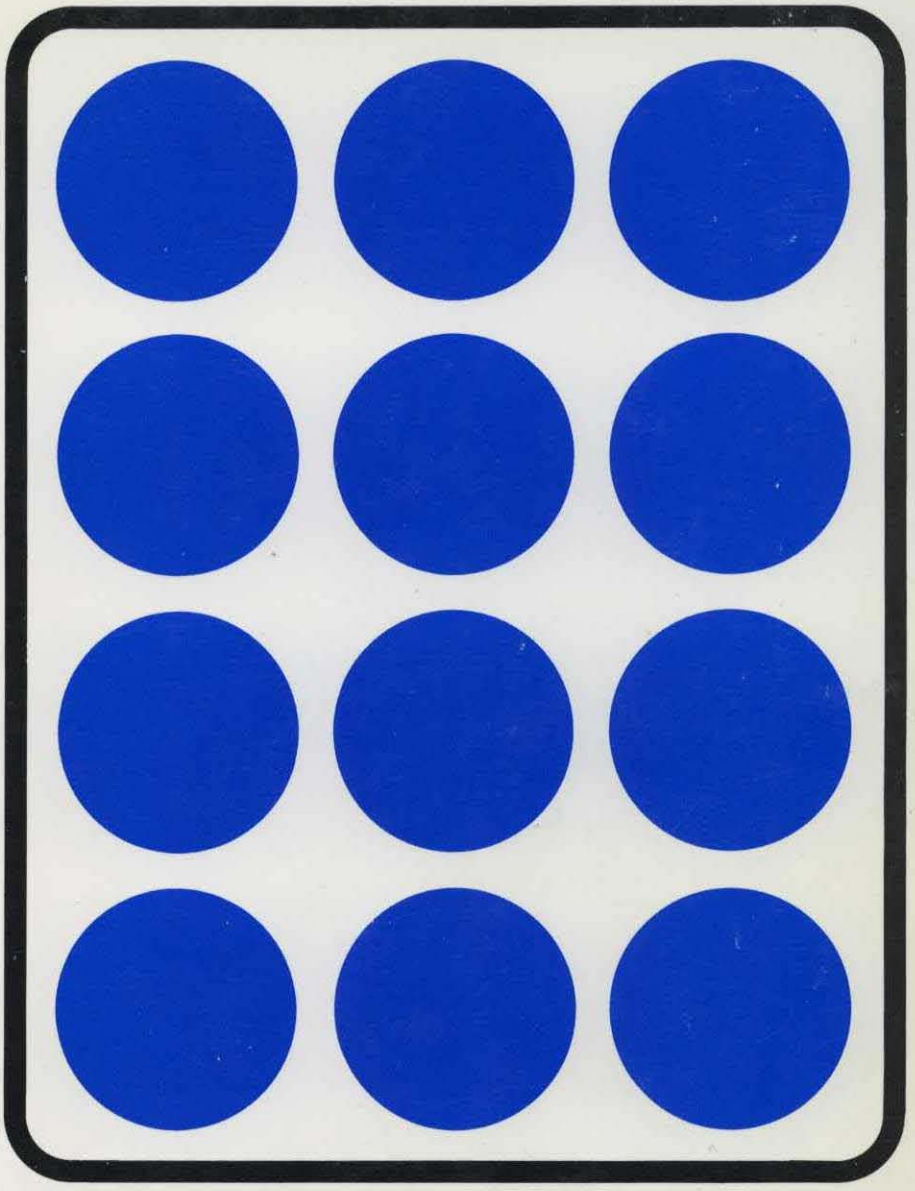
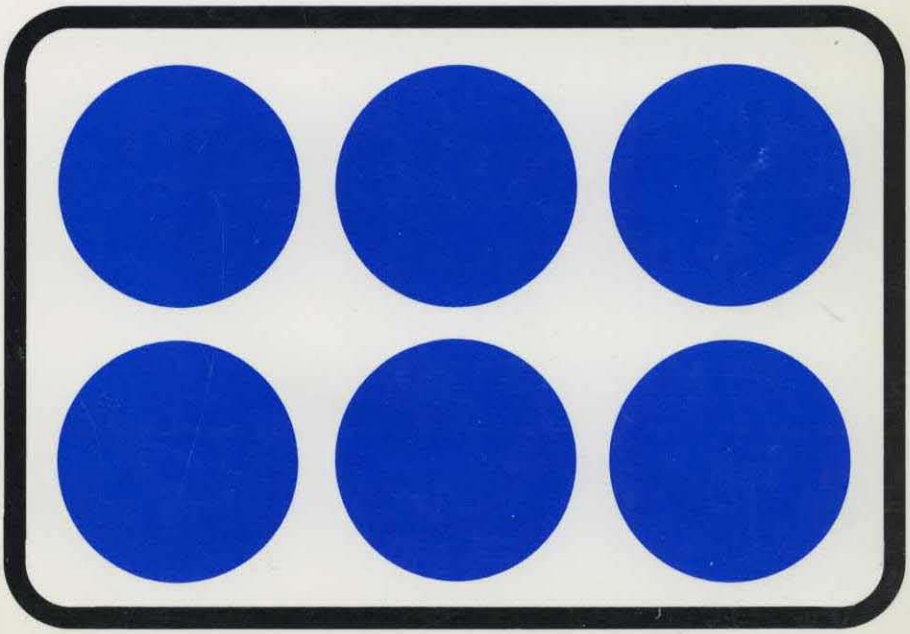


1994 DISK/TREND® REPORT



RIGID DISK DRIVES

1994 DISK/TREND® REPORT

RIGID DISK DRIVES

October, 1994

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FOREWORD

Most of the disk drive industry is finding 1994 to be a better year than the last one, and the pace of product development continues to make the industry one of the most dynamic marketplaces in the world. The rate of technology improvement continually refreshes the market with new products, extends disk storage into new applications, and forces the industry's executives to manage multinational operations which increase in complexity every year.

In its eighteenth year, the DISK/TREND Report has again expanded its list of annual reports. This year the DISK/TREND Report is being published in five volumes. A new report on removable data storage was published for the first time in September, and it includes new coverage on PCMCIA flash cards, plus data extracted from several other DISK/TREND Reports, much of it specially organized for the new edition. The report on disk drive arrays was released in April for the second year, still the industry's only market study with complete coverage of the emerging disk drive array business. It was followed in July with the 1994 report on optical disk drives, and this report on rigid disk drives will be followed, as usual, with a separate report on flexible disk drives to be released in November.

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

We are always willing to help you at any time by providing additional information on the industry which we may have available. 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

Please note the new organization of product groups

We've had to change the product groups used in the DISK/TREND Report on rigid disk drives several times in past years, and this year we have done it again. It has always been our objective to use product groupings which reflect the principal clusters of product activity each year, and that continues to change. Because of the rapid decline in total shipments of lower capacity drives, all fixed disk drives with capacities less than 100 megabytes have been combined into a single product group. On the other hand, the high growth for drives with capacities more than 2 gigabytes has created the opposite situation, and the previous single product group in that capacity range has been split in two: One product group covers drives in the 2-3 gigabyte range and a separate group covers drives with capacities more than 3 gigabytes.

You're not seeing double

For the first time this year, we published the new DISK/TREND Report on removable data storage, which includes some information also included in this volume on disk cartridge drives and on 1.8" PCMCIA disk drives, plus coverage of PCMCIA flash cards, small optical disk drives and high capacity floppy drives. In that report, the section on disk cartridge drives is substantially the same as the product group in this report on disk cartridge drives. However, if you compare the two reports' coverage of 1.8" drives, please note that the data in the removable data storage report includes only 1.8" drives in PCMCIA or comparable formats, while the 1.8" data included in several sections of this report includes all 1.8" drives, not just the ones in PCMCIA card format.

This reminder still seems to be necessary

Various market studies report revenues and unit shipments in several ways, and you will find the information in this report much more helpful if you understand the basic ground rules we have followed:

* We report all disk drive revenues at the level of the product's first public sale, at the estimated transaction price, whether the sale occurs at the captive, PCM/Reseller or OEM/Integrator levels.

* All unit totals are given in spindles, or individual head/disk assemblies, in the DISK/TREND Report. A disk drive enclosure containing two spindles is counted as two spindles, except for drives designed to be the plug compatible equivalent of specific IBM mainframe drives, which are counted in units equivalent to the corresponding IBM drive models.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

As a business, the rigid disk drive industry was a loser in 1993, with an overall reduction in sales revenue and negative profitability -- despite an 18.1% increase in total unit shipments. Worldwide sales revenue declined for the third straight year, down 11.6%, at $21.7 billion.

The continuing decline in the share of the industry's sales revenues held by captive drives sold at end user prices has depressed the revenue total. In 1990, captive drive revenues were $16.4 billion, 64.3% of the overall revenue total, but in 1993 captive revenues were $9.4 billion, 43.3% of the industry total. But the biggest negative influence on revenues in 1993 was the industry's well publicized price-cutting binge, which affected noncaptive sales in all disk drive capacity ranges (see Table 7) and forced accelerated reductions for many captive drive prices.

