCDAT	MF81M1-GIEATXX
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	1	1	1
Chip count per card	8	8	8	8	8
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	1 x 8/.512 x 16	1 x 8/.512 x 16	1 x 8/.512 x 16	1 x 8/.512 x 16	1 x 8/.512 x 16
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	1	1	1	1	1
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	200	200	250
Media read rate (MB/Sec)	4	4	5	5	4
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1991				
COMMENTS	EEPROM attribute memory.			EEPROM attribute memory.	

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF8257-G4EATXX	MF8257-G5EATXX	MF8257-GBDAT	MF8257-GCDAT	MF8257-GIEATXX
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	1	1	1
Chip count per card	2	2	2	2	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	.256	.256	.256	.256	.256
SECTOR ENDURANCE: (Kcycles)	10			10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	200	200	250
Media read rate (MB/Sec)	4	4	5	5	4
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT					
COMMENTS	EEPROM attribute memory.			EEPROM attribute memory.	

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF82M1-G4EATXX	MF82M1-G5EATXX	MF82M1-G7DATXX	MF82M1-GBDAT	MF82M1-GCDAT
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	1	1	1
Chip count per card	16	16	16	16	16
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.01	PCMCIA 2.01
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	2	2	2	2	2
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	200	200	200
Media read rate (MB/Sec)	4	4	5	5	5
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT					
COMMENTS	EEPROM attribute memory.		Uses Intel chips. EEPROM attribute memory.		EEPROM attribute memory.

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF82M1-GIEATXX	MF84M1-G4EATXX	MF84M1-G5EATXX	MF84M1-G7DATXX	MF84M1-GIEATXX
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1				1
Chip count per card	16				10
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes		Yes	Yes
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	2	4	4	4	4
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	250	200	250
Media read rate (MB/Sec)	4	4	4	5	4
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT		1994	1994	1994	1994
COMMENTS		EEPROM attribute memory.		Uses Intel chips. EEPROM attribute memory.	

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF8513-G4EATXX	MF8513-G5EATXX	MF8513-GBDAT	MF8513-GCDAT	MF8513-GIEATXX
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	1	1	1
Chip count per card	4	4	4	4	4
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	.512	.512	.512	.512	.512
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	250	250	200	200	250
Media read rate (MB/Sec)	4	4	5	5	4
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	.0625
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT					
COMMENTS	EEPROM attribute memory.				

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF88M1-G7DATXX	MF91M1-98DAT	MF91M1-99DAT	MF91M5-98DAT	MF91M5-99DAT
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	4	1	1	1	1
Chip count per card	16	4	4	4	8
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01
XIP	Yes	Yes	Yes	Yes	
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY:					
Total capacity (Mbytes)	8	.512	.512	.512	1
SECTOR ENDURANCE: (Kcycles)	10	10	10	10	
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE:					
Avg. access time (ns)	200	200	200	200	
Media read rate (MB/Sec)	5	5	5	5	
Media write rate (MB/Sec)	.0625	.0625	.0625	.0625	
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1994				
COMMENTS	Uses Intel chips. EEPROM attribute memory.	Includes .512 KB SRAM.	Includes .512 KB SRAM.	Includes 1 MB SRAM.	Includes .512 KB SRAM.

MANUFACTURER	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI	MITSUBISHI
MODEL	MF92M1-98DAT	MF92M1-99DAT	MF810M-G7DATXX	MF816M-G7DATXX	MF820M-G7DATXX
DISK/TREND GROUP	40	40	41	41	41
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	4	4	4
Chip count per card	4	8			
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	.512	1	10	16	20
SECTOR ENDURANCE: (Kcycles)					10
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)			200	200	200
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT			1994	1994	1994
COMMENTS	Includes 1 MB SRAM.	Includes 1 MB SRAM.	Uses Intel chips. EEPROM attribute memory.	EEPROM attribute memory.	Uses Intel chips. EEPROM attribute memory.

MANUFACTURER	NEW MEDIA	NEW MEDIA	NEW MEDIA	NEW MEDIA	NEW MEDIA
MODEL	NMC00101	NMC00102	NMC00103	NMC00104	NMC00105
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP	Yes	Yes	Yes	Yes	Yes
Erasable block size (KB)					
Internal ECC	None	None	None	None	None
CAPACITY: Total capacity (Mbytes)	.256	.512	1	2	4
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	150	150	150	150	150
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1993	1993	1993	1993	
COMMENTS					

MANUFACTURER	NEW MEDIA	NEW MEDIA	NEW MEDIA	NEW MEDIA	SANDISK
MODEL	NMC00123	NMC00124	NMC00125	NMC00126	SDCF-2 CompactFlash
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Disk
Chip density (Mb)					32
Chip count per card					1
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					2, 16, 123
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Typ II*
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1/IDE
XIP					No
Erasable block size (KB)					.512
Internal ECC	None	None	None	None	Yes
CAPACITY: Total capacity (Mbytes)	.256	.512	1	2	2
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	300
Spare sectors	--	--	--	--	Yes
Wearout leveling	--	--	--	--	No
PERFORMANCE: Avg. access time (ns)	150	150	150	150	1.25 ms
Media read rate (MB/Sec)					4
Media write rate (MB/Sec)					4
Burst transfer rate (MB/Sec)					6
Block erase time (ms)					0.75 ms
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	*5 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	3.3 V, 5 V
FIRST CUSTOMER SHIPMENT					1995
COMMENTS					*With SDCF-01 adapter.

MANUFACTURER	SANDISK	SANDISK	SANDISK	SANDISK	SANDISK
MODEL	SDCF-4 CompactFlash	SDIB-4 SDIBT-4	SDP3B-2	SDP3B-4	SDP3B-6
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	32	32	32	32
Chip count per card	1	1	1	1	2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2, 32, 123	2, 32, 123			
FEATURES: Package	PC Card Typ II*	1.3" IDE	PC Card Type II	PC Card Type II	PC Card Type II
Interface	PCMCIA 2.1/IDE	IDE	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)	.512	.512	.512	.512	.512
Internal ECC	Yes	Yes	Yes	Yes	Yes
CAPACITY:					
Total capacity (Mbytes)	4	4	2	4	6
SECTOR ENDURANCE: (Kcycles)	300	300	300	300	300
Spare sectors	Yes	Yes	Yes	Yes	Yes
Wearout leveling	No	No	No	No	No
PERFORMANCE:					
Avg. access time (ns)	1.25 ms	1.25 ms	1.25 ms	1.25 ms	1.25 ms
Media read rate (MB/Sec)	4	4	4	4	4
Media write rate (MB/Sec)	4	4	4	4	4
Burst transfer rate (MB/Sec)	6	6	6	6	6
Block erase time (ms)	0.75 ms	.75 ms	1.5	1.5	1.5
SIZE: (mm: H x W x D)	*5 x 54 x 85.6	10.5 x 50.8 x 43.5	5 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V
FIRST CUSTOMER SHIPMENT	1995	1996	1996	1996	1996
COMMENTS	*With SDCF-01 adapter.	T version has 1.8" package.			

MANUFACTURER	SANDISK	SANDISK	SANDISK	SANDISK	SANDISK
MODEL	SDCF-10 CompactFlash	SDCF-15 CompactFlash	SDIB-10 SDIBT-10	SDP3B-10	SDP3B-20
DISK/TREND GROUP	41	41	41	41	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	32	32	32	32
Chip count per card	3	4	3	3	6
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2, 32, 320	2, 32, 458	2, 32, 320		
FEATURES: Package	PC Card Typ II*	PC Card Typ II*	1.3" IDE	PC Card Type II	PC Card Type II
Interface	PCMCIA 2.1/IDE	PCMCIA 2.1/IDE	IDE	PCMCIA-ATA	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)	.512	.512	.512	.512	.512
Internal ECC	Yes	Yes	Yes	Yes	Yes
CAPACITY: Total capacity (Mbytes)	10.5	15.7	10.4	10.4	20
SECTOR ENDURANCE: (Kcycles)	300	300	300	300	300
Spare sectors	Yes	Yes	Yes	Yes	Yes
Wearout leveling	No	No	No	No	No
PERFORMANCE: Avg. access time (ns)	1.25 ms	1.25 ms	1.25	1.25 ms	1.25 ms
Media read rate (MB/Sec)	4	4	4	4	4
Media write rate (MB/Sec)	4	4	4	4	4
Burst transfer rate (MB/Sec)	6	6	6	6	6
Block erase time (ms)	1.5	1.5	.75 ms	1.5	1.5
SIZE: (mm: H x W x D)	*5 x 54 x 85.6	*5 x 54 x 85.6	10.5 x 50.8 x 43.6	5 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	3.3 V, 5 V Dynamic	3.3 V, 5 V Dynamic	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V
FIRST CUSTOMER SHIPMENT	1995	1995	1996	1996	1996
COMMENTS	*With SDCF-01 adapter.	*With SDCF-01 adapter.	T version has 1.8" package.		

MANUFACTURER	SANDISK	SANDISK	SANDISK	SANDISK	SANDISK
MODEL	SDIB-20 SDIBT-20	SDIB-40 SDIBT-40	SDIB-80	SDIBT-60	SDP3B-85
DISK/TREND GROUP	41	42	42	42	42
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	32	32	32	32
Chip count per card	6				
Chip logic type	NOR	NOR	NOR	NOR	
Chip organization	2, 32, 640				
FEATURES: Package	1.3" IDE	1.3" IDE	1.3" IDE	1.8" IDE	PC Card Type II
Interface	IDE	IDE	IDE	IDE	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)	.512	.512	.512	.512	
Internal ECC	Yes	Yes	Yes	Yes	
CAPACITY: Total capacity (Mbytes)	20.9	42.8	83.9	62.9	85
SECTOR ENDURANCE: (Kcycles)	300	300	300	300	
Spare sectors	Yes	Yes	Yes	Yes	
Wearout leveling	No	No	No	No	
PERFORMANCE: Avg. access time (ns)	1.25 ms	1.25 ms	1.25 ms	1.25 ms	
Media read rate (MB/Sec)	4	4	4	4	
Media write rate (MB/Sec)	4	4	4	4	
Burst transfer rate (MB/Sec)	6	6	6	6	
Block erase time (ms)	.75	.75	.75	.75	
SIZE: (mm: H x W x D)	10.5 x 50.8 x 43.5	10.5 x 50.8 x 43.5	10.5 x 50.8 x 43.5	10.5 x 50.8 x 43.5	5 x 54 x 86
OPERATING VOLTAGE:	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V	5 V or 3.3 V
FIRST CUSTOMER SHIPMENT	1996	1996	1996	1996	4Q95
COMMENTS	T version has 1.8" package.	T version has 1.8" package.			

MANUFACTURER	SANDISK	SANDISK	SANDISK	SCM MICROSYSTEMS	SCM MICROSYSTEMS
MODEL	SDIB-140	SDP3B-110	SDP3B-175	FC001MB1	FC002MB2
DISK/TREND GROUP	43	43	43	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Memory	Flash Memory
Chip density (Mb)	32	32	32		8
Chip count per card					2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	1.8" IDE	PC Card TypeIII	PC Card TypeIII	PC Card Type I	PC Card Type I
Interface	IDE	PCMCIA-ATA	PCMCIA-ATA	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No		
Erasable block size (KB)	.512	.512	.512		
Internal ECC	Yes	Yes	Yes		
CAPACITY: Total capacity (Mbytes)	140	110.1	175.4	1	2
SECTOR ENDURANCE: (Kcycles)	300	300	300	10	100
Spare sectors	Yes	Yes	Yes	--	--
Wearout leveling	No	No	No	--	--
PERFORMANCE: Avg. access time (ns)	1.25 ms	1.25 ms	1.25 ms	200/250	170/200
Media read rate (MB/Sec)	4	3	3		
Media write rate (MB/Sec)	4	3	3		
Burst transfer rate (MB/Sec)	6	6	6		
Block erase time (ms)	.75	1.5	1.5	2000	1500
SIZE: (mm: H x W x D)	9.6 x 50.8 x 76.2	10 x 54 x 85.6	10 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	3.3 V, 5 V	3.3 V, 5 V	3.3 V, 5 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1996	3Q96	3Q96	4Q94	4Q94
COMMENTS				Intel chips.	Intel chips.

MANUFACTURER	SCM MICROSYSTEMS	SCM MICROSYSTEMS	SCM MICROSYSTEMS	SCM MICROSYSTEMS	SCM MICROSYSTEMS
MODEL	FC004MB2	FC256KB	FC512KB	FC010MB2	FC020MB2
DISK/TREND GROUP	40	40	40	41	41
MARKET	PCM	PCM	PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	8			8	8
Chip count per card	4			10	20
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)					
Internal ECC					
CAPACITY:					
Total capacity (Mbytes)	4	.256	.512	10	20
SECTOR ENDURANCE: (Kcycles)	100	10	10	100	100
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE:					
Avg. access time (ns)	170/200	200/250	200/250	170/200	170/200
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)	1500	2000	2000	1500	1500
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	4Q94	4Q94	4Q94	1995	1995
COMMENTS	Intel chips.	Intel chips.	Intel chips.	Intel chips.	Intel chips.

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON
MODEL	ATA202SD11/01	ATA502SD11/01	HWB101ESX0/40	HWB201ESX0/40	HWB201S8X0/40
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type II	PC Card Type II	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01
XIP	No	No			
Erasable block size (KB)	.512	.512			
Internal ECC	Yes	Yes	--	--	--
CAPACITY:					
Total capacity (Mbytes)	2.6	5.2	.512	1	1
SECTOR ENDURANCE: (Kcycles)	200	200			
Spare sectors	Yes	Yes	--	--	--
Wearout leveling	Yes	Yes	--	--	--
PERFORMANCE:					
Avg. access time (ns)	1.25 ms	1.25 ms	200	200	200
Media read rate (MB/Sec)	.625	.625			
Media write rate (MB/Sec)	.075	.075			
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	5 x 54 x 85.6	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V	5 V			
FIRST CUSTOMER SHIPMENT					
COMMENTS	Made by SanDisk	Made by SanDisk			

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON
MODEL	HWB257ESX0/40	HWB401ESX0/40	HWB401S8X0/40	HWB513ESX0/40	HWB801S8X0/40
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM	OEM	OEM	OEM	OEM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.01
XIP					
Erasable block size (KB)					
Internal ECC	--	--	--	--	--
CAPACITY: Total capacity (Mbytes)	.128	2	2	.256	4
SECTOR ENDURANCE: (Kcycles)					
Spare sectors	--	--	--	--	--
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	200	200	200	200	200
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:					
FIRST CUSTOMER SHIPMENT					
COMMENTS					

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON
MODEL	Mini-2 FLASH-PACKER	Mini-4 FLASH-PACKER	SDP5-2-5 FLASH-PACKER	SDP5-5 SDP5HP-5 FLASH-PACKER	ATA112SD11/01
DISK/TREND GROUP	40	40	40	40	41
MARKET	PCM	PCM	PCM	PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)	32	32			
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	2, 16, 123	2, 32, 123			
FEATURES: Package	PC Card TypeII*	PC Card TypeII*	PC Card Type II	PC Card Type II	PC Card Type II
Interface	PCMCIA 2.0	PCMCIA 2.0	PCMCIA 2.0	PCMCIA 2.0	PCMCIA-ATA
XIP	No	No	No	No	No
Erasable block size (KB)	.512	.512	.512	.512	
Internal ECC	Yes	Yes	Yes	Yes	
CAPACITY: Total capacity (Mbytes)	2	4	2.6	5.2	10.4
SECTOR ENDURANCE: (Kcycles)	300	300	200	200	200
Spare sectors	Yes	Yes	Yes	Yes	
Wearout leveling	Yes	Yes	Yes	Yes	
PERFORMANCE: Avg. access time (ns)	1.25 ms	1.25 ms	1.25 ms	1.25 ms	1.25 ms
Media read rate (MB/Sec)	.625	.625	.625	.625	.625
Media write rate (MB/Sec)	.075	.075	.075	.075	.075
Burst transfer rate (MB/Sec)	6	6	6	6	
Block erase time (ms)	.75	.75	2	2	
SIZE: (mm: H x W x D)	5 x 36.4 x 42.8	5 x 36.4 x 42.8	5 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6
OPERATING VOLTAGE:	3.3 V, 5 V	3.3 V, 5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1995	1995	1995	1995	
COMMENTS	*Fits into Type II adapter. Sold in Japan. Made by SanDisk	*Fits into Type II adapter. Sold in Japan. Made by SanDisk	Made by SanDisk Sold in Japan.	Made by SanDisk Sold in Japan.	Made by SanDisk

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON
MODEL	ATA212SD11/01	HWB111S8X0/80	HWB161S8X0/80	Mini-10 FLASH-PACKER	Mini-15 FLASH-PACKER
DISK/TREND GROUP	41	41	41	41	41
MARKET	OEM, PCM	OEM	OEM	PCM	PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Memory	Flash Memory	Flash Disk	Flash Disk
Chip density (Mb)				32	32
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization				2, 32, 320	2, 32, 458
FEATURES: Package	PC Card Type II	PC Card Type I	PC Card Type I	PC Card TypeII*	PC Card TypeII*
Interface	PCMCIA-ATA	PCMCIA 2.01	PCMCIA 2.01	PCMCIA 2.0	PCMCIA 2.0
XIP	No			No	No
Erasable block size (KB)				.512	.512
Internal ECC		--	--	Yes	Yes
CAPACITY:					
Total capacity (Mbytes)	20.9	10	16	10.4	15.7
SECTOR ENDURANCE: (Kcycles)	200			300	300
Spare sectors		--	--	Yes	Yes
Wearout leveling		--	--	Yes	Yes
PERFORMANCE:					
Avg. access time (ns)	1.25 ms	200	200	1.25 ms	1.25 ms
Media read rate (MB/Sec)	.625			.625	.625
Media write rate (MB/Sec)	.075			.075	.075
Burst transfer rate (MB/Sec)				6	6
Block erase time (ms)				.75	.75
SIZE: (mm: H x W x D)	5 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	5 x 36.4 x 42.8	5 x 36.4 x 42.8
OPERATING VOLTAGE:	5 V			3.3 V, 5 V	3.3 V, 5 V
FIRST CUSTOMER SHIPMENT				1995	1995
COMMENTS	Made by SanDisk			*Fits into Type II adapter. Sold in Japan. Made by SanDisk	*Fits into Type II adapter. Sold in Japan. Made by SanDisk

MANUFACTURER	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SEIKO EPSON	SIMPLE TECHNOLOGY
MODEL	SDP5-10 SDP5HP-10 FLASH-PACKER	SDP5-20 SDP5HP-20 FLASH-PACKER	ATA412SD12/02	SDP5-40 SDP5HP-40 FLASH-PACKER	STI-FL/2A
DISK/TREND GROUP	41	41	42	42	40
MARKET	PCM	PCM	OEM, PCM	PCM	PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Disk	Flash Memory
Chip density (Mb)			16		1
Chip count per card					2
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization			4, 32, 640		1 x 8
FEATURES: Package	PC Card Type II	PC Card Type II	PC Card Type II	PC Card Type II	PC Card Type I
Interface	PCMCIA 2.0	PCMCIA 2.0	PCMCIA-ATA	PCMCIA 2.0	PCMCIA 2.1
XIP	No	No	No	No	
Erasable block size (KB)	.512	.512	.512	.512	
Internal ECC	Yes	Yes		Yes	
CAPACITY: Total capacity (Mbytes)	10.4	20.9	40	41.9	2
SECTOR ENDURANCE: (Kcycles)	200	200	200	200	100
Spare sectors	Yes	Yes		Yes	
Wearout leveling	Yes	Yes		Yes	
PERFORMANCE: Avg. access time (ns)	1.25 ms	1.25 ms	1.25 ms	1.25 ms	5
Media read rate (MB/Sec)	.625	.625	.625	.625	.100
Media write rate (MB/Sec)	.075	.075	.075	.075	
Burst transfer rate (MB/Sec)	6	6		6	
Block erase time (ms)	2	2		2	
SIZE: (mm: H x W x D)	5 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6	
OPERATING VOLTAGE:	5 V	5 V	5 V	5 V	
FIRST CUSTOMER SHIPMENT	1995	1995	1994	1995	
COMMENTS	Made by SanDisk Sold in Japan.	Made by SanDisk Sold in Japan.	Made by SanDisk	Made by SanDisk Sold in Japan.	

MANUFACTURER	SIMPLE TECHNOLOGY	SIMPLE TECHNOLOGY	SIMPLE TECHNOLOGY	SIMPLE TECHNOLOGY	SMART MODULAR TECHNOLOGIES
MODEL	STI-FL/4A	STI-FL/8A	STI-FL/10A	STI-FL/16A	SM9FL1MP3 SM9FL1MP35V
DISK/TREND GROUP	40	40	41	41	40
MARKET	PCM	PCM	PCM	PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)	1	1	1	1	
Chip count per card	4	8	10	16	
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization	1 x 8	1 x 8	1 x 8	1 x 8	
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)					
Internal ECC					None
CAPACITY: Total capacity (Mbytes)	4	8	10	16	1
SECTOR ENDURANCE: (Kcycles)	100	100	100	100	
Spare sectors					None
Wearout leveling					--
PERFORMANCE: Avg. access time (ns)	5	5	5	5	150/200/250
Media read rate (MB/Sec)	.100	.100	.100	.100	
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)					3.3 x 54 x 85.6
OPERATING VOLTAGE:					5 V, 12 V
FIRST CUSTOMER SHIPMENT					1992
COMMENTS					5V is 5 volt unit.

MANUFACTURER	SMART MODULAR TECHNOLOGIES	SMART MODULAR TECHNOLOGIES	SMART MODULAR TECHNOLOGIES	SMART MODULAR TECHNOLOGIES	SMART MODULAR TECHNOLOGIES
MODEL	SM9FL256KP3 SM9FL256KP35V	SM9FL2MP3 SM9FL2MP35V	SM9FL4MP3 SM9FL4MP35V	SM9FL512KP3 SM9FL512KP35V	SM9FL8MP3 SM9FL8MP35V
DISK/TREND GROUP	40	40	40	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Memory
Chip density (Mb)					
Chip count per card					
Chip logic type	NOR	NOR	NOR	NOR	NOR
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1
XIP					
Erasable block size (KB)					
Internal ECC	None	None	None	None	None
CAPACITY: Total capacity (Mbytes)	.256	2	4	.512	8
SECTOR ENDURANCE: (Kcycles)					
Spare sectors	None	None	None	None	None
Wearout leveling	--	--	--	--	--
PERFORMANCE: Avg. access time (ns)	150/200/250	150/200/250	150/200/250	150/200/250	150/200/250
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)					
Block erase time (ms)					
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V	5 V, 12 V
FIRST CUSTOMER SHIPMENT	1992	1992	1992	1992	1992
COMMENTS	5V is 5 volt unit.	5V is 5 volt unit. Secure version available.	5V is 5 volt unit. Secure version available.	5V is 5 volt unit.	5V is 5 volt unit.

MANUFACTURER	SMART MODULAR TECHNOLOGIES	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
MODEL	SM9FL16MP3 SM9FL16MP35V	TC5816ADC	TH6SS160031AAA	TH6SS160051AAA	TH6SS160101AAA
DISK/TREND GROUP	41	40	40	40	41
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Disk	Flash Disk	Flash Disk
Chip density (Mb)		16	16	16	16
Chip count per card		1	2	3	6
Chip logic type	NOR	NAND	NAND	NAND	NAND
Chip organization		2 x 8	2 x 8	2 x 8	
FEATURES: Package	PC Card Type I	SSFDC	PC Card Type I	PC Card Type I	PC Card Type I
Interface	PCMCIA 2.1	SSFDC	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
XIP		No	No	No	No
Erasable block size (KB)		4	8 x .512	8 x .512	8 x .512
Internal ECC	None	No	Yes	Yes	Yes
CAPACITY: Total capacity (Mbytes)	16	2.0625	3	5	10
SECTOR ENDURANCE: (Kcycles)		250	250	250	250
Spare sectors	None	Yes	Yes	Yes	Yes
Wearout leveling	--		Yes	Yes	Yes
PERFORMANCE: Avg. access time (ns)	150/200/250	80	300	300	300
Media read rate (MB/Sec)		5.7			
Media write rate (MB/Sec)		.8			
Burst transfer rate (MB/Sec)			8	8	8
Block erase time (ms)		6	6-100	6-100	6-100
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	.76 x 37 x 45	3.3 x 54 x 85.6	3.3 x 54 x 85.6	3.3 x 54 x 85.6
OPERATING VOLTAGE:	5 V, 12 V	5 V	5 V	5 V	5 V
FIRST CUSTOMER SHIPMENT	1992	2Q96	4Q94	4Q94	4Q94
COMMENTS	5V is 5 volt unit.				

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TRANSCEND	TRANSCEND
MODEL	TH6SS160201AAA	TH6SS160302AAA	TH6SS160402AAA	Flash 2 MB	Flash 4 MB
DISK/TREND GROUP	41	42	42	40	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk	Flash Memory	Flash Memory
Chip density (Mb)	16	16	16		
Chip count per card	11	16	21		
Chip logic type	NAND	NAND	NAND		
Chip organization					
FEATURES: Package	PC Card Type I	PC Card Type II	PC Card Type II	PC Card Type I	PC Card Type I
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA 2.1	PCMCIA 2.1
XIP	No	No	No		
Erasable block size (KB)	8 x .512	8 x .512	8 x .512		
Internal ECC	Yes	Yes	Yes		
CAPACITY: Total capacity (Mbytes)	20	30	40	2	4
SECTOR ENDURANCE: (Kcycles)	250	250	250		
Spare sectors	Yes	Yes	Yes		
Wearout leveling	Yes	Yes	Yes		
PERFORMANCE: Avg. access time (ns)	300	300	300		
Media read rate (MB/Sec)					
Media write rate (MB/Sec)					
Burst transfer rate (MB/Sec)	8	8	8		
Block erase time (ms)	6-100	6-100	6-100		
SIZE: (mm: H x W x D)	3.3 x 54 x 85.6	5 x 54 x 85.6	5 x 54 x 85.6	3.3 x 34.6 x 85.6	3.3 x 34.6 x 85.6
OPERATING VOLTAGE:	5 V	5 V	5 V		
FIRST CUSTOMER SHIPMENT	4Q94	4Q94	4Q94	3Q95	3Q95
COMMENTS					

MANUFACTURER	TRANSCEND	TRANSCEND	TRANSCEND	TRANSCEND	VISIONTEK
MODEL	Flash 5 MB	Flash 8 MB	Flash 16 MB	Flash 20 MB	VT12150.0
DISK/TREND GROUP	40	40	41	41	40
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	PCM
PRODUCT TYPE: Generic	Flash Memory	Flash Memory	Flash Memory	Flash Memory	Flash Disk
Chip density (Mb)					16
Chip count per card					2
Chip logic type					NOR
Chip organization					2, 32, 80
FEATURES: Package	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type I	PC Card Type II
Interface	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA 2.1	PCMCIA-ATA
XIP					No
Erasable block size (KB)					.512
Internal ECC					Yes
CAPACITY: Total capacity (Mbytes)	5	8	16	20	2.5
SECTOR ENDURANCE: (Kcycles)					200
Spare sectors					Yes
Wearout leveling					Yes
PERFORMANCE: Avg. access time (ns)					1.25 ms
Media read rate (MB/Sec)					.625
Media write rate (MB/Sec)					.025
Burst transfer rate (MB/Sec)					6
Block erase time (ms)					2
SIZE: (mm: H x W x D)	3.3 x 34.6 x 85.6	3.3 x 34.6 x 85.6	3.3 x 34.6 x 85.6	3.3 x 34.6 x 85.6	5 x 5.4 x 8.56
OPERATING VOLTAGE:					5 V
FIRST CUSTOMER SHIPMENT	3Q95	3Q95	3Q95	3Q95	4Q96
COMMENTS					

MANUFACTURER	VISIONTEK	VISIONTEK	VISIONTEK		
MODEL	VT12151.0	VT12152.0	VT12153.0		
DISK/TREND GROUP	40	41	41		
MARKET	PCM	PCM	PCM		
PRODUCT TYPE: Generic	Flash Disk	Flash Disk	Flash Disk		
Chip density (Mb)	16	16	16		
Chip count per card	3	5	10		
Chip logic type	NOR	NOR	NOR		
Chip organization	2, 32, 160	2, 32, 320	2, 32, 640		
FEATURES: Package	PC Card Type II	PC Card Type II	PC Card Type II		
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA		
XIP	No	No	No		
Erasable block size (KB)	.512	.512	.512		
Internal ECC	Yes	Yes	Yes		
CAPACITY: Total capacity (Mbytes)	5	10	20		
SECTOR ENDURANCE: (Kcycles)	200	200	200		
Spare sectors	Yes	Yes	Yes		
Wearout leveling	Yes	Yes	Yes		
PERFORMANCE: Avg. access time (ns)	1.25 ms	1.25 ms	1.25 ms		
Media read rate (MB/Sec)	.625	.625	.625		
Media write rate (MB/Sec)	.025	.025	.025		
Burst transfer rate (MB/Sec)	6	6	6		
Block erase time (ms)	2	2	2		
SIZE: (mm: H x W x D)	5 x 5.4 x 8.56	5 x 5.4 x 8.56	5 x 5.4 x 8.56		
OPERATING VOLTAGE:	5 V	5 V	5 V		
FIRST CUSTOMER SHIPMENT	4Q96	4Q96	4Q96		
COMMENTS					

PC CARD RIGID DISK DRIVE SPECIFICATIONS

1996 DISK/TREND REPORT

PC CARD RIGID DISK DRIVE SPECIFICATIONS

Coverage

This section includes removable rigid disk drives packaged in PCMCIA form factors, frequently known as "PC Card" drives, intended for data storage which are now in new production or announced, arranged alphabetically by manufacturer. Product specifications use the same format employed in the DISK/TREND Report on rigid disk drives.

Specifications on drive models sold by computer system manufacturers, but purchased on an OEM basis from others, have been included in some cases, for identification purposes. In the case of captive disk drives manufactured by some system manufacturers, captive drives which are similar to OEM/Integrator models made by the same manufacturer are usually not listed.

Capacities

Formatted native capacity has been used to determine the appropriate DISK/TREND product group for each drive in this product group, with specific formatted capacities indicated by "F".

Interfaces

Specific interfaces available are indicated for most drives, using references to manufacturers' own unique interfaces or to industry standards, either de facto or formalized. However, this is a rapidly changing area, so please be alert to the need to check for manufacturers' latest information if you need precise data. Most PC Card drives currently available adhere to the PCMCIA-ATA interface specifications.

Average access time

All DISK/TREND specifications use the term "average access time" to describe the combination of average head positioning time and average disk rotational delay. Some in the industry have fallen into the habit of using the term average access time to describe average positioning time, or "seek" time, but this usage fails to adequately describe the time required for a disk drive to start to respond to a system request. The DISK/TREND specifications show separately the average positioning time, average rotational delay, and average access time, in order to avoid confusion.

Transfer rate

The transfer rate shown in the specifications is the rate at which data is transferred between the drive and the computer to which it is attached, in the case of drives with embedded controllers. If the manufacturer has specified more than one communication mode, such as synchronous and asynchronous, both data rates are indicated.

Accuracy

All information in this section has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries have been required.

1996 DISK/TREND product groups for PC Card rigid disk drives included in the Removable Data Storage report

Group number	Drives included
2.	PC Card rigid disk drives, less than 300 megabytes
3.	PC Card rigid disk drives, 300 - 500 megabytes
4.	PC Card rigid disk drives, 500 megabytes - 1 gigabyte
5.	PC Card rigid disk drives, 1 - 2 gigabytes

MANUFACTURER	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY
DRIVE	CT-130MC CT-130FD callunacard	CT-170MC CT-170FD callunacard	CT-260MC CT-260FD callunacard	CT-390MC CT-390FD callunacard	CT-520MC CR-520FD callunacard
DISK/TREND GROUP	2	2	2	3	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	48 mm	48 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 130	F: 170	F: 260	F: 390	F: 520
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	4	4	3	4
Tracks per surface	1958	1768	1958	2576	2576
Track density (TPI)	4400	4400	4400	6000	6000
Maximum linear density (BPI) (FCI)	82391 61793	58082 43561	82391 61793	118285 88714	118285 88714
Areal density (Mb/square inch)	362.5	255.6	362.5	709.7	709.7
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4800	4800	4800	4800	4800
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16	12	12
Average rotational delay (msec)	6.25	6.25	6.25	6.25	6.25
Average access time (msec)	22.25	22.25	22.25	18.25	18.25
Data transfer rate (MBytes/sec) Internal, min/max External	 2.3/4.5 11.1	 1.8/3.1 11.1	 2.3/4.5 11.1	 3.4/6.4 20.0	 3.4/6.4 20.0
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	5/94	9/94	3/95	3Q96	3Q96
COMMENTS	PCMCIA Type III *Carbon disk. CT-130FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-170FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-260FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-390FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-520FD is 50 pin IDE version

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	8105PA Viper	8170PA Viper 170	8260PA Viper 260	PocketFile 105	PocketFile 170
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	PCM	PCM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	48 mm	48 mm
Recording medium	Thin Film	Thin Film*	Thin Film*	Thin Film	Thin Film*
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 105.4	F: 170.8	F: 260.4	F: 105.4	F: 170.8
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	4	4
Tracks per surface	1107	1370	1650	1107	1370
Track density (TPI)	2840	3800	4300	2840	3800
Maximum linear density (BPI)	70000	84000	112350	70000	84000
(FCI)	52000	63000	84260	52000	63000
Areal density (Mb/square inch)	198.8	319.2	483.1	198.8	319.2
Recording code	1,7 RLL	1,7 RLL	1,7 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15	12	12	15	12
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	21.7	18.7	18.7	21.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max	--/3.0	--/3.5	--/5.7	--/3.0	--/3.5
External	10.7	12.0	16.0	10.7	12.0
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	11/93	3/94	3Q94	1/94	3/94
COMMENTS	PCMCIA Type III Ramp loaded heads.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads.	PCMCIA Type III Ramp loaded heads. *Untextured disks.