Fortunately for most disk drive manufacturers, 1994 has turned out to be a better year. Worldwide shipments for 1994 are forecasted at 60.3 million drives, an increase of 16.3% over the previous year, and overall sales revenues are expected to be up 5.7%, reaching a total of almost $23 billion. Revitalized product lines have cut the estimated decline in captive sales revenues to only 1.5% in 1994. Noncaptive drive revenues are forecasted to increase 11.2% for the year, benefiting from the combination of updated product lines and insufficient supply for drives in several capacity ranges during the first half of 1994.

Continuing growth in demand for disk storage is expected to continue in most of the industry's major market segments through 1997, and existing markets will be supplemented by new applications such as video/multimedia servers in business applications and consumer video-on-demand systems. The unit shipment total is projected to reach 83.9 million drives in 1997, an average annual increase for 1995-97 of 11.6%. Worldwide disk drive sales revenues are forecasted to grow at an average annual rate of 13.1% during the same period, with 1997 total revenues placed at $33.2 billion, as captive drive shipments recover momentum and the industry moves continually to higher average disk drive capacities.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993		Forecast							
	Revenues		1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	4,911.6	7,194.1	4,776.1	7,075.3	5,185.0	7,857.8	6,479.2	9,920.9	7,051.2	11,000.7
Other U.S. Captive	688.2	1,037.6	689.0	1,076.5	288.0	368.3	358.3	497.2	397.1	582.5
TOTAL U.S. CAPTIVE	5,599.8	8,231.7	5,465.1	8,151.8	5,473.0	8,226.1	6,837.5	10,418.1	7,448.3	11,583.2
PCM/Reseller	1,772.7	3,144.9	2,112.1	3,561.4	2,667.6	4,445.0	3,259.0	5,375.6	3,515.5	5,727.3
OEM/Integrator	4,666.1	7,219.9	5,130.8	7,978.6	6,547.6	9,999.5	7,601.5	11,572.1	7,575.9	11,807.8
TOTAL U.S. NONCAPTIVE	6,438.8	10,364.8	7,242.9	11,540.0	9,215.2	14,444.5	10,860.5	16,947.7	11,091.4	17,535.1
TOTAL U.S. REVENUES	12,038.6	18,596.5	12,708.0	19,691.8	14,688.2	22,670.6	17,698.0	27,365.8	18,539.7	29,118.3
Non-U.S. Manufacturers										
Captive	52.7	1,186.4	127.8	1,120.6	145.0	781.4	181.7	797.1	204.2	977.2
PCM/Reseller	424.7	1,008.4	422.6	1,015.5	364.6	915.6	239.0	767.7	196.4	756.0
OEM/Integrator	297.6	938.5	410.1	1,138.0	565.7	1,377.0	781.5	1,916.6	915.4	2,304.1
TOTAL NON-U.S. REVENUES	775.0	3,133.3	960.5	3,274.1	1,075.3	3,074.0	1,202.2	3,481.4	1,316.0	4,037.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	12,813.6	21,729.8	13,668.5	22,965.9	15,763.5	25,744.6	18,900.2	30,847.2	19,855.7	33,155.6

Marketing channels

The worldwide rigid disk drive industry continues to see a rapid decline in the number of participating manufacturers. The total has shrunk from 47 drive manufacturers in 1992 to 40 in 1993, and in 1994 the list is down to 30 companies. Most of the dropouts during the last few years had small market shares and were not able to compete efficiently as shipments rose and prices fell. The Asian manufacturers deleted from the list this year all suffered from obsolete product lines with negligible markets. The South American companies which dropped their disk drive product lines were all Brazilian firms with noncompetitive disk drive product lines, after Brazil's tariff and import restrictions on computer industry products were lifted.

The noncaptive marketing channels for rigid disk drives are currently evolving into new patterns. During the last five years, the PCM/Reseller channel, including the drives sold through distributors, mass merchandisers and storage subsystem builders, grew from 12.5% of the industry's total revenues in 1989, to 19.9% in 1994. Underlying this growth was the extensive upgrading of disk storage on existing personal computers, driven by growing use of Microsoft's Windows and related applications software. However, most personal computer system manufacturers are now installing much larger disk drives at the originating factory, and it appears that the disk drive upgrade market will be held to its existing level. DISK/TREND forecasts indicate that PCM/Reseller revenues will stay at approximately the same share of worldwide revenues through 1997, while OEM/Integrator revenues will rise from 23.9% of 1989's total to 42.5% in 1997.

An understanding of the relative price levels of captive, PCM/Reseller and OEM/Integrator drives is important in interpreting DISK/TREND revenue statistics, to avoid an exaggerated impression of the share of the industry's total unit shipments held by captive drives. The price used for each drive is the estimated value at the first time it is sold to a nonaffiliated buyer, at captive end user, PCM/Reseller or OEM/Integrator levels. For example, captive drive revenues for 1993 totaled $9.4 billion, 43.3% of the overall revenue worldwide total. But 1993 captive drive shipments totaled 6.7 million units, only 12.9% of all worldwide shipments. The reason for the large difference in the percentages is found in the higher end user prices at which captive drives are sold and the fact that a higher percentage of captive drives are expensive high-end models.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1993 Revenues $M	1993 Revenues %	Forecast 1994 $M	1994 %	1995 $M	1995 %	1996 $M	1996 %	1997 $M	1997 %
U.S. Manufacturers										
IBM Captive	7,194.1 -19.6%	33.1%	7,075.3 -1.7%	30.8%	7,857.8 +11.1%	30.5%	9,920.9 +26.3%	32.1%	11,000.7 +10.9%	33.1%
Other U.S. Captive	1,037.6 -12.0%	4.7%	1,076.5 +3.7%	4.6%	368.3 -65.8%	1.4%	497.2 +35.0%	1.6%	582.5 +17.2%	1.7%
PCM/Reseller	3,144.9 -13.1%	14.4%	3,561.4 +13.2%	15.5%	4,445.0 +24.8%	17.2%	5,375.6 +20.9%	17.4%	5,727.3 +6.5%	17.2%
OEM/Integrator	7,219.9 +10.8%	33.2%	7,978.6 +10.5%	34.7%	9,999.5 +25.3%	38.8%	11,572.1 +15.7%	37.5%	11,807.8 +2.0%	35.6%
Total U.S. Manufacturers	18,596.5 -8.3%	85.4%	19,691.8 +5.9%	85.6%	22,670.6 +15.1%	87.9%	27,365.8 +20.7%	88.6%	29,118.3 +6.4%	87.6%
Non-U.S. Manufacturers										
Captive	1,186.4 -37.1%	5.4%	1,120.6 -5.5%	4.8%	781.4 -30.3%	3.0%	797.1 +2.0%	2.5%	977.2 +22.6%	2.9%
PCM/Reseller	1,008.4 -12.7%	4.6%	1,015.5 +.7%	4.4%	915.6 -9.8%	3.5%	767.7 -16.2%	2.4%	756.0 -1.5%	2.2%
OEM/Integrator	938.5 -26.6%	4.6%	1,138.0 +21.3%	5.2%	1,377.0 +21.0%	5.6%	1,916.6 +39.2%	6.5%	2,304.1 +20.2%	7.3%
Total Non-U.S. Manufacturers	3,133.3 -27.5%	14.6%	3,274.1 +4.5%	14.4%	3,074.0 -6.1%	12.1%	3,481.4 +13.3%	11.4%	4,037.3 +16.0%	12.4%
Worldwide Recap										
Captive	9,418.1 -21.6%	43.3%	9,272.4 -1.5%	40.4%	9,007.5 -2.9%	35.0%	11,215.2 +24.5%	36.4%	12,560.4 +12.0%	37.9%
PCM/Reseller	4,153.3 -13.0%	19.1%	4,576.9 +10.2%	19.9%	5,360.6 +17.1%	20.8%	6,143.3 +14.6%	19.9%	6,483.3 +5.5%	19.6%
OEM/Integrator	8,158.4 +4.6%	37.6%	9,116.6 +11.7%	39.7%	11,376.5 +24.8%	44.2%	13,488.7 +18.6%	43.7%	14,111.9 +4.6%	42.5%
Total All Manufacturers	21,729.8 -11.6%	100.0%	22,965.9 +5.7%	100.0%	25,744.6 +12.1%	100.0%	30,847.2 +19.8%	100.0%	33,155.6 +7.5%	100.0%

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

Product mix

The race to higher disk drive capacities for all of the industry's major application areas has not slowed its pace. Individual personal computer users use more disk capacity for Windows and additional applications, travelers want to be able to do everything on their notebook computers that they can do with their office PC's, network file servers must be constantly upgraded with more disk capacity, the disk capacity used with mainframe computers is still expanding, and new major disk storage requirements for consumer video-on-demand and business video servers are starting to appear. The result is continuous upward movement in the typical capacities of individual disk drives used for most applications.

In 1993, fixed disk drives with capacities below 100 megabytes shrank to a shipment level less than half of the previous year, with 7.4 million drives, and is expected to drop 91.2% in 1994, to 652,000 drives, with the last year of shipments for the entire product group expected in 1996. Shipments of 100-200 megabyte drives are falling into the same pattern, following the group's shipment peak in 1993, with 20 million drives. 1994's shipments are expected to be less than half those of the previous year, and by 1997 the product group's shipments are projected at only 590,000 units.

200-300 megabyte drives have assumed shipment leadership in 1994, with a forecasted total of 21.6 million units, but the upward trend in capacities will not cease, and 300-500 megabyte drives will be the 1995 leader with a projected 23.7 million drives. As usual, each group will decline after its single peak year. The peak for drives in the 500 megabyte - 1 gigabyte product group is expected to last a bit longer, covering both 1996 and 1997, as the entry level personal computer market responds to the low cost single platter 3.5" drives expected to be available during those years.

The three product groups with capacities over 1 gigabyte will have high growth rates through the forecast period, with very large quantities of drives in the 1-2 gigabyte group needed for high-end personal computers with the next generation of processors and software. Growth for all three groups over 1 gigabyte will also be driven by expanding usage of disk drive arrays and other storage subsystems used with network file servers and mainframes, plus the continually expanding workstation market. Although difficult to define at this time,

it is also clear that future video and image storage requirements for a variety of consumer and business applications will provide a major new market for high capacity disk drives.

3.5" rigid disk drives are now used in all DISK/TREND Report product groups, and 1993 shipments of almost 44 million 3.5" drives represent 84.8% of the overall worldwide total. An expected average annual growth rate of 9.3% for the 1994-97 period will push 1997's shipments to 62.6 million 3.5" drives, representing 74.6% of the total for all rigid disk drives. Following the industry's normal pattern, smaller drives will assume a greater share of total shipments by 1997, as each year's improvements in recording density extend the usefulness of 2.5" and 1.8" drives into new territory. In 1997, 2.5" drives are projected to hold 19.3% of the industry's unit shipments, with 16.2 million drives, and 1.8" drives will secure 5.5% of the total, at a shipment level of 4.6 million drives. 5.25" drives will still be in production in 1997, offering very high capacities at a very low price per megabyte, but all drives with larger diameter disks are expected to be gone by the end of 1996.

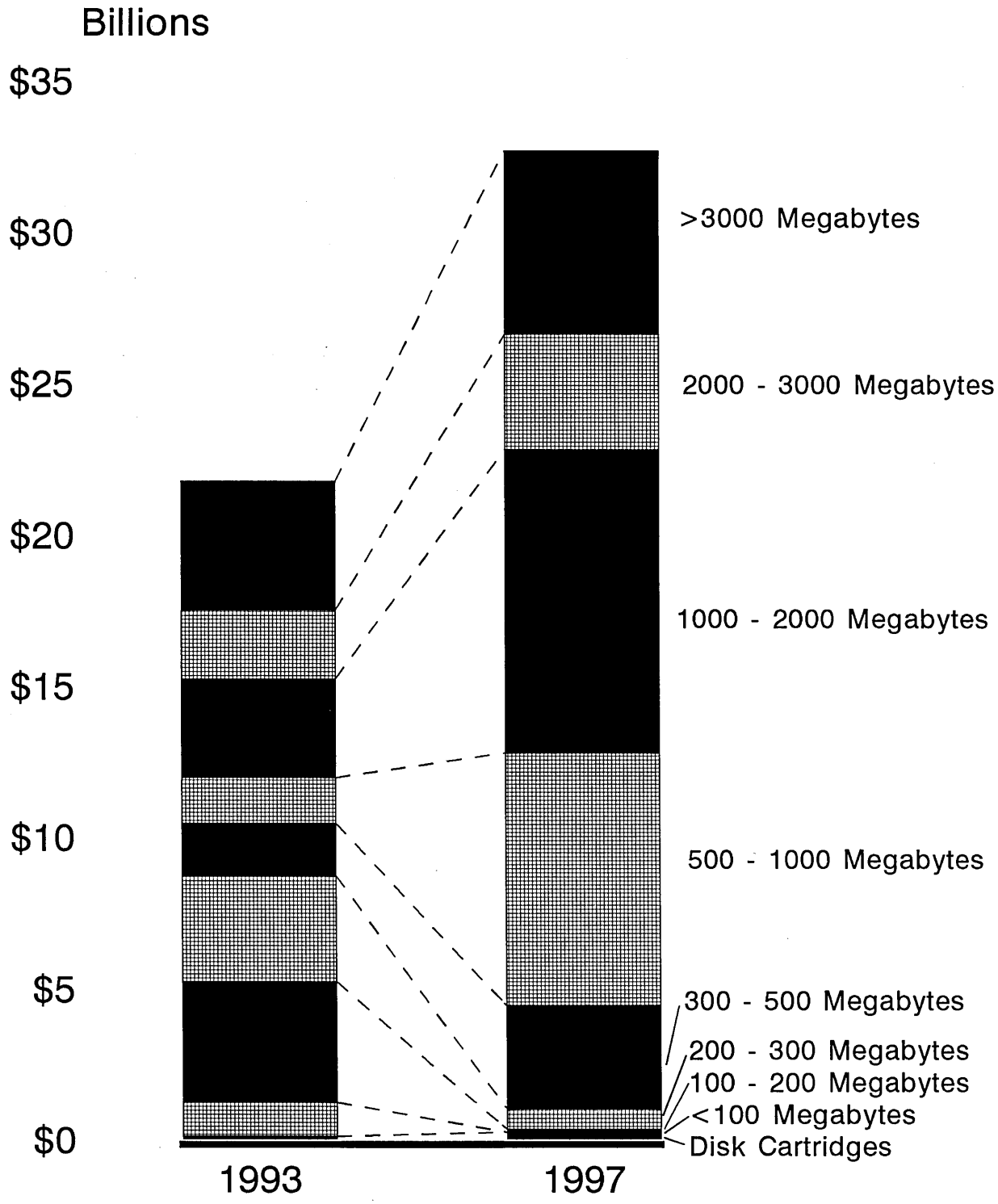
The long-term problem for the 3.5" drive format, as it was for the larger drives which preceded it, is the industry's unstoppable trend to improved areal density -- which eventually will make it possible for 2.5" and smaller disk drives to provide cost-effective competition for 3.5" drives. By 1997, 2.5" disk drives with more than 2 gigabytes capacity will undoubtedly be available, probably in a form factor only half an inch thick. Such a drive capacity may be above the requirements for mainstream notebook computers, but at that point, we can expect to see a repetition of the classic disk drive phenomenon: The smaller disk drive starts to replace the older one, in its basic markets.

Manufacturers of 1.8" drives have been struggling to increase capacities and to solve the packaging problems of PCMCIA card configurations, while waiting for the subnotebook computer market to actually materialize. 1994 has been the year when several drive manufacturers were able to start volume production of PCMCIA drives with capacities in the 100-200 megabyte range, and 1.8" drives with capacities up to 420 megabytes have been announced. With PCMCIA slots now appearing on most new notebook computers, it appears that 1.8" drives will finally have a significant market. Shipments are forecasted to ramp to 4.6 million drives in 1997, with a continuous upward movement in average capacities.

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue



1994 DISK/TREND REPORT

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1993 Revenues $M	 %	Forecast 1994 $M	 %	 1995 $M	 %	 1996 $M	 %	 1997 $M	 %
CARTRIDGE DISK DRIVES	86.5 +5.2%	.4%	132.7 +53.4%	.6%	173.8 +31.0%	.7%	216.4 +24.5%	.7%	223.7 +3.4%	.7%
FIXED DISK DRIVES less than 100 Megabytes	1,133.7 -70.8%	5.2%	132.2 -88.3%	.6%	17.4 -86.8%	.1%	2.7 -84.5%	--	-- --	--
FIXED DISK DRIVES 100 - 200 Megabytes	3,995.8 -22.5%	18.4%	1,556.8 -61.0%	6.8%	555.1 -64.3%	2.2%	249.9 -55.0%	.8%	98.7 -60.5%	.3%
FIXED DISK DRIVES 200 - 300 Megabytes	3,484.0 +93.4%	16.0%	3,946.9 +13.3%	17.2%	2,040.8 -48.3%	7.9%	1,490.8 -27.0%	4.8%	682.5 -54.2%	2.1%
FIXED DISK DRIVES 300 - 500 Megabytes	1,734.6 -1.0%	8.0%	3,372.1 +94.4%	14.7%	5,043.0 +49.6%	19.6%	3,930.4 -22.1%	12.7%	3,418.9 -13.0%	10.3%
FIXED DISK DRIVES 500 Megabytes - 1 GB	1,500.8 -26.6%	6.9%	3,567.3 +137.7%	15.5%	5,484.4 +53.7%	21.3%	7,807.1 +42.4%	25.3%	8,334.0 +6.7%	25.1%
FIXED DISK DRIVES 1 - 2 Gigabytes	3,270.2 -15.6%	15.0%	3,195.2 -2.3%	13.9%	4,662.4 +45.9%	18.1%	7,689.9 +64.9%	24.9%	10,031.2 +30.4%	30.3%
FIXED DISK DRIVES 2 - 3 Gigabytes	2,275.8 +38.9%	10.5%	3,546.7 +55.8%	15.4%	3,146.7 -11.3%	12.2%	3,465.8 +10.1%	11.2%	3,803.9 +9.8%	11.5%
FIXED DISK DRIVES more than 3 Gigabytes	4,248.4 -2.5%	19.6%	3,516.0 -17.2%	15.3%	4,621.0 +31.4%	17.9%	5,994.2 +29.7%	19.4%	6,562.7 +9.5%	19.7%
Total Worldwide Revenue	21,729.8 -11.6%	100.0%	22,965.9 +5.7%	100.0%	25,744.6 +12.1%	100.0%	30,847.2 +19.8%	100.0%	33,155.6 +7.5%	100.0%