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	MOMENTUM PERIPHERALS	MOMENTUM PERIPHERALS
DRIVE	PocketFile 260	8340PA Viper 340	8510PA Viper 510	MOMENTUM 130	MOMENTUM 170
DISK/TREND GROUP	2	3	4	2	2
MARKET	PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	48 mm	48 mm
Recording medium	Thin Film*	Thin Film*	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR	Thin Film	Thin Film
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 260.4	F: 340.6	F: 514	F: 130	F: 170
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	4	4
Tracks per surface	1650	2000	2600	1076	1407
Track density (TPI)	4200	5100	6640	3200	3200
Maximum linear density (BPI) (FCI)	105000 78750	123600 92700	120000 90000	76500 51000	76500 51000
Areal density (Mb/square inch)	441.0	630.4	796.8	244.8	244.8
Recording code	1,7 PRML	1,7 PRML	1,7 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4464	4464
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	13	15	15
Average rotational delay (msec)	6.7	6.7	5.77	6.7	6.7
Average access time (msec)	18.7	18.7	18.77	21.7	21.7
Data transfer rate (MBytes/sec) Internal, min/max External	--/5.7 16.0	--/6.0 16.0	--/6.4 10.0	1.9/3.2 5000	1.9/3.2 5000
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	3Q94	4Q94		5/96	5/96
COMMENTS	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III	PCMCIA Type III	PCMCIA Type III

MANUFACTURER	SEIKO EPSON				
DRIVE	EHDD170 Hard Disk Card				
DISK/TREND GROUP	2				
MARKET	PCM				
MEDIA: Disk diameter	48 mm				
Recording medium	Thin Film*				
DRIVE: Heads	Thin Film				
Interface	PCMCIA-ATA				
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--				
REMOVABLE	F: 170.8				
Capacity per track (Bytes)	Varies by zone				
Data surfaces per spindle	4				
Tracks per surface	1370				
Track density (TPI)	3800				
Maximum linear density (BPI) (FCI)	84000 63000				
Areal density (Mb/square inch)	319.2				
Recording code	1,7 RLL				
Rotational speed (RPM)	4500				
PERFORMANCE					
Actuator type	Rotary, Voice Coil				
Servo type	Embedded				
Average positioning time (msec)	12				
Average rotational delay (msec)	6.7				
Average access time (msec)	18.7				
Data transfer rate (MBytes/sec) Internal, min/max External	12.0				
SIZE: (mm) H x W x D	10.5 x 54 x 85.6				
FIRST CUSTOMER SHIPMENT	3/94				
COMMENTS	PCMCIA Type III Ramp loaded heads. *Untextured disks. Mfg by Integral Peripherals.				

RIGID DISK CARTRIDGE DRIVE SPECIFICATIONS

1996 DISK/TREND REPORT

RIGID DISK CARTRIDGE DRIVE SPECIFICATIONS

Coverage

This section includes removable rigid disk cartridge drives intended for computer data storage which are now in new production or announced, arranged alphabetically by manufacturer. Product specifications use the same format employed in the DISK/TREND Report on rigid disk drives.

Capacities

Formatted capacities are given for captive drives and noncaptive drives with embedded controllers, such as SCSI or IDE. Specific formatted capacities are indicated by "F". Capacities per track are listed, except for drives with zoned recording.

Average access time

All DISK/TREND specifications use the term "average access time" to describe the combination of average head positioning time and average disk rotational delay. Some in the industry have fallen into the habit of using the term average access time to describe average positioning time, or "seek" time, but this usage fails to adequately describe the time required for a disk drive to start to respond to a system request. The DISK/TREND specifications show separately the average positioning time, average rotational delay, and average access time, in order to avoid confusion.

Transfer rate

The transfer rate shown in the specifications is the rate at which data is transferred between the drive and the computer to which it is attached, in the case of drives with embedded controllers. If the manufacturer has specified more than one communication mode, such as synchronous and asynchronous, both data rates are indicated.

Interfaces

Specific interfaces available are indicated for most drives, using references to manufacturers' own unique interfaces or to industry standards, either de facto or formalized. However, this is a rapidly changing area for noncaptive drives, so please be alert to the need to check for manufacturers' latest information if you need precise data. In particular, there are many noninterchangeable forms of SCSI interfaces.

Accuracy

All information in this section has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries have been required.

1996 DISK/TREND product groups for rigid disk cartridge drives included in the Removable Data Storage report

Group number	Drives included
1.	Rigid disk cartridge drives

MANUFACTURER	AVATAR SYSTEMS	AVATAR SYSTEMS	AVATAR SYSTEMS	AVATAR SYSTEMS	IOMEGA
DRIVE	AR-2170NI Remington	AR-2170NS Remington	AR-3170FI Magnum	AR-3170FS Magnum	Jaz 1GB IDE
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film*	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 170	F: 170	F: 170	F: 170	F: 540/1,070
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	4
Tracks per surface	2404	2404	2404	2404	4204
Track density (TPI)	4300	4300	4300	4300	4301
Maximum linear density (BPI) (FCI)	81000 60750	81000 60750	81000 60750	81000 60750	89200 66900
Areal density (Mb/square inch)	348.3	348.3	348.3	348.3	383.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3805	3805	3805	3805	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	10 RD/12 WR
Average rotational delay (msec)	8	8	8	8	5.6
Average access time (msec)	20	20	20	20	15.6 RD/17.6 WR
Data transfer rate (MBytes/sec) Internal, min/max External	1.5/2.8 13.3 DMA Mode 1	1.5/2.8 10.0 synch.	1.5/2.8 13.3 Mode 1	1.5/2.8 10.0 synch.	3.5/6.7 13.3 PIO Mode 4
SIZE: (mm) H x W x D	17.5 x 72.4 x 107.9	17.5 x 72.46 x 107.9	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 149.9
FIRST CUSTOMER SHIPMENT	6/95	6/95	6/95	6/95	1Q96
COMMENTS	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk. Includes 3.5" 1.44 MB floppy drive.	Removable data cartridge. *Glass disk. Includes 3.5" 1.44 MB floppy drive.	

MANUFACTURER	IOMEGA	NOMAI	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	Jaz 1GB SCSI	MCD-I	SQ3270A	SQ3270S	SQ5200C
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG		Ferrite
Interface	SCSI-2	SCSI-2, IDE	IDE	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 540/1,070	F: 540	F: 270	F: 270	F: 200
Capacity per track (Bytes)	Varies by zone	Varies by zone	F:	F:	Varies by zone
Data surfaces per spindle	4	2	2	2	2
Tracks per surface	4204		3140	3140	2260
Track density (TPI)	4301	4250	3280	3280	1875
Maximum linear density (BPI) (FCI)	89200 66900	100000	60000 45000	60000 45000	49820 37365
Areal density (Mb/square inch)	383.6	425.0	196.8	196.8	93.4
Recording code	1,7 RLL	8,9 PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4500	3600	3600	3220
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10 RD/12 WR	10	13.5	13.5	18
Average rotational delay (msec)	5.6	6.6	8.3	8.3	9.32
Average access time (msec)	15.6 RD/17.6 WR	16.6	21.8	21.8	27.32
Data transfer rate (MBytes/sec) Internal, min/max External	3.5/6.7 10.0 synch. 5.0 asynch.	4.1/8.8 10.0	2.3/4.0 4.0	2.3/4.0 4.0	2.6/3.6 5.0 synch. 3.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 149.9	25.4 x 102 x 150	25.4 x 101.6 x 150	25.4 x 101.6 x 150	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	4Q95	4Q95	4Q93	2/94	2Q94
COMMENTS			Removable data cartridge. Read/write compatible with 105 MB & 270 MB cartridges.	Removable data cartridge. Read/write compatible with 105 MB & 270 MB cartridges.	Removable data cartridge. Read/write compatible with 44 MB, 88 MB & 200 MB cart.

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	EZ135A	EZ135S	EZFlyer A	EZFlyer S	SyJET S
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI/Parallel	SCSI	Parallel Port	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 135	F: 135	F: 230	F: 230	F: 1,300
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	1	1	1	1	4
Tracks per surface	3140	3140	4192	4192	4680
Track density (TPI)	3280	3280	4200	4200	4650
Maximum linear density (BPI) (FCI)	60000 45000	60000 45000	77800 58400	77800 58400	101000 114000
Areal density (Mb/square inch)	196.8	196.8	326.8	326.8	469.7
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	3600	3600	3600	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13.5	13.5	13.5	13.5	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.5
Average access time (msec)	21.8	21.8	21.8	21.8	17.5
Data transfer rate (MBytes/sec) Internal, min/max	2.3/4.0	2.3/4.0			5.5/11.5
External	4.0	4.0 synch.	10.0 synch. 5.0 asynch.	1.25	10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 150	25.4 x 101.6 x 150	40.1 x 146.1 x 191.2	38.1 x 135.9 x 184.2	38.1 x 133 x 200
FIRST CUSTOMER SHIPMENT	7/95	7/95	2Q96	2Q96	3Q96
COMMENTS	Removable data cartridge. Internal model.	Removable data cartridge. External model.	Removable data cartridge. Internal model.	Removable data cartridge. External model.	Removable data cartridge. External model.

MANUFACTURER	SYQUEST TECHNOLOGY				
DRIVE	SyJET A				
DISK/TREND GROUP	1				
MARKET	OEM, PCM				
MEDIA: Disk diameter	95 mm				
Recording medium	Thin Film				
DRIVE: Heads	Thin Film				
Interface	IDE				
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--				
REMOVABLE	F: 1,300				
Capacity per track (Bytes)	Varies by zone				
Data surfaces per spindle	4				
Tracks per surface	4680				
Track density (TPI)	4650				
Maximum linear density (BPI) (FCI)	101000 114000				
Areal density (Mb/square inch)	469.7				
Recording code	PRML				
Rotational speed (RPM)	5400				
PERFORMANCE					
Actuator type	Rotary, Voice Coil				
Servo type	Embedded				
Average positioning time (msec)	12				
Average rotational delay (msec)	5.5				
Average access time (msec)	17.5				
Data transfer rate (MBytes/sec) Internal, min/max External	 5.5/11.5 16.6 PIO Mode 4				
SIZE: (mm) H x W x D	25.4 x 101.6 x 149.3				
FIRST CUSTOMER SHIPMENT	3Q96				
COMMENTS	Removable data cartridge. Internal model.				

SMALL OPTICAL DISK DRIVE SPECIFICATIONS

1996 DISK/TREND REPORT

OPTICAL DISK DRIVE SPECIFICATIONS

Coverage: This product section includes 3.5" and 2.5" optical disk drives intended for computer data storage used as computer peripherals 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 basic type of recording technology is given. Most drives in this product group use magneto-optic recording: Other recording technologies that may be encountered include phase change and dye polymer.

Operating mode: Rewritable (erasable) drives are indicated with the technology type in parentheses if it is other than magneto-optic. Where the drive is a magneto-optic type and supports multifunctionality using MO-WORM media, the designation "Rewritable-(MF)" is used.

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

Speed control: Various abbreviations are used:

CAV = constant angular velocity.

CLV = constant linear velocity.

ZCAV = zoned constant angular velocity.
(Sometimes called MCAV = modified constant angular velocity).

Capacities: "F" is used to indicate formatted capacities. For optical drives that can access only one side of the media, the capacity given is in terms of one side, even if the drive uses two-sided media. As optical media is preformatted, the capacity given is the formatted capacity. Track capacity in CLV drives is variable, so this parameter is given only for CAV drives.

Rotational speed: If more than one speed range exists, 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 the drive manufacturer contacted for details.

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

> If separated by a hyphen, the figures represent the drive's minimum and maximum transfer rates.
>
> If separated by a slash, the figures represent the rates obtained when the drive operates at more than one RPM or offers more than one capacity.
>
> Figures followed by the abbreviations "asynch." or "synch." are transfer rates between the drive and the host computer.

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 drive product groups included in the Removable Data Storage report

Group number	Drives included
22.	Optical disk drives less than 2 gigabytes

All optical disk drives using 3.5" and 2.5" optical disks which were included in the DISK/TREND Report on optical disk drives have been included in this report on removable data storage. Other optical disk drives are covered in the annual DISK/TREND Report on optical disk drives.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	2512A MOcity	M2511A DynaMO 128	M2512A DynaMO 230	M2513A Cat-4	M2541B DynaMO 230 Portable
DISK/TREND GROUP	22	22	22	22	22
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IDE
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: 128	F: 128/230	F: 640/540	F: 128/230
Capacity per track (Bytes)	F: 12800/N/A	F: 12800	F: 12800/12800	F: 34816/12800	F: 12800/N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	10000	10000/17940	18480/42042	10000/17940
Track density (TPI)	15875/18273	15875	15875/18275	23090	15875/18275
Maximum linear density (BPI)	24400/29296	24400	24400/29300	52900	24400/29300
Rotational speed (RPM)	3600	3600	3600	3600	2700
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	30	30	30	30	70
Average rotational delay (msec)	8.3	8.3	8.3	8.3	11
Average access time (msec)	38.3	38.3	38.3	38.3	81
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	1.3-2.1 5.0 synch.	1.09 4.0 synch.	1.3-2.1 5.0 synch.	2.3-3.9 5.0/10.0 synch.	.975-1.575
Buffer/cache size (Kbytes)	256	256	256	2000/512	128
SIZE (mm: H x W x D)	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	25.4 x 101.6 x 146	17 x 101.6 x 140
FIRST CUSTOMER SHIPMENT	1995	1992	3/94	4/96	10/95
COMMENTS	Sold in Europe.	DynaMO is external subsystem.	DynaMO is external subsystem.	DynaMO is external subsystem.	DynaMO is external subsystem. Direct overwrite.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	KONICA
DRIVE	M2541BD MicroCat-3	M2541BF Pismo	M2541BS PCMCIA	M2541S MicroMO	OMD-7060
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Interface	IDE	Power Book	PCMCIA	PCMCIA	
Speed control & zones	CAV	CAV	CAV	CAV/ZCAV	ZCAV
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 128/230	F: 128/230	F: 128/230	F: 128/230	F: 128/230/640
Capacity per disk (Mbytes)				F: 128/230	F: 128/230/640
Capacity per track (Bytes)	F: 12800	F: 12800	F: 12800	F: 12800/N/A	F:
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	10000/17940	10000/17940	10000/17940	10000/17940	
Track density (TPI)	15875/18275	15875/18275	15875/18275	15875/18273	
Maximum linear density (BPI)	24400/29300	24400/29300	24400/29300	24400/29296*	
Rotational speed (RPM)	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)	70	65	70	65	
Average rotational delay (msec)	11.1	11.1	11.1	11	
Average access time (msec)	81.1	76.1	81.1	76	
Spin-up/Spin-down times (sec)				7/6	
Data transfer rate (MBytes/sec) Internal	1.0-1.6	1.0-1.6	1.0-1.6	1.0-1.6	
External				8.0	
Buffer/cache size (Kbytes)	128	128	128	128(512 option)	
SIZE (mm: H x W x D)	17.2 x 101.6 x 140	17.2 x 101.6 x 140	25.3 x 113.5 x 164.8	25.3 x 113.5 x 164.8	25 x 101.6 x 150
FIRST CUSTOMER SHIPMENT	1996	1996	1996	1Q96	3Q96
COMMENTS				*2,7 RLL Code. Battery pack available.	Preliminary specification.

MANUFACTURER	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MATSUSHITA ELECTRIC INDUSTRIAL	MOUNTAIN OPTECH	OLYMPUS
DRIVE	LF-3200JA	LF-3200JD	LF-3294	CS-250 R/W SE-250 R/W SI-250 R/W ST-250 R/W	230MO Plus* 230MO Turbo
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	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Interface	SCSI	SCSI	SCSI	SCSI	SCSI-2
Speed control & zones	ZCAV	ZCAV	ZCAV	ZCAV	CAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 229.1	F: 229.1	F: 229.1	F: 230	F: 230/128
Capacity per track (Bytes)	F: 12800*	F: 12800*	F: 12800*	F: 12800	F: 12800
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11510/17853*	11510/17853*	11510/17853*	11510/17853*	11500
Track density (TPI)	18273	18273	18273	18273	18273
Maximum linear density (BPI)	29540	29540	29540	29540	29300
Rotational speed (RPM)	3600	3600	3600	3600	4200
PERFORMANCE Positioner type	Voice Coil	Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Continuous
Average positioning time (msec)	35	35	35	40	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.1
Average access time (msec)	43.3	43.3	43.3	48.3	35.1
Spin-up/Spin-down times (sec)					
Data transfer rate (MBytes/sec) Internal External	2.1 5.0 synch.	2.1 5.0 synch.	2.1 5.0 synch.	1.475 max.	1.075-1.72/.896
Buffer/cache size (Kbytes)	256	256	256	64	1000*
SIZE (mm: H x W x D)	56 x 168 x 240	56 x 168 x 240	41.3 x 101.6 x 151.5	44.5 x 117.5 x 206.4	
FIRST CUSTOMER SHIPMENT	3Q94	3Q94	2Q94	1Q95	10/94
COMMENTS	*Logical tracks External mount. For use with Macintosh.	*Logical tracks External mount. For use w/DOS, PC-9800 and Panacom systems	*Logical tracks	Ruggedized. *Logical tracks CS-250 is commercial version.	*Includes cache

MANUFACTURER	OLYMPUS	OLYMPUS	OLYMPUS	SEIKO EPSON	SONY
DRIVE	MOS320E MOS320S MOS321E* MOS321S*	MOS330E MOS330S MOS331E* MOS331S*	SYS-230	OMD 6020	HS-1
DISK/TREND GROUP	22	22	22	22	22
MARKET	OEM	OEM	PCM	OEM	PCM
MEDIA: Disk diameter	86 mm	86 mm	86 mm	86 mm	86 mm
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic	Magneto-Optic
DRIVE: Operating mode	Rewritable	Rewritable	Rewritable	Rewritable	Rewritable
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
Speed control & zones	CAV/ZCAV	CAV/ZCAV	CAV/ZCAV	ZCAV	ZCAV
CAPACITY/RECORDING DENSITY On-line capacity (Mbytes) Capacity per disk (Mbytes)	F: 230/128	F: 230/128	F: 128/230 F: 128/230	F: 230	F: 650 F: 650
Capacity per track (Bytes)	F: 12800	F: 12800	F: 12800	F: 12800*	N/A
Data surfaces per spindle	1	1	1	1	1
Tracks per surface	11500**	11500**	11500*	17853*	17665
Track density (TPI)	18273	18273	18273	18273	21200
Maximum linear density (BPI)	29300	29300	29300	29540**	60500
Rotational speed (RPM)	4500	4200	4200	3600	2400
PERFORMANCE Positioner type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Continuous	Continuous	Continuous	Continuous	Sampled
Average positioning time (msec)	26	27	27	28	33
Average rotational delay (msec)	7.1	7.1	7.1	8.3	12.5
Average access time (msec)	33.1	34.1	34.1	36.3	45.5
Spin-up/Spin-down times (sec)					8/5*
Data transfer rate (MBytes/sec) Internal External	1.075-1.84/.896	1.075-1.72/.896	2.4	.900-1.44	1-2 10
Buffer/cache size (Kbytes)	256, 1000*	256, 1000*	256*	500	512
SIZE (mm: H x W x D)	41.3 x 101.6 x 160	25.4 x 101.6 x 153.5	25.4 x 101.6 x 153.5	25.4 x 101.6 x 146	177 x 60 x 250
FIRST CUSTOMER SHIPMENT	2Q94	2Q96	3Q96	4Q94	2/96
COMMENTS	*1 MB optional. **17900 logical tracks.	*1 MB optional. **37600 logical tracks.	*37600 logical tracks.	*Logical tracks **2,7 RLL Code. Split optics.	External subsystem of HS-D650. *Loading/eject time included.