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

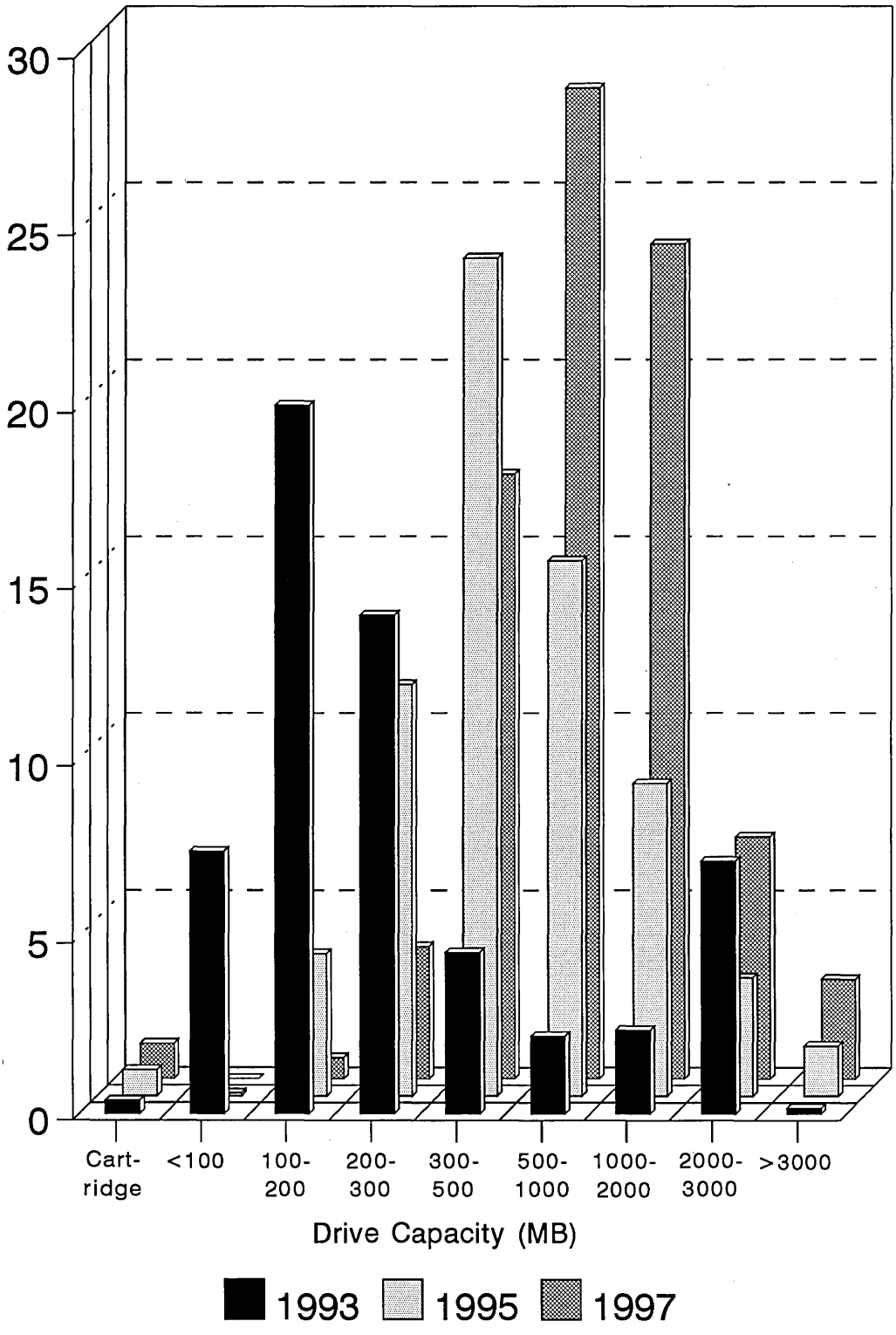


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1993 Shipments Units	1993 Shipments %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %
CARTRIDGE DISK DRIVES	375.0	.7%	552.4	.9%	740.0	1.1%	905.0	1.2%	985.0	1.2%
	+18.0%		+47.3%		+34.0%		+22.3%		+8.8%	
FIXED DISK DRIVES less than 100 Megabytes	7,403.7	14.3%	652.0	1.1%	88.0	.1%	15.0	--	--	--
	-58.1%		-91.2%		-86.5%		-83.0%		--	
FIXED DISK DRIVES 100 - 200 Megabytes	20,026.7	38.6%	9,286.2	15.4%	4,033.4	5.9%	1,695.0	2.2%	590.0	.7%
	+14.4%		-53.6%		-56.6%		-58.0%		-65.2%	
FIXED DISK DRIVES 200 - 300 Megabytes	14,067.0	27.1%	21,545.2	35.7%	11,616.5	16.9%	8,390.0	10.9%	3,735.0	4.5%
	+245.9%		+53.2%		-46.1%		-27.8%		-55.5%	
FIXED DISK DRIVES 300 - 500 Megabytes	4,558.9	8.8%	14,017.7	23.2%	23,673.5	34.4%	18,220.0	23.6%	17,070.0	20.4%
	+152.1%		+207.5%		+68.9%		-23.0%		-6.3%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	2,191.7	4.2%	7,633.2	12.7%	15,120.9	22.0%	24,717.0	32.0%	27,990.0	33.4%
	+112.6%		+248.3%		+98.1%		+63.5%		+13.2%	
FIXED DISK DRIVES 1 - 2 Gigabytes	2,362.6	4.6%	4,178.2	6.9%	8,830.0	12.8%	15,935.0	20.6%	23,570.0	28.1%
	+92.4%		+76.8%		+111.3%		+80.5%		+47.9%	
FIXED DISK DRIVES 2 - 3 Gigabytes	712.0	1.4%	1,930.5	3.2%	3,348.0	4.9%	5,047.0	6.5%	6,820.0	8.1%
	+263.1%		+171.1%		+73.4%		+50.7%		+35.1%	
FIXED DISK DRIVES more than 3 Gigabytes	160.0	.3%	502.9	.8%	1,414.6	1.9%	2,346.0	3.0%	3,100.0	3.6%
	+56.6%		+214.3%		+181.3%		+65.8%		+32.1%	
Total Worldwide Shipments	51,857.6	100.0%	60,298.3	100.0%	68,864.9	100.0%	77,270.0	100.0%	83,860.0	100.0%
	+18.1%		+16.3%		+14.2%		+12.2%		+8.5%	
% U.S. Manufacturers	91.4%		90.6%		90.1%		88.5%		86.8%	
Total Capacity (Terabytes)	14,855.5		28,705.5		46,795.5		73,201.4		100,578.4	