MANUFACTURER	SONY	SONY	SONY		
DRIVE	HS-D650	MDH-10	RMO-S330		
DISK/TREND GROUP	22	22	22		
MARKET	OEM	PCM	PCM		
MEDIA: Disk diameter	86 mm	64 mm	86 mm		
Recording technology	Magneto-Optic	Magneto-Optic	Magneto-Optic		
DRIVE: Operating mode	Rewritable	Rd.Only,Rewrit.	Rewritable		
Interface	SCSI-2	SCSI-2	SCSI-2		
Speed control & zones	ZCAV	CLV	CAV		
CAPACITY/RECORDING DENSITY					
On-line capacity (Mbytes)	F: 650	F: 140	F: 128		
Capacity per disk (Mbytes)	F: 650	F: 140	F: 128		
Capacity per track (Bytes)	N/A	NA	F: 12800		
Data surfaces per spindle	1	1	1		
Tracks per surface	17665	10000	10000		
Track density (TPI)	21200	15875	15875		
Maximum linear density (BPI)	60500	39827	24420		
Rotational speed (RPM)	2400	940-422	1800		
PERFORMANCE					
Positioner type	Linear, Voice Coil	Linear, DC Motor	Linear, Voice Coil		
Servo type	Sampled	Continuous	Continuous		
Average positioning time (msec)	33	455	120		
Average rotational delay (msec)	12.5	45	16.6		
Average access time (msec)	45.5	500	136.6		
Spin-up/Spin-down times (sec)	8/5*				
Data transfer rate (MBytes/sec)					
Internal	1-2	.150	.375		
External	5	2.5 asynch.	4.0 synch.		
Buffer/cache size (Kbytes)	512		128		
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		
FIRST CUSTOMER SHIPMENT	11/95	3Q94	7/94		
COMMENTS	*Loading/eject time included.		External mount.		

HIGH CAPACITY FLEXIBLE DISK DRIVE SPECIFICATIONS

1996 DISK/TREND REPORT

HIGH CAPACITY
FLEXIBLE DISK DRIVE SPECIFICATIONS

Coverage

This section includes high capacity flexible disk drives intended for computer data storage, with capacities exceeding five megabytes, which are now in production or announced, arranged alphabetically by manufacturer. Product specifications use the same format employed in the separate DISK/TREND Report on flexible disk drives published in previous years.

Specifications of flexible disk drive models sold by computer system manufacturers, but purchased on an OEM basis from others, may be included in a few cases for clarity. In the case of captive flexible disk drives manufactured by some system manufacturers, captive drives which are similar to individual OEM/Integrator models made by the same system manufacturer are usually not listed.

Capacities

Formatted native capacities have been used to be consistent with the disk drive industry's trend to identify all drives by formatted capacities. All capacities are per spindle, one individual drive. Capacities per track are listed, except for drives with zoned recording.

Average access time

DISK/TREND Reports use the term "average access time" to describe the combination of average head positioning time and average disk rotational delay. Some in the industry have fallen into the habit of using the term average access time to describe average positioning time, or "seek" time, but this usage fails to adequately describe the time required for a disk drive to start to respond to a system request. In this product group, average positioning time is given in the comments section for several drives, due to the higher performance provided by the voice coil actuators utilized. In some cases, settling time is included in the total for average positioning time.

Accuracy

All information has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries were necessary.

1996 DISK/TREND product groups for flexible disk drives included in the Removable Data Storage report

Group number	Drives included
14.	High capacity flexible disk drives

MANUFACTURER	IOMEGA	IOMEGA	IOMEGA	IOMEGA	IOMEGA
DRIVE	Bernoulli 150	Bernoulli 230	Zip 100 IDE Interface Internal Model	Zip 100 Parallel Port External Model	Zip 100 SCSI Interface External Mode
DISK/TREND GROUP	14	14	14	14	14
MARKET	OEM, PCM	OEM, PCM	PCM	PCM	PCM
MEDIA: Nominal disk diameter	5.25"	5.25"	3.5"	3.5"	3.5"
Recording medium	Metal Powder	Metal Powder	Metal Powder	Metal Powder	Metal Powder
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 150.9	F: 230	F: 25/100	F: 25/100	F: 25/100
Capacity per track (Bytes)	F: 35,328	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	2594	2885	1817	1817	1817
Track density (TPI)	2117	2353	2118	2118	2118
Maximum linear density (BPI)	35990 BPI 26992 FCI	49323 BPI 36992 FCI	46000 BPI 34500 FCI	46000 BPI 34500 FCI	46000 BPI 34500 FCI
Recording code	1,7 RLL	1,7 RLL	1,8 RLL	1,8 RLL	1,8 RLL
Rotational speed (RPM)	2368	2439	2941	2941	2941
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
POSITIONING: Track to track(msec)	2.5 (including settling)	3.7	4	4	4
Settling time (msec)	--	--	--	--	--
Average rotational delay (msec)	12.7	12.3	10.1	10.1	10.1
Data transfer rate (KBytes/sec)	5000 synch.* 3000 asynch.*	5000 synch.* 3000 asynch.*	--*	1400*	4000 synch.*
SIZE (mm: H x W x D)	41.3 x 146 x 203.2	41.3 x 146 x 202.3	25.5 x 101.5 x 165	36.9 x 134.1 x 181.6	38.6 x 134.1 x 181.6
FIRST CUSTOMER SHIPMENT	4Q92	9/94	1Q96	3/95	3/95
COMMENTS	*SCSI. 25 msec average positioning time. Downward comp. 90 MB read/write 44 MB read.	*SCSI. 25 msec average positioning time. Downward comp. 150, 105, 90, 65, 35 MB read/write; 44 MB read.	*IDE. 29 msec average positioning time. 25 and 100 MB disk cartridges available.	*Parallel port. 29 msec average positioning time. 25 and 100 MB disk cartridges available.	*SCSI. 29 msec average positioning time. 25 and 100 MB disk cartridges available.

MANUFACTURER	IOMEGA	MATSUSHITA-KOTOBUKI ELECTRONICS	O.R. TECHNOLOGY	SEIKO EPSON	SEIKO EPSON
DRIVE	Zip 100 SCSI Interface Internal Mode	LS-120	FD-3120A	EZ 110A Zip	EZ 111A Zip
DISK/TREND GROUP	14	14	14	14	14
MARKET	PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	Metal Powder	Metal Powder	Metal Powder	Metal Powder	Metal Powder
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 25/100	F: 120/1.44	F: 120/1.44	F: 25/100	F: 25/100
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	1817	1736/80	1736/80	1817	1817
Track density (TPI)	2118	2490/135	2490/135	2118	2118
Maximum linear density (BPI)	46000 BPI 34500 FCI	44880 BPI 33660 FCI	44880 BPI 33660 FCI	46000 34500	46000 34500
Recording code	1,8 RLL	1,7 RLL/MFM	1,7 RLL/MFM	1,8 RLL	1,8 RLL
Rotational speed (RPM)	2941	720	720	2945	2945
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
POSITIONING: Track to track(msec)	4	10/15	10/15	4	4
Settling time (msec)	--	--	--	--	--
Average rotational delay (msec)	10.1	41.7	41.7	10.1	10.1
Data transfer rate (KBytes/sec)	4000 synch.*	4000	4000	1250 asynch.	1250 asynch.
SIZE (mm: H x W x D)	25.5 x 101.5 x 165	25.4 x 101.6 x 150	25.4 x 101.6 x 150	41.3 x 146.1 x 189	41.3 x 146.1 x 189
FIRST CUSTOMER SHIPMENT	2Q96	3Q96	3Q96	1996	1996
COMMENTS	*SCSI. 29 msec average positioning time. 25 and 100 MB disk cartridges available.	65 msec average positioning time. Downward compatible 720 KB/1.2 MB/ 1.44 MB.	65 msec average positioning time. Downward compatible 720 KB/1.2 MB/ 1.44 MB. Uses LS-120 disks.	SCSI interface.	Parallel port interface.

MANUFACTURER	SWAN INSTRUMENTS				
DRIVE	UHC 3260				
DISK/TREND GROUP	14				
MARKET	OEM, PCM				
MEDIA: Nominal disk diameter	3.5"				
Recording medium	Metal Powder				
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: 130 Fixed F: 130 Remov. F: 1.44 Remov.				
Capacity per track (Bytes)	Varies by zone				
Data surfaces per spindle	4				
Tracks per surface					
Track density (TPI)	2200/135				
Maximum linear density (BPI)	73200/17434				
Recording code	1,7 RLL/MFM				
Rotational speed (RPM)	3600				
PERFORMANCE					
Actuator type	Linear, Voice Coil				
POSITIONING: Track to track(msec)	3.5				
Settling time (msec)	--				
Average rotational delay (msec)	8.3				
Data transfer rate (KBytes/sec)	6000/10000				
SIZE (mm: H x W x D)	25.4 x 101.6 x 146.1				
FIRST CUSTOMER SHIPMENT	1997				
COMMENTS	18 msec. average head positioning. Parallel port, SCSI-2 or IDE interface.				

LOW CAPACITY FLEXIBLE DISK DRIVE SPECIFICATIONS

LOW CAPACITY
FLEXIBLE DISK DRIVE SPECIFICATIONS

Coverage

This section includes low capacity flexible disk drives intended for data storage, with capacities less than five megabytes, which are now in production or announced, arranged alphabetically by manufacturer. Product specifications use the same format employed in the separate DISK/TREND Report on flexible disk drives published in previous years. Specifications of flexible disk drive models sold by computer system manufacturers, but purchased on an OEM basis from others, may be included in a few cases for clarity. In the case of captive flexible disk drives manufactured by system manufacturers, captive drives which are similar to individual OEM/Integrator models made by the same system manufacturer are usually not listed.

Capacities

Formatted native capacities have been used to be consistent with the disk drive industry's trend to identify all drives by formatted capacities. Capacities are listed as "F" for formatted. All capacities are per spindle, one individual drive. Capacities per track are listed, except for drives with zoned recording.

Accuracy

All information has been cross-checked for accuracy. However, it is anticipated that some errors may be included, since many manufacturers' published specifications do not cover all of the items listed, and numerous verbal inquiries were necessary.

DISK/TREND product groups

In most cases the product groups used for individual drives are clear, but a few arbitrary decisions have been made. Please note that all drives with capacities under 5 megabytes have been placed in the low capacity group, regardless of disk diameter.

1996 DISK/TREND product groups for flexible disk drives included in the Removable Data Storage report

Group number	Drives included
13.	Low capacity flexible disk drives

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	DF 328N	DF 334H	DF 334N	DF 354H	DF 354N
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	Barium Ferrite	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2/1.4/ 2.88	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/7,680/ 9,216/18,432	F: 4,608/9,216	F: 4,608/7,680/ 9,216	F: 4,608/9,216	F: 4,608/7,680/ 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77/80/80	80	80/77/80	80	80/77/80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184/ 17434/34868	8717/17434	8717/14184/ 17434	8717/17434	8717/14184/ 17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360/300/300	300	300/360/300	300	300/360/300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100	100/83.3	100/83.3	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5/125	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	12.7 x 96 x 126	25.4 x 101.6 x 145	25.4 x 101.6 x 145	25.4 x 101.6 x 145	25.4 x 101.6 x 145
FIRST CUSTOMER SHIPMENT	11/92	5/94	5/94	12/95	12/95
COMMENTS	Direct drive.	Direct drive.	Direct drive.	Direct drive.	Direct drive.

MANUFACTURER	CHINON	CHINON	CITIZEN	CITIZEN	CITIZEN
DRIVE	FG-357	FZ-357	BXW	OSDA	OSDB
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.4	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.2
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/7,680
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80/77/80	80	80/77
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/17434	8717/17434	8717/17434	8717/17434	8717/14184
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	300	300/360	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	100	100/83.3	100	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	25.4 x 101.6 x 145	25.4 x 101.6 x 130	15 x 100 x 140	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9
FIRST CUSTOMER SHIPMENT	1Q95	1Q90	1Q95	4Q87	4Q87
COMMENTS			External mount of W1 models.		

MANUFACTURER	CITIZEN	CITIZEN	CITIZEN	CITIZEN	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	OSDE	W1DA	W1DB	W1DE	JU-226A
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.2	F: .7/1.2/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/7,680/ 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80	80/77/80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/17434	8717/17434	8717/14184	8717/17434	17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	300	300/360	300/360	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	100	100/83.3	100/83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	62.5
SIZE (mm: H x W x D)	25.4 x 101.6 x 149.9	10.9 x 96.5 x 116.8	10.9 x 96.5 x 116.8	10.9 x 96.5 x 116.8	12.7 x 101.6 x 106
FIRST CUSTOMER SHIPMENT	4Q89	2Q93	2Q93	2Q93	1994
COMMENTS					

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE	JU-227A	JU-256A	JU-257	JU-257A	JU-475
DISK/TREND GROUP	13	13	13	13	13
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.4	F: .360/.7 or F: .6/1.2
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/7,680/ 9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/7,680
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	77/80
Track density (TPI)	135	135	135	135	96
Maximum linear density (BPI)	17434	17434	8717/17434	8717/17434	5922/9646
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	300	300	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	100	100	100	100/83.3
Data transfer rate (KBytes/sec)	62.5	62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	12.7 x 101.6 x 106	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9	41.3 x 146 x 203.2
FIRST CUSTOMER SHIPMENT	1994	1994	1987	1987	1983
COMMENTS					

MANUFACTURER	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MATSUSHITA ELECTRONIC COMPONENTS	MITSUBISHI ELECTRIC CORPORATION
DRIVE	EME-213	EME-219	EME-273 EME-278	EME-279	MF 355F
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608	F: 4,608/7,680/ 9,216	F: 4,608/9,216	F: 4,608/7,680/ 9,216	F: 4,608/7,680 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717	8717/14528/ 17434	8717/17434	8717/14528/ 17434	8717/14184/ 17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	300/360/300	300	300/360/300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	6	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	100/83/100	100	100/83/100	100/83.3
Data transfer rate (KBytes/sec)	31.25	31.25/62.5/62.5	31.25/62.5	31.25/62.5/62.5	31.25/62.5
SIZE (mm: H x W x D)	25.4 x 101.6 x 150.0	25.4 x 101.6 x 150.0	15 x 96 x 130	15 x 96 x 130	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1989	1994	4/91	1992	3Q93
COMMENTS					

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	MF 355H	MF 356F	D 353F2	D 353F2E	D 353G
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	Barium Ferrite	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2/1.4	F: .7/1.2/ 1.4/2.88	F: .7/1.2/1.4	F: .7/1.2/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/7,680 9,216	F: 4,608/7,680/ 9,216/18,432	F: 4,608/7,860 9,216	F: 4,608/7,860 9,216	F: 4,608/7,680 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80/77
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184/ 17434	8717/14184/ 17434/34868	8717/14528/ 17434	8717/14528/ 17434	8717/14582/ 17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300/360	300/360	300/360	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100/83.3	100/83.3	100/83.3	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5/125	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	12.7 x 96 x 126	25.4 x 101.6 x 146	12.7 x 96 x 130	19.5 x 106 x 145	12.7 x 101.6 x 105.6
FIRST CUSTOMER SHIPMENT	1Q94	3Q93	3Q93	1Q95	2Q95
COMMENTS	15 mm high version available with auto eject.				

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	D 353T5 D 353T7	D 357T5	D 358F2	D 359F2	D 359F2E
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2/1.4	F: .7	F: .7/1.2	F: .7/1.4	F: .7/1.4
Capacity per track (Bytes)	F: 4,608/7,680 9,216	F: 4,608	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14528/ 17434	8717	8717/14528	8717/17434	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	6	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100	100/83.3	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	25.4 x 101.6 x 150	25.4 x 101.6 x 150	12.7 x 96 x 130	12.7 x 96 x 130	19.5 x 106 x 143
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	3Q93	3Q93	1Q95
COMMENTS					External model.

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	D 359G	D 359T5 D 359T6 D 359T7	DP 119F2	DP 129F2	DP 239T5
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.4	F: .7/1.4	F: .7/1.4	F: .7/1.4	F: .7/1.4
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14528/ 17434	8717/17434	8717/17434	8717/17434	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	300	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	100	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	12.7 x 101.6 x 105.6	25.4 x 101.6 x 150	25.4 x 101.6 x 170	25.4 x 101.6 x 170	42 x 146 x 182
FIRST CUSTOMER SHIPMENT	2Q95	2Q94	4Q95	3Q96	3Q96
COMMENTS			Combines FDD with slot for PCMCIA Card Types I, II, or III.	Combines FDD with slot for PCMCIA Card Types I, II, or III.	Combines FDD with slot for PCMCIA Card Types I, II, or III.