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

Figure 3

DISK DIAMETER SUMMARY

Worldwide Shipments in Millions of Units

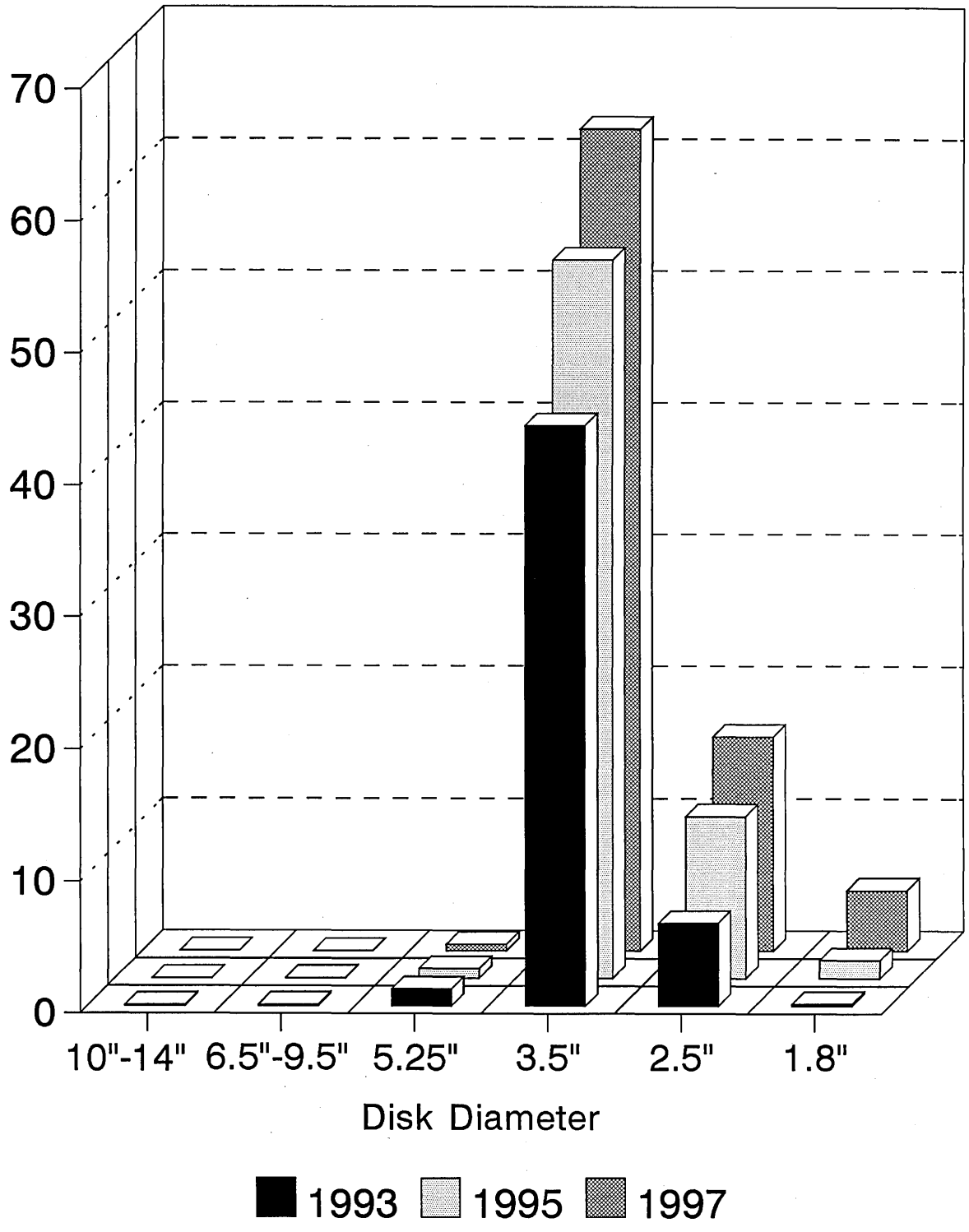


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
SUMMARY BY DISK DIAMETER

UNIT SHIPMENTS IN THOUSANDS	1993 Shipments Units	%	1994 Forecast Units	%	1995 Forecast Units	%	1996 Forecast Units	%	1997 Forecast Units	%
10 - 14 INCH	79.5 -19.1%	.2%	45.6 -42.6%	.1%	5.6 -87.7%	--	-- --	--	-- --	--
6.5 - 9.5 INCH	100.5 -35.2%	.2%	72.2 -28.2%	.1%	26.5 -63.3%	--	7.0 -73.6%	--	-- --	--
5.25 INCH	1,278.1 -42.0%	2.5%	849.2 -33.6%	1.4%	732.8 -13.7%	1.1%	714.0 -2.6%	.9%	490.0 -31.4%	.6%
3.5 INCH	43,954.4 +21.0%	84.8%	49,581.7 +12.8%	82.2%	54,436.0 +9.8%	79.1%	59,079.0 +8.5%	76.5%	62,565.0 +5.9%	74.6%
2.5 INCH	6,287.9 +22.9%	12.1%	9,294.7 +47.8%	15.4%	12,270.0 +32.0%	17.8%	14,630.0 +19.2%	18.9%	16,200.0 +10.7%	19.3%
1.8 INCH OR LESS	157.2 +624.4%	.3%	454.9 +189.4%	.8%	1,394.0 +206.4%	2.0%	2,840.0 +103.7%	3.7%	4,605.0 +62.2%	5.5%
Total Worldwide Shipments	51,857.6 +18.1%	100.0%	60,298.3 +16.3%	100.0%	68,864.9 +14.2%	100.0%	77,270.0 +12.2%	100.0%	83,860.0 +8.5%	100.0%