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	FD 1139C	FD 1139H	FD 1139T	FD 1231H	FD 1231T
DISK/TREND GROUP	13	13	13	13	13
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/7,680 9,216	F: 4,608/9,216	F: 4,608/7,680 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14528	8717/17434	8717/14528/ 17434	8717/17434	8717/14528/ 17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300	300/360	300	300/360
PERFORMANCE					
Actuator type	Linear, Pulse Motor	Linear, Pulse Motor	Linear, Pulse Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100	100/83.3	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	15 x 101.6 x 101.6	15 x 101.6 x 101.6	15 x 101.6 x 101.6	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	2/91	2/91		2Q95	2Q95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	S.F.R.	SAMSUNG ELECTRONICS
DRIVE	FD 1238H	FD 1238T	FD 1239H	DS-34AC DS-35AC Safronic	SFD-321D SFD-321DT
DISK/TREND GROUP	13	13	13	13	13
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.4	F: .7/1.4	F: .7/1.4
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/7,680 9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/17434	8717/14528/ 17434	8717/17434	8717/17434	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	300/360	300	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	100	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	12.7 x 96 x 126	12.7 x 96 x 126	12.5 x 101.6 x 106	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9
FIRST CUSTOMER SHIPMENT	1Q95	1Q95	1Q96	1989	2Q89
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SEIKO EPSON	SEIKO EPSON	SONY	SONY
DRIVE	SFD-560D SFD-560DT	DYO-211 DYO-212	SMD-1340	MPF520	MPF720
DISK/TREND GROUP	13	13	13	13	13
MARKET	Captive, OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	5.25"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: .7/1.4	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/7,680/ 9,216	F: 4,608/7,680/ 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80	80	80	80
Track density (TPI)	96	135	135	135	135
Maximum linear density (BPI)	5922/9646	8717/17434	8717/17434	8717/14528/ 17434	8717/14528/ 17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300	300	300/360/300	300/360/300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	83.3	100	100	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5/62.5	31.25/62.5/62.5
SIZE (mm: H x W x D)	41.3 x 146 x 203.2	41.5 x 146 x 192	25.4 x 101.6 x 146	25.4 x 101.6 x 145	12.7 x 96 x 130
FIRST CUSTOMER SHIPMENT	4Q87	1Q95	1Q95	2Q94	2Q95
COMMENTS		Combines SMD-1340 FDD with slot for PCMCIA Card Types I, II, or III. DYO-212 has 2nd rear panel Type III slot. US market only.			

MANUFACTURER	TAE-IL MEDIA	TAE-IL MEDIA	TEAC	TEAC	TEAC
DRIVE	TFD-310	TFD-510	FD-04GF	FD-04HF	FD-04HG
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	5.25"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.4	F: .7/1.2	F: .7/1.2	F: .7/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/7,680	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	96	135	135	135
Maximum linear density (BPI)	8717/17434	5722/9870	8717/14184	8717/17434	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300	360	300/360	300	300/360
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100	83.3	100/83.3	100	100/83.3
Data transfer rate (KBytes/sec)	31.25/62.5	37.5//62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	25 x 102 x 130	41.3 x 146 x 193	12.7 x 101.6 x 106	12.7 x 101.6 x 106	12.7 x 101.6 x 106
FIRST CUSTOMER SHIPMENT	8/95	7/95	2Q95	2Q95	2Q95
COMMENTS			Direct drive motor.	Direct drive motor.	Direct drive motor.

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-05GF	FD-05HF	FD-05HG	FD-05HGS	FD-05HS
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.2/1.4	F: .7/1.4
Capacity per track (Bytes)	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184	8717/17434	8717/17434	8717/17434	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300	300/360	300/360	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100	100/83.3	100/83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	12.7 x 101.6 x 129.5	12.7 x 101.6 x 129.5	12.7 x 101.6 x 129.5	25.4 x 101.6 x 144.5	25.4 x 101.6 x 144.5
FIRST CUSTOMER SHIPMENT	10/91	10/91		2Q93	2Q93
COMMENTS	Direct drive motor. 101.6 mm or 96 mm width available.	Direct drive motor. 101.6 mm or 96 mm width available.	Direct drive motor. 101.6 mm or 96 mm width available.	SCSI interface.	SCSI interface.

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-05PGF	FD-05PHF	FD-05PHG	FD-235GF	FD-235HF
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: .7/1.4	F: .7/1.2/1.4	F: .7/1.2	F: .7/1.4
Capacity per track (Bytes)	F: 4,608/7,680	F: 4,608/9,216	F: 4,608/9,216	F: 4,608/7,680	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80	80	80	80	80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184	8717/17434	8717/17434	8717/14528	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300	300/360	300/360	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100	100/83.3	100/83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	15.5 x 106.2 x 146	15.5 x 106.2 x 146	15.5 x 106.2 x 146	25.4 x 101.6 x 145	25.4 x 101.6 x 145
FIRST CUSTOMER SHIPMENT	4/92	4/92	4/92	2Q88	2Q88
COMMENTS	External drive unit.	External drive unit.	External drive unit.		

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	TEAC
DRIVE	FD-235HG	FD-235HS	FD-505	FD-55BR	FD-55FR
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"/5.25"	5.25"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated	Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2/1.4	F: .7/1.4	F: 1.4/1.2	F: .360	F: .7
Capacity per track (Bytes)	F: 4,608/9,216	F: 4,608/9,216	F: 9,216/7,680	F: 4,608	F: 4,608
Data surfaces per spindle	2	2	2/2	2	2
Tracks per surface	80	80	80/80	40	80
Track density (TPI)	135	135	135/96	48	96
Maximum linear density (BPI)	8717/17434	8717/17434	17434/9646	5876	5922
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300	300/360	300	300
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Band Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3/3	4/6	3
Settling time (msec)	15	15	15/15	10/15	15
Average rotational delay (msec)	100	100	100/83.3	100	100
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5	62.5/62.5	31.25	31.25
SIZE (mm: H x W x D)	25.4 x 101.6 x 145	41.9 x 104.1 x 161.8	41.3 x 146 x 198	41.3 x 146 x 203.2	41.3 x 146 x 203.2
FIRST CUSTOMER SHIPMENT		1990	1992	1987	1987
COMMENTS		SCSI interface.	Combines 5.25" and 3.5" floppy drives.		

MANUFACTURER	TEAC	TEAC	TEAC	TEAC	Y-E DATA
DRIVE	FD-55GFR	FD-55GR	FD-55GS	FD-155GF	2100
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	5.25"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: 1.2	F: .7/1.2	F: .7/1.2	F: .7/1.4
Capacity per track (Bytes)	F: 4,608/7,680	F: 7,680	F: 4,608/7,680	F: 4,608/7,680	F: 4,608/9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	77	80/77	80/77	80
Track density (TPI)	96	96	96	96	135
Maximum linear density (BPI)	5922/9646	9646	5922/9646	5922/9646	8717/17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	360	300/360	300/360	300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	83.3	100/83.3	100/83.3	100
Data transfer rate (KBytes/sec)	31.25/62.5	62.5	31.25/62.5	31.25/62.5	31.25/62.5
SIZE (mm: H x W x D)	41.3 x 146 x 203.2	41.3 x 146 x 203.2	43.2 x 144.8 x 203.2	25.4 x 146 x 191	25.4 x 101.8 x 150
FIRST CUSTOMER SHIPMENT	1987	1987	1990	8/91	1Q95
COMMENTS	Dual speed.		SCSI interface		Combines FDD with slot for PCMCIA Card Types I, II, or III.

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-686C	YD-701B YD-702B YD-702D	YD-701B-6336H	YD-701B-6331S	YD-701B-6431H
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	3.5"	3.5"	3.5"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: .7/1.2/1.4	F: .7/1.2/1.4	F: .7/1.2/1.4	F: .7/1.2/1.4
Capacity per track (Bytes)	F: 4,608/7,680	F: 4,608/7,680 9,216	F: 4,608/7,680 9,216	F: 4,608/7,680 9,216	F: 4,608/7,680 9,216
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77	80/77/80	80/77/80	80/77/80	80/77/80
Track density (TPI)	135	135	135	135	135
Maximum linear density (BPI)	8717/14184	8717/14184/ 17434	8717/14184/ 17434	8717/14184/ 17434	8717/14184/ 17434
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	300/360	300/360	600/720/600	600/720/600	1200/1440/1200
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	100/83.3	100	50/41.6/50	50/41.6/50	25/20.8/25
Data transfer rate (KBytes/sec)	31.25/62.5	31.25/62.5/62.5	62.5/125/125	62.5/125/125	125/250/250
SIZE (mm: H x W x D)	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9
FIRST CUSTOMER SHIPMENT	1Q87	1Q87	2Q95	2Q95	3Q95
COMMENTS			Doublespeed drive sold for duplicators	Doublespeed R/W drive sold for duplicators	Quadspeed drive sold for duplicators

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-701B-6431S	YD-702J	YD-380B-1710B	YD-380B-1714B	YD-380B-1734H
DISK/TREND GROUP	13	13	13	13	13
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	3.5"	3.5"	5.25"	5.25"	5.25"
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2/1.4	F: .7/1.2/1.4	F: 1.2	F: .7/1.2	F: .7/1.2
Capacity per track (Bytes)	F: 4,608/7,680 9,216	F: 4,608/7,680 9,216	F: 7,680	F: 4,608/7,680	F: 4,608/7,680
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	80/77/80	80/77/80	77	80/77	80
Track density (TPI)	135	135	96	96	96
Maximum linear density (BPI)	8717/14184/ 17434	8717/14184/ 17434	9646	5922/9646	5922/9870
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	1200/1440/1200	300/360/300	360	300/360	600/720
PERFORMANCE					
Actuator type	Lead Screw, Stepping Motor	Lead Screw, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
POSITIONING: Track to track(msec)	3	3	3	3	3
Settling time (msec)	15	15	15	15	15
Average rotational delay (msec)	25/20.8/25	100/83.3/100	83.3	100/83.3	50/41.6
Data transfer rate (KBytes/sec)	125/250/250	31.25/62.5/62.5	62.5	31.25/62.5	75/125
SIZE (mm: H x W x D)	25.4 x 101.6 x 149.9	12.7 x 96 x 129.5	41.3 x 146 x 203.2	41.3 x 146 x 203.2	41.3 x 146 x 203.2
FIRST CUSTOMER SHIPMENT	3Q95	2Q94	4/86	4/86	6/90
COMMENTS	Quadspeed R/W drive sold for duplicators				Double speed drive sold for duplicators.

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	
DRIVE	YD-380B-1734S	YD-380D-1711D	YD-801 YD-802	YD-180	
DISK/TREND GROUP	13	13	13	13	
MARKET	OEM	OEM	OEM	OEM	
MEDIA: Nominal disk diameter	5.25"	5.25"	5.25"	8"	
Recording medium	High Density Oxide Coated	High Density Oxide Coated	High Density Oxide Coated	Oxide Coated	
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes)	F: .7/1.2	F: .7/1.2	F: 1.2/2.4	F: .6/1.2	
Capacity per track (Bytes)	F: 4,608/7,680	F: 4,608/7,680	F: 20,832	F: 4,096/8,192	
Data surfaces per spindle	2	2	2	2	
Tracks per surface	80/77	80	80	77	
Track density (TPI)	96	96	96	48	
Maximum linear density (BPI)	5922/9870	5922/9870	19740	3408/6816	
Recording code	MFM	MFM	MFM	MFM	
Rotational speed (RPM)	600/720	360	180/360	360	
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	
POSITIONING: Track to track(msec)	3	3	3	3	
Settling time (msec)	15	15	15	15	
Average rotational delay (msec)	50/41.6	83.3	166.7	83.3	
Data transfer rate (KBytes/sec)	75/125	37.5/62.5	62.5	31.25/62.5	
SIZE (mm: H x W x D)	41.3 x 146 x 203.2	41.3 x 146 x 203.2	41.3 x 146 x 203.2	57.2 x 217.2 x 320	
FIRST CUSTOMER SHIPMENT	6/91	4/86	1Q87	9/81	
COMMENTS	Double speed R/W drive sold for duplicators		Compatible with 1.0 and 1.6 MB formats.		

MANUFACTURER PROFILES

1996 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing the types of removable data storage products covered by this report, or those which are expected to eventually enter the market, are listed in this section. "1995 total net sales" covers the fiscal year ending in 1995 for each firm unless noted otherwise, or for the parent company if the storage product manufacturer is a subsidiary. The fiscal year of listed firms ends 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 cited by the Federal Reserve Bulletin.

Country	Currency	Currency units/U.S. dollar
Germany	Deutschmark	1.43
Italy	Lira	1,629.5
Japan	Yen	94.0
Netherlands	Guilder	1.60
South Korea	Won	773.0
Taiwan	Dollar	26.5
United Kingdom	Pound	.633

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

U.S. Manufacturers

ACTIONTEC, INC. (Formerly Premax Electronics, Inc.)
750 North Mary Avenue
Sunnyvale, CA 94086

Founded in 1993, Premax specializes in PC Card storage and peripheral boards. The firm's manufacturing is done in Taiwan. Intel chips are used in a line of flash memory cards that range from 256 kilobytes to 16 megabytes in capacity. The company changed its name in 1995 to eliminate confusion with other organizations and as a step to establish a stronger brand image.

ADVANCED MICRO DEVICES
1 AMD Place
Sunnyvale, CA 94088

1995 total net sales: $2,429,724,000 Net income: $300,511,000

AMD, founded in 1969, is the fifth largest U.S. semiconductor manufacturer. The firm produces memories, microprocessors, programmable logic devices and other semiconductor products.

AMD's flash product line includes flash chips and PC Card flash memory cards operating on 5 volts. Card capacities from 1 to 20 megabytes are available. AMD relies upon outside contractors to assemble its flash memory cards, as the firm's primary emphasis is upon chips.

In mid-1994, AMD announced that SGS-Thomson Microelectronics would become a second source for AMD's flash chips and would work with AMD on future developments. A 1992 agreement also established Fujitsu as an AMD chip second source, and jointly funded development has resulted in the production of 16 megabit chips by both firms in 1995. AMD introduced lines of 5 volt and 3 volt Miniature Cards in 1996.

AMP INCORPORATED
Harrisburg, PA 17105

1995 total net sales: $5,227,226,000 Net income: $427,334,000

AMP is a major manufacturer of electronic hardware and the largest manufacturer of electrical and electronic connectors. The firm produces a line of flash memory cards ranging from 128 kilobytes to 16 megabytes. AMP is using Atmel, AMD and Intel chips in the flash memory cards it produces. In 1993, the firm acquired a minority interest in New Media, which includes flash memory cards in its own product line. AMP is one of the companies producing flash cards not fully compliant with the computer oriented PC Card interface specification, but suitable for use with industrial equipment.

AURA ASSOCIATES
2605 South Winchester Boulevard
Campbell, CA 95008

Aura Associates, founded by disk drive industry veterans in mid-1986, initially planned to develop a 2.5" drive using multiple actuators and offering very fast access time and transfer rate. An early model of the drive was demonstrated at the 1988 Fall Comdex, but was never produced. More recently, Aura designed 1.8" drives which were produced by NEC, but for which Aura also retained manufacturing and sales rights. The firm began shipments of PC Card Type III rigid disk drives in 1993, but suspended sales due to market weakness. The company is currently developing an electronic camera which will use PC Card Type III drives.

AVATAR SYSTEMS CORPORATION
1455 McCarthy Boulevard
Milpitas, CA 95035

Avatar was founded in 1991 by John Bizjak, a veteran of several pioneering disk drive programs, to develop high capacity disk cartridge drives. The company started production of an 85 megabyte 2.5" disk cartridge drive in mid-1993, using glass disks, and intended for portable and desktop applications. After management changes in 1994, emphasis has been placed on 170 megabyte drive models, with an emphasis on OEM markets. Drive development is centered in Milpitas, using a manufacturing facility established in Thailand in 1995.

BERG ELECTRONICS, INC.
101 Hanley Road, Suite 400
St. Louis, MO 63105

Berg Electronics, founded in the 1950's, was sold to DuPont in 1972 and resold to outside investors in 1993. An aggressive acquisition policy has driven rapid growth since Berg's reemergence as an independent entity. The firm is the third largest supplier of electronic connectors and cable assemblies, and also performs contract design and manufacturing services. Berg facilities are located in the U.S., Europe and Asia, with marketing and engineering located in Pennsylvania. The firm manufactures flash memory cards for AMD.

CENTENNIAL TECHNOLOGIES, INC.
37 Manning Road, Suite 1
Billerica, MA 01821

Centennial was founded in 1962 as a supplier of printer fonts and font hardware modules. The firm got into the small printer font cartridge market in the mid-eighties and subsequently evolved into a supplier of PC Card memory in 1992, including flash memory, SRAM, DRAM and read-only memory.

CIRRUS LOGIC, INC.
3100 West Warren Avenue
Fremont, CA 94538

Cirrus Logic is a producer of specialized controller and interface chips and related products. The company entered the PC Card market in 1995 with a line of flash disk cards based on Samsung 16 megabit NAND logic chips. The company sells complete cards or portions thereof to OEM customers. Production began in mid-1995.

INTEGRAL PERIPHERALS
5775 Flatiron Parkway
Boulder, CO 80301

Integral Peripherals was founded in September, 1990, by engineering and management personnel who previously pioneered in early 2.5" drives at PrairieTek. The company was the first to design and manufacture 1.8" disk drives. Its initial product was a 20 megabyte drive, first produced in the second half of 1991, and for which the available market was minimal. Integral had somewhat better luck with a 42 megabyte model, in production since early 1992, and a succession of higher capacity models which followed. The existing 1.8" drives use ramp loaded heads, and are designed to high operating shock and vibration specifications, with low power requirements, in anticipation of wide usage in subnotebook computers and other mobile computer applications.