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

Figure 4

CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

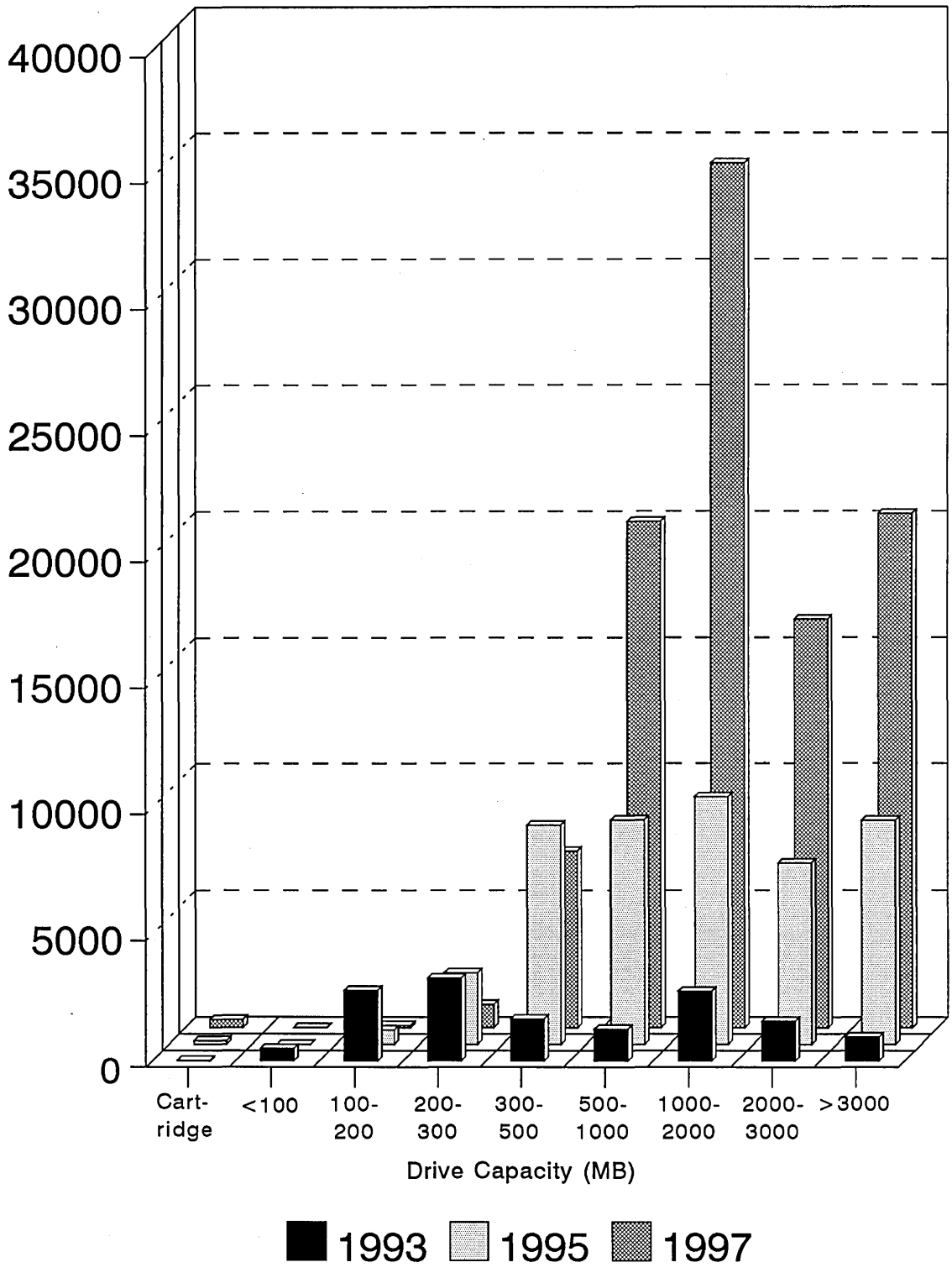


TABLE 6

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1993 Shipments Tbytes	1993 Shipments %	1994 Tbytes	1994 %	1995 Forecast Tbytes	1995 Forecast %	1996 Forecast Tbytes	1996 Forecast %	1997 Forecast Tbytes	1997 Forecast %
CARTRIDGE DISK DRIVES	33.0 +61.8%	.2%	90.1 +173.0%	.3%	148.2 +64.5%	.3%	236.6 +59.6%	.3%	315.1 +33.2%	.3%
FIXED DISK DRIVES less than 100 Megabytes	496.2 -63.7%	3.3%	41.9 -91.6%	.1%	3.8 -90.9%	--	.6 -82.4%	--	-- --	--
FIXED DISK DRIVES 100 - 200 Megabytes	2,795.6 +33.0%	18.8%	1,392.7 -50.2%	4.9%	567.4 -59.3%	1.2%	252.0 -55.6%	.3%	95.2 -62.2%	.1%
FIXED DISK DRIVES 200 - 300 Megabytes	3,284.0 +260.9%	22.1%	5,259.0 +60.1%	18.3%	2,831.6 -46.2%	6.1%	2,046.9 -27.7%	2.8%	904.5 -55.8%	.9%
FIXED DISK DRIVES 300 - 500 Megabytes	1,671.7 +149.6%	11.3%	5,187.3 +210.3%	18.1%	8,645.4 +66.7%	18.5%	7,066.0 -18.3%	9.7%	6,956.2 -1.6%	6.9%
FIXED DISK DRIVES 500 Megabytes - 1 GB	1,270.2 +91.0%	8.6%	4,503.0 +254.5%	15.7%	8,849.7 +96.5%	18.9%	15,816.5 +78.7%	21.6%	20,017.5 +26.6%	19.9%
FIXED DISK DRIVES 1 - 2 Gigabytes	2,765.3 +70.1%	18.6%	4,764.3 +72.3%	16.6%	9,766.9 +105.0%	20.9%	20,327.5 +108.1%	27.8%	34,233.0 +68.4%	34.0%
FIXED DISK DRIVES 2 - 3 Gigabytes	1,581.0 +190.4%	10.6%	4,021.3 +154.4%	14.0%	7,152.9 +77.9%	15.3%	11,047.2 +54.4%	15.1%	16,140.3 +46.1%	16.0%
FIXED DISK DRIVES more than 3 Gigabytes	958.5 --	6.5%	3,445.9 +259.5%	12.0%	8,829.3 +156.2%	18.8%	16,407.8 +85.8%	22.4%	21,916.6 +33.6%	21.8%
Total Capacity (Terabytes)	14,855.5 +88.0%	100.0%	28,705.5 +93.2%	100.0%	46,795.5 +63.0%	100.0%	73,201.4 +56.4%	100.0%	100,578.4 +37.4%	100.0%

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

Price per megabyte

The disk drive industry's severe 1993 price wars accelerated the normal rate of decline in pricing for noncaptive drives. The disk drive industry normally expects prices to fall each year, responding to the lower unit costs associated with continuous parts count reduction, improved manufacturing systems and higher production quantities. But the 1993 reductions in noncaptive prices display the desperate attempts of some disk drive manufacturers to gain market share through overaggressive pricing, in order to unload excess inventory, and in some cases to overcome the disadvantage of too many aging products.

The price per megabyte for some of the older low capacity drives now declining in shipments is expected to remain relatively stable. The largest price drops are now occurring with the drives shipped in large quantities for mainstream applications with PC's, notebook computers, network file servers and workstations. Noncaptive disk drives with more than 3 gigabytes capacity are currently experiencing the fastest decline in price per megabyte as older, very expensive large drives fade away, and the capacities of 5.25" and 3.5" drives grow relentlessly. The noncaptive price per megabyte for drives in this product group was $2.67 in 1993, it is estimated at $.56 in 1994, and is projected at $.11 in 1997.

Severe drops in noncaptive disk drive pricing also affect pricing for captive disk drives. The captive drive producers must respond to prices in the noncaptive market, as the noncaptive drives are resold by other system manufacturers at aggressive prices. IBM is easily the largest participant in captive disk drive markets and has aggressively lowered its pricing structures to stay competitive. Also affecting the disk drive prices set by IBM and other captive manufacturers is their continuing movement to new, smaller drives, at lower costs.

The tables in each product section display the average price per megabyte for that product group broken down by distribution channel and disk diameter, and the summary tables in this section display separately the worldwide price per megabyte of captive and noncaptive drives, broken down by DISK/TREND product group. Please note that the data shown in these tables is not merely an average of the price per megabyte of all individual disk drive models offered, but represents the estimated total sales revenues for each product type divided by the total capacity of all drives of that type sold.

Figure 5

PRICE PER MEGABYTE SUMMARY

Noncaptive Worldwide Shipments ($/MB)

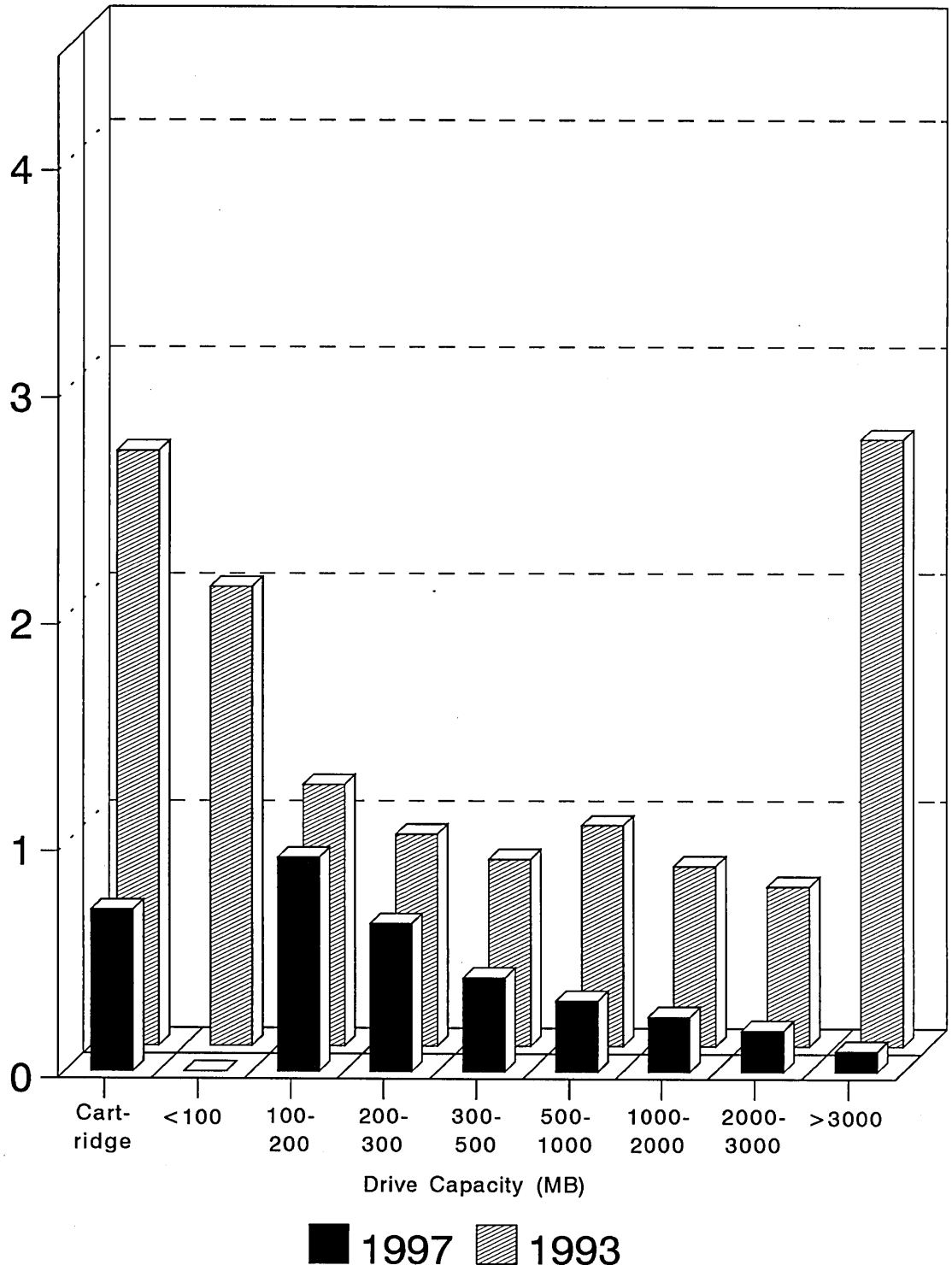


TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1993	1994	1995	1996	1997
CARTRIDGE DISK DRIVES	2.62 -34.9%	1.47 -43.8%	1.17 -20.4%	.91 -22.0%	.71 -22.4%
FIXED DISK DRIVES less than 100 Megabytes	2.02 -12.5%	2.93 +45.0%	4.35 +48.3%	3.57 -17.9%	*,***.** --
FIXED DISK DRIVES 100 - 200 Megabytes	1.15 -42.0%	.92 -19.8%	.84 -9.7%	.89 +6.2%	.91 +2.0%
FIXED DISK DRIVES 200 - 300 Megabytes	.93 -43.7%	.65 -30.3%	.62 -4.6%	.64 +2.7%	.65 +2.3%
FIXED DISK DRIVES 300 - 500 Megabytes	.82 -53.9%	.52 -36.6%	.48 -7.3%	.45 -7.0%	.41 -8.9%
FIXED DISK DRIVES 500 Megabytes - 1 GB	.97 -40.0%	.60 -38.7%	.49 -17.3%	.39 -21.9%	.31 -19.3%
FIXED DISK DRIVES 1 - 2 Gigabytes	.79 -29.7%	.51 -35.3%	.41 -19.3%	.32 -21.7%	.24 -24.3%
FIXED DISK DRIVES 2 - 3 Gigabytes	.70 -71.9%	.43 -38.0%	.32 -26.8%	.25 -22.7%	.18 -25.0%
FIXED DISK DRIVES more than 3 Gigabytes	2.67 --	.56 -79.1%	.25 -55.8%	.15 -40.0%	.11 -23.3%

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

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 8

CAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1993	1994	1995	1996	1997
CARTRIDGE DISK DRIVES	-- --	-- --	-- --	-- --	-- --
FIXED DISK DRIVES less than 100 Megabytes	3.84 -36.7%	3.58 -6.7%	7.07 +97.4%	7.06 --	-- --
FIXED DISK DRIVES 100 - 200 Megabytes	3.14 -55.0%	2.28 -27.6%	1.81 -20.3%	3.24 +78.7%	3.53 +8.8%
FIXED DISK DRIVES 200 - 300 Megabytes	2.25 -54.6%	1.61 -28.6%	1.43 -10.9%	1.57 +9.6%	1.57 --
FIXED DISK DRIVES 300 - 500 Megabytes	2.81 -55.8%	1.52 -45.9%	1.36 -10.4%	1.21 -11.5%	1.05 -12.9%
FIXED DISK DRIVES 500 Megabytes - 1 GB	5.09 -38.8%	1.47 -71.2%	1.03 -30.0%	.92 -10.1%	.83 -9.6%
FIXED DISK DRIVES 1 - 2 Gigabytes	2.45 -59.4%	1.41 -42.4%	1.05 -25.8%	.90 -14.1%	.76 -15.7%
FIXED DISK DRIVES 2 - 3 Gigabytes	2.76 -59.3%	2.00 -27.7%	1.32 -34.0%	.86 -34.5%	.69 -19.8%
FIXED DISK DRIVES more than 3 Gigabytes	5.62 --	3.30 -41.2%	2.03 -38.7%	1.42 -29.9%	1.09 -23.0%

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

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.

Noncaptive market

Although the total quantities of noncaptive disk drives are expected to increase at an annual average of 11.8% in the 1994-97 period, reaching 70.4 million drives in 1997, the noncaptive share of total disk drive shipments is destined to decline slightly, from 87.1% in 1993 to 84% in 1997. In contrast, noncaptive revenues are expected to increase their share of the worldwide total slightly, from 56.7% in 1993 to 62.1% in 1997. The increasing share of revenues for noncaptive drives is rooted in the continually growing share of higher capacity drives, at relatively higher prices, which are sold through noncaptive channels, plus the fact that the difference between captive drive prices and noncaptive prices is gradually being reduced.

Independent disk drive manufacturers have moved quickly during the last decade to exploit technology advances which have enabled them to respond with appropriate products for the computer industry's fastest growth sectors: Desktop and portable personal computers, engineering workstations and network file servers. In the process, they led the industry in developing high volume production capability for small drive formats, starting with 5.25", then 3.5", and more recently with 2.5" and 1.8". OEM drives in each of these form factors arrived in the market well before captive drives and set the patterns for the entire industry.

The market for noncaptive disk drives is dominated by mostly American companies, which were able to successfully sell to rapidly growing system manufacturers because they were able to deliver new disk drive configurations early in each product life cycle. Young California and Colorado companies had the right formula for success, as they listened to customers' requests, made management decisions quickly, and moved rapidly to the most cost-effective manufacturing sites. The surviving U.S. start-up companies of the 1980's are now large firms, several with annual sales between $1-4 billion.

The noncaptive drive leaders now face new challenges, as they adjust to continually lower prices, increasing production and demanding product development requirements. New competitive alignments will also change the picture, as Seagate demonstrated in 1989 with the Imprimis acquisition, and Quantum has done in 1994 by acquiring Digital Equipment's disk drive business.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1993 Revenues $M	 %	1994 Forecast $M	 %	1995 Forecast $M	 %	1996 Forecast $M	 %	1997 Forecast $M	 %
CARTRIDGE DISK DRIVES	86.5 +5.2%	.7%	132.7 +53.4%	1.0%	173.8 +31.0%	1.0%	216.4 +24.5%	1.1%	223.7 +3.4%	1.1%
FIXED DISK DRIVES less than 100 Megabytes	860.2 -68.4%	7.0%	81.0 -90.6%	.6%	15.4 -81.0%	.1%	2.1 -86.4%	--	-- --	--
FIXED DISK DRIVES 100 - 200 Megabytes	2,777.4 -26.8%	22.6%	1,104.4 -60.2%	8.0%	483.4 -56.2%	2.9%	233.2 -51.8%	1.2%	86.7 -62.8%	.4%
FIXED DISK DRIVES 200 - 300 Megabytes	2,776.7 +103.6%	22.6%	3,075.3 +10.8%	22.6%	1,548.0 -49.7%	9.3%	1,183.1 -23.6%	6.0%	526.6 -55.5%	2.6%
FIXED DISK DRIVES 300 - 500 Megabytes	1,229.5 +25.3%	10.0%	2,364.3 +92.3%	17.2%	3,716.0 +57.2%	22.3%	2,737.8 -26.3%	14.1%	2,493.9 -8.9%	12.2%
FIXED DISK DRIVES 500 Megabytes - 1 GB	1,175.6 +38.9%	9.5%	2,086.5 +77.5%	15.3%	3,343.0 +60.2%	19.9%	4,886.0 +46.2%	24.9%	4,986.6 +2.1%	24.2%
FIXED DISK DRIVES 1 - 2 Gigabytes	1,668.9 +22.7%	13.6%	2,005.8 +20.2%	14.6%	3,622.7 +80.6%	21.7%	5,942.1 +64.0%	30.2%	7,586.1 +27.7%	36.8%
FIXED DISK DRIVES 2 - 3 Gigabytes	711.5 -40.5%	5.8%	1,247.7 +75.4%	9.1%	2,000.4 +60.3%	11.9%	2,422.3 +21.1%	12.4%	2,678.9 +10.6%	13.0%
FIXED DISK DRIVES more than 3 Gigabytes	1,025.4 +348.9%	8.2%	1,595.8 +55.6%	11.6%	1,834.4 +15.0%	10.9%	2,009.0 +9.5%	10.1%	2,012.7 +.2%	9.7%
Total Worldwide Revenues	12,311.7 -2.1%	100.0%	13,693.5 +11.2%	100.0%	16,737.1 +22.2%	100.0%	19,632.0 +17.3%	100.0%	20,595.2 +4.9%	100.0%

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

TABLE 10

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1993 Shipments Units	1993 Shipments %	1994 Forecast Units	1994 Forecast %	1995 Forecast Units	1995 Forecast %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %
CARTRIDGE DISK DRIVES	375.0	.8%	552.4	1.1%	740.0	1.2%	905.0	1.4%	985.0	1.4%
	+18.0%		+47.3%		+34.0%		+22.3%		+8.8%	
FIXED DISK DRIVES less than 100 Megabytes	6,482.4	14.5%	456.3	.8%	83.5	.2%	14.0	--	--	--
	-57.0%		-93.0%		-81.7%		-83.2%		--	
FIXED DISK DRIVES 100 - 200 Megabytes	17,210.6	38.1%	8,047.4	15.7%	3,788.4	6.4%	1,660.0	2.5%	570.0	.8%
	+8.3%		-53.2%		-52.9%		-56.2%		-65.7%	
FIXED DISK DRIVES 200 - 300 Megabytes	12,652.7	28.0%	19,384.0	37.4%	10,240.0	17.3%	7,590.0	11.7%	3,320.0	4.7%
	+246.8%		+53.2%		-47.2%		-25.9%		-56.3%	
FIXED DISK DRIVES 300 - 500 Megabytes	4,044.7	9.0%	12,143.4	23.5%	20,918.0	35.2%	15,455.0	23.5%	14,650.0	20.9%
	+176.4%		+200.2%		+72.3%		-26.1%		-5.2%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	2,099.7	4.6%	5,999.4	11.6%	11,745.9	19.8%	19,627.0	29.9%	21,645.0	30.8%
	+147.9%		+185.7%		+95.8%		+67.1%		+10.3%	
FIXED DISK DRIVES 1 - 2 Gigabytes	1,785.3	4.0%	3,413.9	6.6%	7,916.0	13.3%	14,190.0	21.6%	20,785.0	29.5%
	+102.7%		+91.2%		+131.9%		+79.3%		+46.5%	
FIXED DISK DRIVES 2 - 3 Gigabytes	437.7	.9%	1,356.8	2.6%	2,932.5	4.9%	4,480.0	6.8%	6,055.0	8.6%
	+160.4%		+210.0%		+116.1%		+52.8%		+35.2%	
FIXED DISK DRIVES more than 3 Gigabytes	81.2	.1%	405.2	.7%	1,047.0	1.7%	1,784.0	2.6%	2,420.0	3.3%
	+401.2%		+399.0%		+158.4%		+70.4%		+35.7%	
Total Worldwide Shipments	45,169.3	100.0%	51,758.8	100.0%	59,411.3	100.0%	65,705.0	100.0%	70,430.0	100.0%
	+17.9%		+14.6%		+14.8%		+10.6%		+7.2%	
% U.S. Manufacturers	91.9%		90.8%		90.1%		88.1%		86.2%	
Total Capacity (Terabytes)	12,044.5	100.0%	23,701.3	100.0%	40,114.0	100.0%	62,888.0	100.0%	86,574.5	100.0%