The company has pioneered in utilizing untextured disks in higher capacity models, a technique made possible by using the ramp loading head method to avoid parking heads on the disk surface. Integral began its high volume manufacturing in Singapore in mid-1992, moved into a new plant in 1995 and has added 1.8" drives with up to 340 megabytes, with a 514 megabyte model announced, all in PC Card Type III format. In 1995, Integral added a 1 gigabyte 2.5" drive as the beginning of a new product family, the result of a design contract with Samsung Electronics to provide designs for 2.5" drives, with both companies entitled to manufacture the drives involved.

INTEL CORPORATION
2200 Mission College Boulevard
Santa Clara, CA 95052

1995 total net sales: $16,202,000,000 Net income: $3,566,000,000

Aside from being the leading manufacturer of microprocessors, Intel manufactures flash chips, flash memory cards and flash disk cards ranging from 1 megabyte to 40 megabytes. Production of the flash memory cards began in 1993, while the flash disk cards began shipments in mid-1994. The company tends to emphasize flash memory over flash disk, and expanded its flash memory offerings during 1995 and 1996, but discontinued its flash disk products. Intel is also the leading promoter of the Miniature Card small form factor flash memory card. Intel's initial flash production program was delayed due to problems at several Japanese firms used for chip production, but demand and capacity are now balanced. Flash chip production is now concentrated at Intel facilities in Albuquerque and with Sharp Corporation.

In mid-1994, Intel revealed a development program capable of storing multiple bits of information in a single flash memory cell. Intel hopes to be able to use the technology to produce a 128 megabyte flash chip by the year 2000.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

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

For many years IBM has been the world's premier computer company. In 1956, IBM became the first company to ship a rigid magnetic disk drive, and maintained a leadership position in storage technology for much of the time between then and the present. Today, the 3.5" and 2.5" rigid disk drives made by IBM's Storage Systems Division use the most advanced heads available in any disk drive. The firm had been producing 3.5" optical drives, but ceased production in 1995. IBM was the earliest manufacturer of floppy disk drives, which it no longer produces.

IBM Microelectronics Division now supplies PC Card flash disk cards, having dropped flash memory cards previously produced. The flash disk cards, which use Toshiba devices and an IBM designed controller chip, became available in 1994. The flash disk cards are manufactured by IBM in Japan, while flash memory and other PC Card peripherals are made by Celestica, an IBM subsidiary in Canada, on a contract basis for other firms.

IOMEGA CORPORATION
1821 West Iomega Way
Roy, UT 84067

1995 total net sales: $326,225,000 Net income: $8,503,000

Iomega, founded in 1980, was successful in establishing production capability for its unique 8" flexible disk drive, which maintained control of head/disk contact with the Bernoulli effect. The product was originally intended as an OEM drive, but Iomega had much better luck with subsystems sold in the personal computer add-on market. The original 8" drives for the IBM PC market provided most of the company's revenue growth until displaced by the 5.25" models in production since 1987, now offered with capacities up to 230 megabytes. But time passes on, and the Bernoulli drive product line is now in its last stage, as Iomega moves on to new products with much larger markets.

Attempting to broaden its product coverage, Iomega licensed the Insite Peripherals "floptical" drive and media, and selected Chinon as a manufacturing partner for the drive. Iomega's 20 megabyte "floptical" drive was introduced in 1992, but was discontinued in 1994 after only limited sales success. That venture convinced Iomega's management that a comparable drive with higher capacity and the right price could be a success. The result was the 100 megabyte "Zip" 3.5" floppy drive, which began shipments in early 1995, and has found a much broader market, due to its unique combination of 100 megabyte disk capacity and less than $200 drive list price. Seiko Epson has been established as a second manufacturing source for the Zip drive. Iomega announced in March, 1996, that more than a million Zip drives had already been shipped, and followed up with a mid-year announcement that they had reached the two million drive mark.

The one gigabyte "Jaz" drive, which first shipped in late 1995, marks Iomega's entry into the rigid cartridge disk drive market. The Jaz is produced for Iomega under contract by Sequel, and also appears to be developing a broad market in several market segments.

MAGICRAM, INC.
1850 Beverly Boulevard
Los Angeles, CA 90057

MagicRAM, founded in 1990, develops and manufactures PC Card products and DRAM memory upgrades for notebook computers. Some of the firm's flash memory cards are internally manufactured, others are provided by third parties. Since 1994, MagicRAM has been evolving from being only an OEM manufacturer to a firm with both manufacturing and distribution capability.

MICRON TECHNOLOGY, Inc.
8000 South Federal Way
Boise, ID 83707

1995 total net sales: $2,952,000,000 Net income: $844,100,000

Micron Technology, a major manufacturer of DRAM, SRAM and flash memory components, has indicated its intent to ship flash memory cards from 10 megabyte to 100 megabyte capacity in the first half of 1997 using Micron's own devices. The nonvolatile memory products will be produced by Micron Quantum Devices, a Micron Technology subsidiary. Some of the Micron cards will be in small form factor formats.

MOST, INC.
11205 Knott Avenue
Cypress, CA 90630

Production of a 128 megabyte 3.5" drive developed by MOST and Nakamichi began in late 1990. A 256 megabyte drive using a GCR recording format was announced in 1991, with shipments beginning in 1992. A 384 megabyte drive (also capable of operating at 230, 256 and 128 megabytes) went into production in the third quarter of 1994. In early 1993, Nakamichi, MOST's parent firm, acquired the Optical Products Division of Applied Magnetics and placed it within MOST, where it continues to produce optical drive heads and mechanisms. In 1995, the firm's senior management purchased MOST from Nakamichi, along with Ocean Microsystems. The firm has discontinued its 3.5" product line and now concentrates upon manufacture of 5.25" drives and mechanisms.

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. 3.5" drives were added in early 1995. The modified drives are used in harsh environments such as seismic survey, aircraft maintenance, and manned spacecraft. The mechanism and electronics have been modified for ruggedized or militarized requirements.

The firm has begun designing its own drives which will include advanced features such as digitally adaptive read/write electronics. A militarized write-once drive for use in an airborne digital mapping system was delivered in late 1990. An upgraded ISO-compatible version was first shipped in 1992, as was a ruggedized version of a currently available 5.25" magneto-optic rewritable drive.

NEW MEDIA CORPORATION
1 Technology, Building A
Irvine, CA 92718

New Media produces flash memory cards ranging from 256 kilobytes to 8 megabytes in capacity. AMP has a minority interest in the company, but AMP and New Media produce separate PC Card flash memory product lines.

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. start-up corporations planning to develop high capacity, high performance optical disk drives.

RAYMOND ENGINEERING
217 Smith Street
Middletown, CT 06457

Raymond Engineering is a supplier of military and aerospace electronics. The firm packages disk drives for use in hostile environments, and in 1994 announced a disk drive array using SanDisk flash drives rather than rigid disk drives. The 320 megabyte array uses 8 of SanDisk's 40 megabyte flash drives. The array will operate with higher capacity storage modules as they become available in the future.

SANDISK CORPORATION (Formerly SunDisk Corporation)
140 Caspian Court
Sunnyvale, CA 94089

Founded in 1988 as SunDisk, SanDisk is today the largest producer of flash disk ATA interfaced PC Card memories. In mid-1995, the company changed its name from SunDisk to SanDisk to avoid confusion with other organizations. Products range from 1.8 megabyte to 175 megabytes in capacity. Matsushita Electronics, NEC and LG Group produce the chips for SanDisk, which are then mounted on boards by Anam, a Korean contract manufacturer. Final card assembly is done in Thailand by still another contractor. In 1993, Seagate acquired a 25% interest in SanDisk, and for a while distributed the SanDisk cards on a nonexclusive basis, an activity which ceased in 1995. Other announced SanDisk customers include Motorola, Seiko Epson and Verbatim. SanDisk has entered into a number of alliances with other firms for development of suitable chips, including NEC, with which it is working on 256 megabit chips for production in 1997.

SanDisk is the primary sponsor of Compact Flash (CF), a small form factor card with an ATA interface. CF, which has acquired its own trade association, was the first of the small form factor formats to enter the market, and its acceptance by manufacturers of digital cameras and other digital consumer equipment places SanDisk in a potentially advantageous position as these consumer markets develop.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1996 total net sales: $8,588,350,000 Net income: $213,261,000
(FY ending 6/28/96)

Seagate, which began shipping rigid disk drives in 1980, is the leading independent disk drive producer. In 1989, the firm acquired the Imprimis disk drive operation from Control Data, adding high capacity 3.5", 5.25" and 8" drives to its existing lower capacity products. Conner Peripherals was acquired in early 1996. Seagate currently manufactures 2.5", 3.5" and 5.25" rigid drives, all above 420 megabytes in capacity. A 43 megabyte 1.8" PC Card Type III rigid disk drive was announced in 1993, but was subsequently dropped. The firm also produces many of its own components, including heads, media and semiconductors.

In 1993, Seagate purchased a 25% share in SanDisk, and began marketing SanDisk PC Card flash disk cards through its own distribution channels. This effort was only marginally successful and Seagate elected to drop its marketing effort in 1995, although the firm retains its interest in SanDisk.

SIMPLE TECHNOLOGY INCORPORATED
3001 Daimler Street
Santa Ana, CA 92705

STI is a manufacturer of PC Cards and memory upgrades. The flash memory product line includes both linear flash and flash disk cards, the latter introduced in 1996.

SMART MODULAR TECHNOLOGIES
45531 Northport Loop West, Building 3B
Fremont, CA 94538

Formed in 1988, SMT is a specialist in add-on and add-in memory card products, especially in SIMM format. The company began selling PC Card flash memory cards in 1992, with its designs based upon Intel and AMD chips.

SWAN INSTRUMENTS
3000 Olcott Street
Santa Clara, CA 95054

Swan Instruments, founded in 1984, is a producer of rigid disk drive head testing instruments and fixtures. It is also among the ranks of the few firms developing high capacity flexible disk drives, and in 1994 announced a high capacity floppy disk drive in a 3.5" form factor, with the combination of fixed and removable metal powder flexible disks. In the current version, the fixed disk will store 130 megabytes, and the removable disk 130 megabytes, and the drive will also have the capability to read and write conventional 1.44 megabyte 3.5" floppy disks. The company plans to begin production with a manufacturing partner when a suitable arrangement is completed.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

1995 disk sales: $152,800,000
1995 total net sales: $299,544,000 Net income: ($11,786,000)
(FY ending 9/30/95)

SyQuest was started in early 1982 to make rigid disk drives using 3.9" (100 mm) plated disks, in both fixed and removable disk cartridge configurations, but after several years of production 3.9" disks were displaced by industry standard sizes. The firm began shipping 5.25" disk cartridge drives with formatted capacity of 44 megabytes and embedded SCSI controllers in 1988, achieving significant success in the Macintosh add-on market, and with its 5.25" disk cartridges, eventually becoming the dominant "prepress" interchange standard for graphics and desktop publishing. In 1989, SyQuest began manufacturing in Singapore.

In the 1990's, SyQuest increased the capacity of its 5.25" cartridge disk drive series to 88 megabytes, then to 200 megabytes. A 3.5" disk cartridge drive program resulted in first shipments of 105 and 270 megabyte models in 1993. SyQuest also manufactures the disk cartridges for the drives, and cartridges account for about half of the firm's revenue. A unique 1.8" drive was announced in 1995, utilizing a disk cartridge designed to be removable from a PC Card Type III disk drive, but the project was stopped in early 1996.

The EZ135, a 135 megabyte drive marketed as a counter to the high capacity floppy Iomega "Zip" drive, began shipping in mid-1995. However, SyQuest has suffered financial difficulties since mid-1995, as the result of costs which were higher than expected for the EZ135, combined with significant penetration of traditional SyQuest markets by both the Iomega Zip drive and the new Jaz 1 gigabyte rigid disk cartridge drive. In the first two quarters of 1996, SyQuest's bottom line loss was larger than total sales revenues, a major management reorganization was undertaken, and 60% of the company's employees were laid off. Subsequently, the firm announced the EZFlyer 230 megabyte 3.5" rigid disk cartridge drive, intended as a low cost competitor to both high capacity floppy drives and 3.5" optical disk drives.

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 Corporation is also a partial owner of the firm.

VISIONTEK
1175 Lakeside Drive
Gurnee, IL 60031

Privately held VisionTek was founded in 1988, functioning originally as a memory broker. The firm rapidly developed manufacturing capabilities and now makes a variety of memory cards and PC Card products that are sold through distribution. While flash memory shipments were all resale as of publication time, production of PC Card format flash memory cards with ATA interfaces is planned for the fourth quarter of 1996, with follow-on production of Compact Flash memories anticipated for 1997.

Asian Manufacturers

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

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

1996 total net sales: $4,105,122,000 Net income: ($21,917,000)

Alps Electric is a diversified manufacturer of electronic components and subassemblies for television, audio, instruments and computer applications. Printers, keyboards, mice and disk drives together account for approximately 26% of Alps' revenues. The firm's big increase in floppy drive shipments came in 1981, with a rapid buildup of shipments to Apple Computer.

In the spring of 1987, Alps became the first Japanese company to manufacture floppy drives in the U.S., with 5.25" drives made in Garden Grove, California. Alps has also manufactured floppy drives in Ireland. Alps began shipping 3.5" microfloppy drives in mid-1984. A prototype 2.5" nonremovable floppy disk drive with a 10 megabyte capacity and average seek time of 50 milliseconds was shown to prospective customers in 1991 but was not formally announced.

CANON ELECTRONICS CO., INC.
Subsidiary of Canon, Inc.
1248, Shimokagemori, Chichibu-city
Saitama, 369-18
Japan

1995 total net sales: $23,063,110,000 (FY ending 12/31/95) Net income: $586,113,000

Canon Electronics produces electronic subassemblies for Canon cameras, as well as other electronic components, including magnetic heads, and systems. Floppy disk drives represented 5% of Canon Electronics' revenues in recent years. One and two sided 5.25" floppy drives were first produced in 1979, originally under a BASF license for one third high drives. Canon also developed its own unique microfloppy using a 97 mm disk, but these drives were dropped, and the firm began shipments of 3.5" microfloppies in late 1984. Canon was one of the early producers of a half high combination drive assembly, using its one third high 5.25" drives and 15.5 millimeter high 3.5" drives. The company was not successful in establishing sales levels high enough to be profitable in the extremely competitive floppy drive business and discontinued shipments in 1996.

CARRY COMPUTER ENGINEERING CO., LTD.
10 Alley 59, Lane 42, Min Chuan Road
Hsin-Tien City
Taipei
Taiwan, R.O.C.

Carry Computer provides a variety of PC Card based products, including memories, modems, network interface cards and card "drives". The flash memory cards use Intel chips and range from 2 to 16 megabytes in capacity.

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

1996 total net sales: $306,624,000 Net income: ($39,627,000)

Chinon is best known for its cameras and lenses, but much of its sales come from floppy disk drives, printers and other equipment for information systems. Eastman Kodak holds approximately 12.3% ownership through Kodak Japan. Chinon has been producing head assemblies for CD equipment and in 1988 began supplying CD-ROM drives to Atari as a custom product. A similar drive has also appeared under Chinon's own label for use with IBM and Apple personal computers. A 128 megabyte 3.5" drive was announced in 1992 and began shipping in early 1993, but is now out of production.

The firm introduced its flexible disk drive product line in 1984, currently consisting of half high 5.25" drives and 3.5" microfloppies. In mid-1992, Chinon established Chinon Asia Private Ltd., a Singapore based company, which manufactures flexible disk drives. Chinon and Iomega had an agreement for Chinon to manufacture the "floptical" disk drive that Iomega licensed from Insite Peripherals, and production started in the second half of 1992. Due to the limited size of the 20 megabyte floptical drive market, Iomega discontinued the product and the Chinon production program was terminated. The floppy drive program is also winding down, with only a few models still being sold.

CITIZEN WATCH CO., LTD.
2-1-1, Nishi-Shinjuku
Shinjuku-ku, Tokyo 160
Japan

1995 FDD sales: $126,800,000
1996 total net sales: $4,099,073,000 Net income: $80,106,000

Citizen is steadily expanding its diversification into additional products, from its basic position of strength as Japan's second largest watch manufacturer. Watches are now down to 47% of sales, machine tools hold 7% and electronic equipment the balance. In addition to printers, displays, and small computers, Citizen introduced 3.5" microfloppies in 1984, offering the first one inch high floppy drive, and began an aggressive sales program in the U.S. and Europe, aimed at the OEM market.

In 1989, Citizen again led the industry in drive packaging, this time with the first introduction of 19 millimeter high 3.5" floppy disk drives, followed in 1990 with drives only 15 millimeters high. A 20.6 megabyte (formatted) floppy drive using metal powder media was announced in late 1989, and since dropped due to weak market reaction. In late 1992 Citizen announced the thinnest 3.5" floppy drive to date, only 11 millimeters in height, and production began in 1993.

EASTERN PERIPHERALS PVT. LTD.
72, S. D. F. III
Seepz, Andheri (E)
Bombay, 400 096
India

Eastern Peripherals was originally established in 1979 to make 5.25" floppy disk drives and components for Tandon Corporation, and is owned by members of the Tandon family. With Tandon Corporation's departure from the disk drive business in 1987, Eastern Peripherals continued as an OEM floppy drive manufacturer, using models developed by Tandon, and also produces heads, stepping motors, and other electronic products.

FUJI PHOTO FILM
2-26-30 Nishi-Azabu
Minato-ku, Tokyo 108

Established in 1934, Fuji Photo Film today obtains nearly half of its revenues from computing and communications related equipment, supplies and accessories. The remainder comes from sales of photographic equipment and supplies, photofinishing equipment and imaging equipment.

The company provides media for the Iomega "Zip" drive and standard floppy disk media for conventional floppy drives. It also markets flash disk and flash memory PC Cards. The more recent and higher capacity cards use Atmel chips.

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

1996 total net sales: $40,053,248,000 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 represent about 66% of Fujitsu's sales. In 1992, Fujitsu became a second source supplier for AMD's flash chip product, and the two companies are currently working together on design and manufacturing of advanced flash chips. Flash memory cards were introduced in 1993.

The firm has also been active in the optical drive area, and has manufactured 8", 5.25" and 3.5" optical drives. Through its aggressive pricing, Fujitsu is the leading supplier of 230 megabyte 3.5" optical drives. The firm has also introduced a 640 megabyte 3.5" optical disk drive.

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

1996 total net sales: $86,515,548,000 Net income: $1,509,798,000

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 revenues are derived from computing and electronic equipment.

The company has been active in the flash chip market for several years, and has developed its own flash cell AND architecture, announced in 1992, which combines features of NAND and NOR architectures. In early 1994, Hitachi and Mitsubishi Electric announced they would jointly develop and market 16 megabit and 64 megabit flash memory products. Each firm will second source the other's chips. A small quantity of low capacity PCMCIA flash memory cards were made by Hitachi in 1994, but the firm's primary effort is expected to be in the chip area with 16 megabit or larger chips. Hitachi and Mitsubishi co-announced 16 megabit chips in late 1995 and is expected to announce 64 megabit chips in late 1996. Hitachi is also moving into ferroelectric chip markets, with product announcements anticipated in the latter part of 1996.

HYUNDAI ELECTRONICS INDUSTRIES CO., LTD.
140-2, Kye-dong
Chongro-ku, Seoul
Korea

Hyundai is manufacturing 4 megabit and 16 megabit flash memory chips for sale to other companies and for use in its own line of flash memory cards (introduced in 1996), which extend from 1 to 20 megabytes. The firm also had a majority ownership in a U.S. subsidiary, LaserByte, which produced 3.5" optical drives until it ceased operations last year.

KINGMAX TECHNOLOGY INC.
295, Section 2, Kuang Fu Road
Hsin-Chu City
Taiwan

Kingmax is a manufacturer of integrated circuit cards, including flash memory cards, as well as computer memory modules, SRAM, Fax/Modem and Ethernet cards. The firm's original flash products were linear flash, but flash disk cards were added in 1996.

LASERBYTE CORPORATION
Subsidiary of Hyundai Electronics Industries Co., Ltd.
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. In 1995 the firm shut down production and disbanded as the result of technical difficulties and lack of a favorable market reception.

MATSUSHITA COMMUNICATION INDUSTRIAL CO., LTD.
Subsidiary of Matsushita Electric Industrial Co., Ltd.
4-3-1 Tsunashima-Higashi
Kohoku-ku, Yokohama 223
Japan

1996 total net sales: $6,339,265,000 Net income: $76,432,000

Matsushita Communication Industrial is a member of the Matsushita Electric Industrial group, a worldwide giant in appliances and electronics. During the early growth of the floppy drive industry, MCI manufactured most of the Shugart Associates floppy drive line under license for the Japanese OEM market. MCI later added floppy drives of its own design, including half high 5.25" and 3.5" microfloppy drives. The firm made half high 5.25" drives on a contract manufacturing basis for Shugart and in 1985 acquired marketing rights in the United States, which has resulted in significant sales by the firm's U.S. Panasonic subsidiary. MCI established a joint venture in the Philippines with Precision Electronics Corporation, to manufacture floppy disk drives and other computer components, and all flexible disk drive production is now located in the Philippines.

The firm introduced a .7 megabyte 2" floppy drive that was adopted by Zenith in 1989 for use in a notebook computer but was otherwise shunned by the computer industry. After several attempts to pioneer various high capacity floppy drive configurations, most of the MCI floppy drive activity is centered on mainstream 5.25" and 3.5" floppy drives.

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

1996 total net sales: $72,362,641,000 Net income: ($605,655,000)

MEI's Panasonic, National, Technics, and Quasar brands are among the most widely known in the world for appliances, consumer electronics, and communications equipment. MEI is the leading manufacturer of 5.25" phase change optical disk drives and also manufactures 3.5" MO drives. The firm is considering the use of phase change technology in 3.5" drives. Matsushita-Kotobuki Electronics produces CD-ROM drives for sale by MEI. High volume production commenced in 1992, and MKE has become one of the largest producers of CD-ROM drives and mechanisms. Matsushita Electronic Components manufactures floppy drives and CD-ROM mechanisms as well.

Matsushita is a flash foundry for SanDisk, and is expanding its capabilities to design and produce flash chips and derivative products. 16 megabit chips have been used since 1994. 32 megabit and 64 megabit chip developments are planned for the future. The company is also developing ferroelectric memories, a potentially competing technology to flash memory, in order to be well positioned in the event ferroelectric technology becomes competitive.

PC Card flash memory cards were introduced in 1993, and are being sold by the Panasonic Battery Sales Group in the U.S. Capacities range from 256 kilobytes to 4 megabytes.

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

A member of the Matsushita Electric Industrial group, Matsushita Electronic Components Co. (MACO), is a diversified manufacturer of electromechanical and circuit components, plus various system and audio products. The company joined with Hitachi in attempting to establish a 3" microfloppy standard, which had widest acceptance in the European market, but was discontinued in 1991. Production of 3.5" floppy drives began in 1987.

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

1996 total net sales: $5,081,406,000 Net income: $71,683,000

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 manufactured for Quantum Corporation, floptical disk drives produced 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.

MKE is manufacturing the second generation 120 megabyte floptical drive known as the LS-120, with sales through Matsushita companies and O.R. Technology. Production is expected to start in the second half of 1996.

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

1996 total net sales: $37,394,665,000 Net income: $630,511,000

Mitsubishi is most noted for heavy machinery production, but is also active in defense electronics and consumer electronics. Data and communication systems represent 34% of sales.

Mitsubishi has entered into product development alliances with several other flash memory producers, including SGS-Thomson (16 megabit chips) and Hitachi (64 megabit chips). 3.3 volt chips went into production in late 1995. The firm currently offers flash memory cards based upon Intel chips with capacities ranging from 256 kilobytes to 20 megabytes.

A family of half high 5.25" floppy drives was introduced in 1982, with capacities up to 1.6 megabytes. Mitsubishi also started shipping a 3.5" microfloppy drive in 1983 and introduced a 1.44 megabyte version as early as 1985. Mitsubishi became a major supplier of flexible disk drives to IBM, following the IBM introduction of PS/2 in 1987. In 1991, the firm introduced a 2.88 megabyte 3.5" drive. After several years of flexible disk drive production at Mitsubishi's Koriyama Works, Melco Manufacturing (Thailand), a joint venture for the manufacture of floppy drives was established with Kang Yong Electric Manufacturing Co. The joint venture is largely owned by Mitsubishi.

MITSUMI ELECTRIC CO., LTD.
8-8-2, Kokuryo-cho
Chofu-City, Tokyo 182
Japan

1996 total net sales: $2,714,217,000 (FY ending 1/31/96) Net income: $57,327,000

Mitsumi is a leading manufacturer of electronic subassemblies and components, including magnetic heads. Floppy disk drives represent about 18% of sales, up from 10% in 1991. The firm established a joint venture facility with Commodore, named Newtronics, to produce 5.25" and 3.5" floppy drives, and acquired complete ownership of Newtronics in 1986. During the last few years, Mitsumi has established a pattern of high growth in floppy drive sales, the result of low cost manufacturing operations and the company's aggressive pricing policy.

In 1984, Mitsumi introduced a very low cost 2.8" drive using a special Maxell disk under the name "Quick Disk", which used a single spiral track with 64,000 kilobytes capacity. It was used primarily in low-end home systems, including games, with final shipments in 1991. One inch high 3.5" drives went into production in 1987, followed by 3/4 inch high drives in 1989 and 12.7 millimeter high 1.44 drives in 1991. The company announced a 128 megabyte 3.5" floppy drive based on an Antec design in November, 1995. However, production has been delayed pending resolution of a patent licensing dispute with Swan Instruments. Mitsumi has established a manufacturing facility in Malaysia for floppy disk drives and began manufacturing at Cebu Mitsumi in the Philippines in early 1992.

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

1996 total net sales: $46,828,456,000 Net income: $821,789,000

NEC has defined its product area as communications and computers, with computer products accounting for about 46% of 1995 revenues. The firm has the largest share of the Japanese PC market. NEC makes a variety of data storage products, including floppy, rigid, CD-ROM and 3.5" optical disk drives.

Under an agreement with Aura Associates, NEC produced PC Card Type III 1.8" drives designed by Aura and also sold by Aura. In mid-1994, NEC and SanDisk announced a joint development effort aimed at producing 256 megabit flash devices by 1997. NEC has also indicated its intent to produce flash chips at the 16 megabit and 64 megabit levels.

Since 1978 the company has manufactured two sided 8" floppy disk drives, and was one of the earliest firms to offer half high 8" floppy drives, with shipments starting in late 1981, and not phased out until 1996. 3.5" microfloppy drives and half high 5.25" drives were introduced in 1984. The majority of NEC's floppy drive shipments have been for captive applications.

NEC was an early participant in the high capacity floppy drive market with the 1988 introduction of a 3.5" 9.4 megabyte drive for sale with its microcomputer systems. A 10 megabyte version with downward compatibility to .7 and 1.44 megabyte drives was introduced in 1990. NEC was very active on the JEIDA committee working to standardize high capacity 3.5" floppy disk drives, and announced a 21.4 megabyte drive. NEC high capacity floppy drive production was limited, and all have been dropped from the company's product line.

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

1996 total net sales: $2,727,881,000 Net income: $21,736,000

Founded in 1919, Olympus Optical company is known primarily for its cameras and optical instruments. In recent years the company has broadened its activities to include electronics and some specialty products, including optical heads for disk drives. Development of optical disk drive technology began in 1981 when Olympus and Fujitsu began a joint project that resulted in one of the first commercial write-once optical disk drives. The firm's optical electronic products include optical heads, an optical card reader compatible with the Drexler Lasercard and a 5.25" erasable optical disk drive announced in November, 1987. The disk drive, which has a capacity of 326 megabytes per side, was provided in sample quantities as of mid-1988, and Olympus mechanisms have been adopted by Ricoh and others as the basis of their own rewritable drives.

Olympus began marketing under its own brand name in 1992 when it introduced a 3.5" 128 megabyte drive. This was followed by a 230 megabyte version in early 1994. At that time the firm also announced 5.25" full height and half height MO drives. A high performance 3.5" MO drive was introduced in 1995. 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 such as optical disk libraries.

O.R. TECHNOLOGY, INC.
Subsidiary of O.R. Computer System Pte. LTD.
42 West Campbell Avenue
Campbell, CA 95008

O.R. Technology, Inc., was formed in November, 1995, as a combination of Insite Peripherals and Optics Research. Insite's announcement of a 20 megabyte 3.5" microfloppy, combining an optical head positioning scheme with magnetic recording, aroused widespread interest in the disk drive industry at the beginning of the 1990's. Trademarked as the "floptical", the drive used an LED on the head assembly to follow optically reflective servo tracks on the surface of 3.5" barium ferrite media. A one inch high version that is downward compatible with standard 3.5" .7 and 1.44 megabyte drives in both read and write modes became available in late 1991, the result of Insite's contract manufacturing arrangement with Matsushita-Kotobuki Electronics. Insite attempted to achieve mainstream status through licensing of established drive and media manufacturers, with Iomega as the first announced licensee. 3M and Hitachi Maxell were granted licenses as media producers, and made equity investments in Insite.

Despite establishment of reliable drive and media manufacturing sources, the Insite drive's price was several times higher than low capacity 3.5" floppy drives during a period of intense price competition in the personal computer industry, the largest market opportunity. As a result, personal computer manufacturers were unwilling to add floptical drives as standard products. The market was confined to storage subsystems builders active in the add-on market and to OEM sales for specialized applications. In order to develop a higher capacity drive with a potentially larger market, several of the companies participating in the floptical program established Optics Research in Boulder, Colorado, to undertake development of a 120 megabyte backward compatible version of the floptical drive. Before completion of the project, Iomega dropped out of the program, in order to develop its own high capacity floppy drive, without backward compatibility, which was introduced in 1995 as the "Zip" 100 megabyte drive. The Optics Research program resulted in the 1995 introduction of the LS-120, with drives to be manufactured by Matsushita-Kotobuki Electronics and media to be supplied by 3M (now Imation).

In the meantime, Insite's development activities and other operations were funded by several rounds of venture capital investments, which were mostly exhausted by the second half of 1993. In late 1993, Insite was sold to O.R. Computer, a subsidiary of Ocean Radio Group, based in Singapore. Ocean Radio has been active for 50 years as a trading company in consumer electronics, components, computers and peripherals. With the new owner's financial backing, the manufacturing arrangement with MKE was continued and sales of the 20 megabyte floptical continued until 1996. As MKE's production of the 120 megabyte LS-120 starts up in the second half of 1996, O.R. Technology is selling the drive through distribution and system integrator channels, in addition to direct sales by Matsushita to system manufacturers, such as Compaq Computer.

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

1996 total net sales: $11,853,355,000 Net income: $232,897,000

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 25% of 1994 revenues. Data storage products include write-once and rewritable optical disk drives.

Ricoh was Pioneer's partner in the development of 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 and 3.5" form factor. After developing several generations of 5.25" and 3.5" optical disk drives, with manufacturing both by Ricoh and outside producers, the company decided in 1996 to close out these product programs and concentrate its optical disk drive activities exclusively on writable CD format drives.

SAMSUNG ELECTRONICS
7 Soonwha-Dong
Seoul
Korea

1995 total net sales: $20,944,200,000 (FY ending 12/95) 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 company's revenues are derived from information systems and related products. The company also produces rigid, flexible and optical disk drives. An active product development center has been established in the United States. Samsung Electronics is using Toshiba's NAND memory architecture in a family of flash chips. The firm has licensed Toshiba's SSFDC small form factor card, but otherwise prefers to manufacture chips rather than memory cards, preferring to be a supplier to card manufacturers.

Samsung got started in floppy drive production in 1983 when Shugart Associates granted a license to manufacture and market the Shugart floppy drives in South Korea. Samsung is currently making half high 5.25" drives with capacities up to 1.2 megabytes, and production of 3.5" 1.44 megabyte one inch high drives began in 1989.

SEIKO EPSON CORPORATION
80 Hirooka
Shiojiri-shi, Nagano 399-07

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also controls Japan's Seiko companies, known for watches and electronics. Epson is best known for its printers, but also manufactures a portable computer, displays, and floppy, optical and rigid disk drives. Seiko Epson announced a 128 megabyte 3.5" drive in 1992. However, the firm has elected to remarket certain 3.5" and 5.25" models rather than produce them internally.

The firm remarkets PC Card flash disk cards made by SanDisk and also manufactures flash memory cards using its own chips. The PCMCIA product line also includes a PC Card Type III rigid disk drive made by Integral Peripherals.

The first Epson floppy drive was a captive 5.25" one third high unit first shipped in 1982 and used with the Epson portable computer. Starting in October, 1983, Epson added an OEM floppy drive product line of 5.25" and 3.5" models, including 3.5" drives with very low power requirements, and in recent years has concentrated on standard 3.5" floppy drive models. In 1996, the company started manufacturing the Iomega Zip drive, selling the drives under the Epson label, as well as producing them under contract for Iomega.

S.F.R.
7-5-17 Nakazato
Tendo-shi, Yamagata 994
Japan

S.F.R., founded in October, 1988, originally was called Digital Systems, Inc., and later adopted the name of its major distributor, Japan Peripherals Network (JPN). In 1991, the firm adopted Safronic Corporation as its, with JPN remaining a separate organization distributing peripherals, including floppy disk drives made by Safronic, and transitioned to the S.F.R. name in 1995. The company has used contract manufacturing sources for half high 5.25" drives and 1.44 megabyte 3.5" drives, and in the second half of 1993 started production in China through a contract manufacturing arrangement managed by a Hong Kong firm. Sales are mostly through distribution.

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

1996 total net sales: $17,579,425,000 Net income: $493,280,000

Founded in 1935, Sharp originally made mechanical pencils. Sharp is now a supplier of electrical and electronic equipment for both consumer electronics and office automation. About 49% of the company's sales are derived from computer or computer related products, including desktop and transportable personal computers.

Sharp is a Sony licensee for the 2.5" MiniDisc system and could be expected to produce a new computer peripheral version of the MiniDisc once Sony establishes the parameters for such a product.

In the flash memory area, Sharp has been one of Intel's foundry operations for flash memory chips. Sharp also markets chips under its own name, with 3 volt, 16 megabit chips added in 1996.

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

1996 total net sales: $48,909,105,000 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 80% of revenues. Sony is also a leading manufacturer of magneto-optic disk drives and high performance CD-ROM drives. The company is vertically integrated and supplies its own media, and is currently the largest producer of magneto-optic media.

Sony sells CD-ROM, write-once and rewritable optical drives. The write-once product line includes 12" drives with up to 3.3 gigabyte per side capacity, while the rewritable drives are 5.25", 3.5" and 2.5" MO models. Sony introduced its 3.5" 128 megabyte rewritable drive in mid-1991. The drive had a specified average seek time of 40 milliseconds and rotated at 3,000 RPM, among the faster optical drives. Sony surprised the industry when it failed to announce a 230 megabyte 3.5" drive in early 1994, but it now appears that the firm has made a strategic decision to leapfrog the competition and go directly to higher capacity drives.

Another 1991 Sony announcement concerned the MiniDisc, a 2.5" magneto-optic drive intended for use in a portable audio recorder and currently in production as an audio device. In mid-1993, Sony proposed a 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. Sony is also looking for opportunities to apply the MD-DATA technology to other form factors.

In 1981 Sony introduced the first drive using a 3.5" flexible diskette, which became the industry's floppy drive standard after several years of struggling with other formats for market dominance. After several generations of floppy drives, Sony's product line evolved into low-cost models in the standard 25.4 and 12.7 millimeter package heights, and the company remains one of the industry production leaders. Sony pioneered the submicrofloppy field with a very high bandwidth .7 megabyte 2" floppy disk drive based upon a Mavica video camera storage device, but the data version of the 2" drive did not find a following in the computer industry.

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

1996 total net sales: $1,204,313,000 Net income: $17,806,000

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.

Shipments of 5.25" floppy drives for the OEM market started in 1978, and in 1985 TEAC announced its line of 3.5" drives, including a 1.44 megabyte model and subsequently added one inch high models.

Rapid growth made TEAC the leader in worldwide noncaptive floppy drive revenues during the last few years. The firm joined Toshiba in 1987 in announcing 2.88 megabyte 3.5" floppy drives using barium ferrite media. 19 millimeter high 3.5" drives were introduced in 1989, and a 2.88 megabyte model was introduced in 1990. In 1991, TEAC introduced the industry's first 12.7 millimeter high 3.5" floppy disk drive, moving to the front in the race to downsize microfloppy drives. TEAC has made manufacturing and licensing arrangements with a number of firms in Japan, Korea, and other countries. Much of TEAC's current production has been moved to Malaysia. The company has also established a drive component manufacturing operation in Singapore.

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

1996 total net sales: $54,527,007,000 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 61% of 1994 revenues were related to data communications or computer products. Toshiba is a leading producer of 2.5" rigid disk drives, and also manufactures CD-ROM drives. The firm also proposed, but did not market, a 1.3 gigabyte 3.5" phase change optical drive.

Toshiba's flash memory program dates back to the mid-1980s, although the firm was unable to capitalize financially on its early participation. In later years the company developed a high performance NAND flash architecture, and is currently supplying chips to several customers, including IBM Microelectronics and National Semiconductor. Toshiba has entered into flash memory development agreements with other firms as well, including licensee Samsung Electronics with which it is developing 64 megabit chips. Toshiba's flash memory and flash disk cards were announced in late 1994. The cards currently use 16 megabit chips. Toshiba is one of the founding members of SSFDC (Solid State Floppy Disk Card association) and a primary sponsor of that format.

8" floppy drives for both captive and OEM markets were produced starting in 1977. Half high two sided 5.25" drives were added in 1982, followed in the mid-1980's by microfloppy drives. High capacity barium ferrite media was developed by Toshiba for 2.88 megabyte 3.5" floppies, with production of drives and media starting in 1988. Several other firms licensed the drive and media. In recent years, Toshiba relied on contract manufacturing arrangements for its supply of floppy drives, which were sold primarily in the North American market, and ultimately discontinued the product line.

TRANSCEND INFORMATION, INC.
465 Chung Hsiao East Road, Section 6
Taipei
Taiwan, R.O.C.

Founded in 1988, Transcend is a manufacturer of controllers, printer memory, memory boards and copy protection devices. Flash memory PC Cards range from 2 megabytes to 20 megabytes in capacity.

Y-E DATA, INC.
182 Shinkoh, Iruma
Saitama, 358
Japan

1996 total net sales: $158,222,000 Net income: ($7,093,000)

Y-E Data is a spin-off of Yaskawa Electric, a diversified manufacturer of heavy electric, factory automation and data processing equipment. Data processing products are the responsibility of Y-E Data, which first manufactured 8" one sided floppy drives in 1974 under an Orbis license. Disk drives represent about two thirds of current sales.

Y-E Data became an early leader in the Japanese OEM markets for both 8" and 5.25" two sided drives. Y-E Data also cooperated with NTT on the standard for 1.2 megabyte 5.25" drives and has been shipping its version since early 1982. Microfloppy drives were added in 1984. Y-E Data's biggest sale of all came in 1984, with IBM's selection of the firm's 1.2 megabyte 5.25" drive for use with the PC AT. In 1986, one inch high 3.5" drives were added to the product line. A 2.88 megabyte 3.5" microfloppy drive using cobalt modified oxide media was introduced in 1988 in an unsuccessful attempt to develop an industry standard, and a 2.88 megabyte 3.5" drive using standard barium ferrite media was first shipped in 1990.

Y-E Data attempted to provide industry leadership in pioneering the market for high capacity floppy drives. A preliminary announcement of a 27.8 megabyte drive using metal particle media was made in 1989, with specifications revised in 1991. The final capacity specification became 20.8 megabytes, with initial shipments in late 1992, but the program was discontinued, due to low demand.

In addition to its drive manufacturing activities, Y-E Data supplies drive kits to manufacturers in India, mainland China and other Asian countries.

European/Middle Eastern Manufacturers

CALLUNA TECHNOLOGY LTD.
Blackwood Road, Eastfield
Glenrothes, Fife KY7 4NP
Scotland

Calluna Technology was founded to design and manufacture 1.8" drives in Glenrothes. The founders are all veterans of Rodime, the pioneer manufacturer of 3.5" drives, and many were previously with the Burroughs disk drive manufacturing facility in Glenrothes. Calluna occupied a new industrial building early in 1992 and started production of disk drives in the PCMCIA Type III PC Card format in mid-1993. The PC Card drive product line has since been expanded, and currently includes announced drives with capacities up to 520 megabytes. Calluna is currently using disks with carbon substrates in all of its drives.

MEMORY CARD TECHNOLOGY
Saralyst Alle 53
DK-8270 Aarhus/Hojbjerg
Denmark

MCT is a manufacturer of memory upgrade products for computers and computer peripherals, with marketing operations in Europe and the United States. The product line includes PC Card flash memories.

M-SYSTEMS FLASH DISK PIONEERS LTD.
ATIDIM Industrial Park, Building 1
Neve Sharet
Tel Aviv 61 580
Israel

Founded in 1989, M-Systems offers flash memory cards and supporting flash file system software, allowing the flash memory cards to emulate disk drives. PC bus cards from 1 to 32 megabytes are available, including an extended operating temperature series. PC Card memories with 20 megabyte capacity became available in mid-1993. The company, along with SCM Microsystems, was a cosponsor of the FTL (Flash Translation Layer) standard used with flash memory cards. In 1996, the firm introduced FLite, flash file system software for use with consumer electronics and embedded applications. FLite brings a DOS-like file capability to processor based equipment that does not use DOS, allowing card interchange with PC based readers.

NOMAI
188, rue de la Liberte -- B.P. 141
50301 AVRANCHES cedex
France

Nomai entered the data storage market in 1992 as a manufacturer and marketer of rigid disk drive cartridges compatible with SyQuest 5.25" drives. After a flurry of legal actions by SyQuest were settled, Nomai was successful in setting up extensive distribution for the disk cartridge product line, including the temporary enlistment of Iomega as a reseller.

In 1995, the company announced the development of high capacity 3.5" rigid disk cartridge drives, with initial shipments starting at the end of 1995. The basic 540 megabyte drive design was done in Scotland by Myrica (U.K.) Limited, a design firm staffed with Rodime graduates, with technology assistance from universities in the U.K. and France. The drive is being manufactured at Havant in the U.K. by Xyratex, the IBM spin-off, and will be sold by both Nomai and Xyratex. In March, 1996, Nomai and SyQuest announced an agreement to utilize a common interchange standard for 3.5" disk cartridges.

N. V. PHILIPS
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. Philips' initial digital optical developments were a 12" write-once drive and the read-only device which became the CD-ROM. Philips, together with Sony, has been instrumental in establishing standards for CD and CD-ROM drives. Philips and Sony continued to innovate standards for CD-ROM, including CD-I and CD-ROM XA. Magneto-optic recording has been under development at Philips for many years, but the effort has been intermittent. Manufacturing of CD-ROM drives, CD-R drives and 3.5" MO drives (and mechanisms) is the responsibility of Philips Key Modules.

In late 1993, Philips and IBM announced a joint development venture leading to the introduction of a one inch high 3.5" MO drive by IBM that used a mechanism manufactured by Philips Key Modules Group. At that time, it was also indicated that Philips would participate in future joint developments, but with IBM's departure from the ranks of small optical drive manufacturers, such participation is problematical.

SCM MICROSYSTEMS GMBH
Pettenkoferstrasse 7
D-85276 Pfaffenhofen
Germany

SCM has been active in flash memory storage products since 1990, developing a flash card host module enabling computers to accept flash cards. The firm, with M-systems, also proposed a flash filing system, much of which was incorporated into the PC Card standards. In November, 1994, SCM announced a line of flash memory cards which extends to 20 megabytes, but the firm emphasizes flash card reader product line rather than the cards themselves.

SGS-THOMSON MICROELECTRONICS
20041 Agrate Brianza
Italy

Jointly owned by the French and Italian governments, SGS-Thomson was founded in 1987 from the merger of SGS Microelettronica and Thomson Semiconducteurs, although the origins of its component companies go as far back as 1957. The firm is a manufacturer of semiconductor components, with over half of its sales made in Europe. The firm is a second source manufacturer for AMD flash chips, but does not at the present time manufacture flash memory cards.

DISK/TREND ON DISK

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., 8255 Overview Court, Suite 100, Roswell, GA 30076.

Trademarks

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 using the Lotus 1-2-3 data parsing commands)

   COPY A:MASK?2.MSK (if you are using AutoImport version 2.xx)
   COPY A:MASK?3.MSK (if you are using AutoImport version 3.xx)

   The utility files named FORMLIN?.PRN are specifically for usage with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   <u>Installing AutoImport V3.xx</u>: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place AutoImport disk 1 in drive A and type: COPY A:*.* and then ENTER. Follow any instructions appearing on the screen until installation is complete. To make AutoImport accessible from any directory, place C:\AIMP in your AUTOEXEC.BAT file's 'PATH' statement. See your MS-DOS instruction manual for information about this step.

   If you are using a floppy-only system, copy the AutoImport disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

3. If you are using AutoImport (highly recommended) for translation of files to spreadsheet format, do the translation at this point. See the following section on using AutoImport for details.

4. Now you are ready to start your spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the spreadsheet system disk in drive A. If you are using a rigid disk system, place a copy of the spreadsheet system disk in floppy drive A if required by the security provisions of your spreadsheet program. Now start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the appropriate file retrieval command to select a file. For Lotus 1-2-3:

   /FR<filename>

   The file names are in the format XTYY.WK1, where: X= Type of data

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

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

   Examples:
   File RT10.WK1 is Rigid Disk Drive Report Table 10
   File OT1.WK1 is Optical Disk Drive Report Table 1
   File AT3.WK1 is Disk Drive Array Report Table 3
   File VT2.WK1 is Removable Data Storage Report Table 2

   The file selected will be loaded as a worksheet. If this is the first time the file has been loaded, you may want to create your own formulas linking the cells of the spreadsheet. See your spreadsheet reference manual for details on numerical manipulations and graphics.

If you don't use AutoImport

If you don't use AutoImport but still want to translate ASCII files to your spreadsheet format, you will have to use spreadsheet tools such as the Lotus 1-2-3 Data Parse commands. They allow the user to convert a table which has been imported in the form of a block of text to a form in which the individual numbers and labels can be manipulated as spreadsheet elements or used to prepare graphics. Let's take Lotus 1-2-3 as an example. Before proceeding, it would be useful to read the Lotus reference manual on this subject if you are not a regular user of the Data Parse commands.

The trickiest and most time-consuming part of using the Data Parse commands is setting up the format line. Several utility files have been provided on the tables disk to make this process easier. These are used with various table formats encountered in the DISK/TREND Reports and correspond with the precomputed masks provided for use with AutoImport:

o FORMLINA.PRN	Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
o FORMLINB.PRN	Used with Table 2.
o FORMLINC.PRN	Used with Tables 3 through 6, 11, 12, 24, 25.
o FORMLIND.PRN	Used with Application tables.
o FORMLINE.PRN	Used with Drive Height and Drive Capacity tables.

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 table below which relates 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 ---->			N/A
MASKE	N/A	Drive height, Drive capacity	Write-Once/ Erasable Analysis	N/A
MASKH	Tables 7,8	Table 30	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	1996 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	--	MASKH	MASKA	MASKA
31	--	MASKD	--	--
32	MASKD	--	--	--
33	MASKI	MASKA	MASKD	--
34	--	MASKA	--	--
35	MASKA	--	MASKA	
36	MASKA	--	MASKA	
37	--	MASKI	--	
38	--	MASKD	--	
39	MASKD	--	MASKE	
40	MASKI	MASKA	MASKD	
41	--	MASKA	--	
42	MASKA	--	MASKA	
43	MASKA	--	MASKA	
44	--	MASKD	--	
45	--	--	--	
46	MASKD	MASKA	MASKA	
47	MASKI	MASKA	MASKA	

Cross-reference (continued)

Table Number	1996 Rigid Report	1996 Removable Report	1996 Optical Report	1995 Array Report
48	--	--	--	
49	MASKA	--	--	
50	MASKA	MASKD	MASKE	
51	--	--	MASKA	
52	--	MASKA	MASKA	
53	MASKD	MASKA	--	
54	MASKI	--	--	
55	--	--	MASKE	
56	MASKA	MASKE	MASKA	
57	MASKA	MASKE	MASKA	
58	--	MASKD	--	
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 the DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

   COPY A:?T*.*
   COPY A:MASK?2.MSK (If using AutoImport version 2.xx)
   COPY A:MASK?3.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 by typing AI, then the ENTER key. When the opening screen appears, select the "File" menu bar item using the mouse or just type /F. (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears (File Selection menu), use the arrow keys or the mouse to select the Mask name option, then select the name of the mask you want from the displayed list. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. 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 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 VT3.96V

5. Select the Output file option on the File Selection menu. (Should always be done after mask retrieval.)

   Enter the name of the file. The file name form recommended is ?Tnn, where ? is the type of report (A, R, V, or O), T is just that, and nn is the DISK/TREND Report table number matching the file being translated. You should not enter the file name extension as the system adds it automatically for you.

   Examples: RT4 OT14 AT20 VT23

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

7. You are ready to translate. Recheck all the file names displayed to be CERTAIN they are correct. Select "CONVERT" button using the mouse (or arrow keys and ENTER). If you are asked "Do you want to load input file *.* named in mask", answer "NO". You will see the file being translated scroll by as the translation proceeds. 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, or use the mouse to select "Quit" on the menu bar to return to the AutoImport main menu, to leave AutoImport and return to DOS. It will save you some keystrokes if you copy your new spreadsheet files to your spreadsheet directory. If you are using a two floppy system, just remove the AutoImport disk from drive A and substitute your spreadsheet disk.

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select "File" using the mouse or type /F.

2. Name the input file you will use as the template to create the mask. The file name will be of the form ?Tnn.yy?, where ? is the type of report (R, O, V or A), nn is the table number and yy is the report year.

   Example: OT10.96O, VT3.96V

   To name the file, select Input file from the File selection menu. Type the desired file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the top left of the report table. Now select "Lines" from the menu bar, then select "Header" from the pop-up window that opens. Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'ENTER'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, selecting "Lines" and "Headings" again, and extending the highlight area over the note and pressing 'ENTER'.

4. Next, locate the longest left margin label (excluding the header lines) in the table. Position the cursor so that it is at the left margin of the line containing the longest label. Select "Column" from the menu bar, then "Auto Define". This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

   In a few cases, the automatic feature may be confused by a table layout and all values will not be picked for conversion. In these unusual cases, you may be able to get the overlooked values included by repeating this step on another line.

   Another unusual case can occur in which the right-hand part of a label is somehow included in a value occurring in the next column to the right. Deal with this rare case as follows:

   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: VT3. 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.

   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)
   C (Cartridge rigid disk drive data)
   S (Semiconductor flash card data)

   In the case of the Removable Data Storage Report, there will be separate specification tables for Optical, Rigid, Cartridge rigid disk, High and Low capacity flexible disk drive and Semiconductor flash card data.

Y= Table number. Usually, there is only one table for each type of data, 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.
RS196 Rigid disk drive specification table.

Note that the specification tables load directly as a data base. You can use the data base functions of Lotus 1-2-3 to sort, count or otherwise manipulate the data for purposes of special analysis. Other spreadsheets may have similar capabilities.

Using the specification data base

Introduction: If you have not used the Lotus 1-2-3 /DATA QUERY commands, it will be helpful for you to review the sections of the Lotus 1-2-3 reference manual that pertain to their use before proceeding further.

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon whether rigid, optical or floppy drives are involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND Report. Each column represents a specific specification parameter, and is equivalent to one row of the specification table in 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, first ship date, and so on.

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

If you are interested in only a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and then use it 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. Some newer Apple systems will directly read files written on IBM PC compatible systems.

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.

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.

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.

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.

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.

<u>Drive specifications</u>: The affected fields for a 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.

PCMCIA flash cards: The affected fields for the flash card data base are:

Group:	Numeric groups: You can extract a range of groups.
Capacity:	Numeric conversion: You can extract by card capacity.
Eras_block:	Numeric conversion: You can extract for the size of erase block.
Endrnce:	Numeric conversion: You can extract for the maximum number of write/erase cycles specified for a chip.
Avg_access:	Numeric conversion: You can extract for a range of average read access times.