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

TABLE 11

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

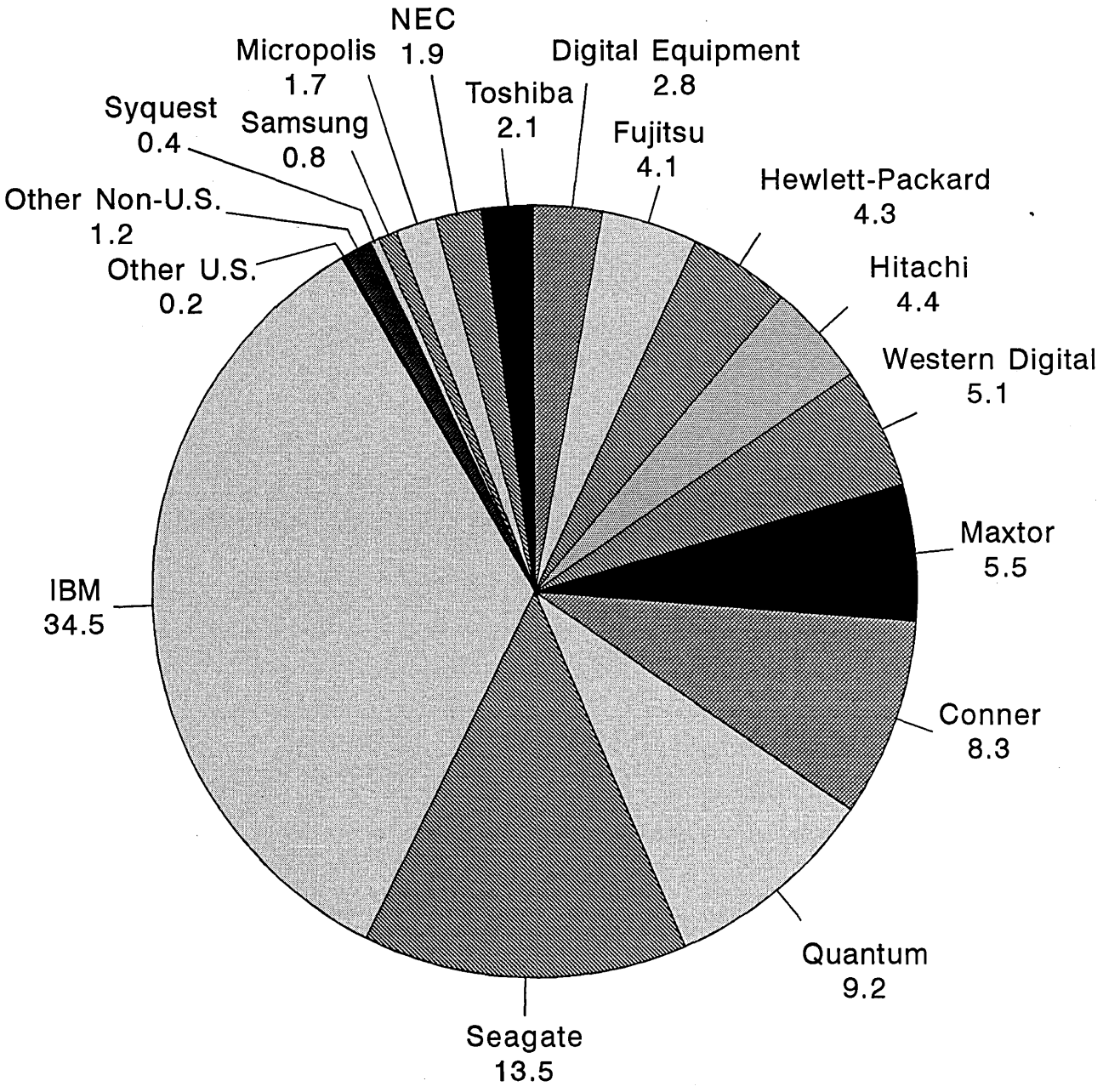
CAPACITY SHIPPED IN TERABYTES	1993 Capacity Units	1993 Capacity %	1994 Units	1994 %	1995 Units	1995 %	1996 Units	1996 %	1997 Units	1997 %
CARTRIDGE DISK DRIVES	33.0	.3%	90.1	.4%	148.2	.4%	236.6	.4%	315.1	.4%
	+61.8%		+173.0%		+64.5%		+59.6%		+33.2%	
FIXED DISK DRIVES less than 100 Megabytes	424.9	3.5%	27.6	.1%	3.5	--	.5	--	--	--
	-63.8%		-93.5%		-87.2%		-83.4%		--	
FIXED DISK DRIVES 100 - 200 Megabytes	2,408.1	20.1%	1,194.1	5.0%	527.9	1.3%	246.9	.4%	91.8	.1%
	+26.3%		-50.4%		-55.8%		-53.2%		-62.8%	
FIXED DISK DRIVES 200 - 300 Megabytes	2,969.8	24.7%	4,717.0	20.0%	2,487.8	6.2%	1,851.1	2.9%	805.4	.9%
	+261.4%		+58.8%		-47.3%		-25.6%		-56.5%	
FIXED DISK DRIVES 300 - 500 Megabytes	1,491.8	12.3%	4,524.4	19.1%	7,671.5	19.2%	6,077.2	9.7%	6,075.9	7.0%
	+172.0%		+203.3%		+69.6%		-20.8%		--	
FIXED DISK DRIVES 500 Megabytes - 1 GB	1,206.3	10.1%	3,492.8	14.8%	6,764.1	16.9%	12,650.5	20.2%	16,006.2	18.6%
	+131.6%		+189.5%		+93.7%		+87.0%		+26.5%	
FIXED DISK DRIVES 1 - 2 Gigabytes	2,111.7	17.5%	3,921.4	16.5%	8,774.0	21.9%	18,384.0	29.2%	31,007.5	35.8%
	+74.6%		+85.7%		+123.7%		+109.5%		+68.7%	
FIXED DISK DRIVES 2 - 3 Gigabytes	1,014.2	8.4%	2,869.1	12.1%	6,282.2	15.6%	9,837.0	15.7%	14,512.5	16.8%
	+111.6%		+182.9%		+119.0%		+56.6%		+47.5%	
FIXED DISK DRIVES more than 3 Gigabytes	384.7	3.1%	2,864.8	12.0%	7,454.5	18.5%	13,604.0	21.5%	17,760.0	20.4%
	--		+644.7%		+160.2%		+82.5%		+30.5%	
Total Capacity (Terabytes)	12,044.5	100.0%	23,701.3	100.0%	40,114.0	100.0%	62,888.0	100.0%	86,574.5	100.0%
	+80.3%		+96.8%		+69.2%		+56.8%		+37.7%	
% U.S. Manufacturers	89.9%		91.0%		90.6%		89.7%		87.9%	

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

Figure 6

1993 ESTIMATED MARKET SHARE

Percentage of Worldwide Revenues



1993 Revenues: $21,729,800,000

TABLE 12

1993 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1993 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Conner Peripherals	--	--	406.0	9.8	1,394.7	17.1	1,800.7	8.3
Digital Equipment	450.3	4.8	64.9	1.6	86.1	1.1	601.3	2.8
Hewlett-Packard	587.5	6.2	62.9	1.5	293.4	3.6	943.8	4.3
IBM	7,193.6	76.4	48.5	1.2	262.1	3.2	7,504.2	34.5
Maxtor	--	--	582.5	14.0	621.6	7.6	1,204.1	5.5
Micropolis	--	--	183.8	4.4	187.7	2.3	371.5	1.7
Quantum	--	--	374.6	9.0	1,626.5	19.9	2,001.1	9.2
Seagate Technology	--	--	989.3	23.8	1,950.8	23.9	2,940.1	13.5
SyQuest Technology	--	--	81.5	2.0	2.2	--	83.7	.4
Western Digital	--	--	338.8	8.2	760.0	9.3	1,098.8	5.1
Other U.S.	.3	--	12.1	.3	34.8	.4	47.2	.2
U.S. Total	8,231.7	87.4	3,144.9	75.7	7,219.9	88.5	18,596.5	85.6
NON-U.S. MANUFACTURERS								
Fujitsu	378.4	4.0	163.9	3.9	344.6	4.2	886.9	4.1
Hitachi	213.8	2.3	676.2	16.3	69.9	.9	959.9	4.4
NEC	313.5	3.3	--	--	105.1	1.3	418.6	1.9
Samsung Electronics	89.4	.9	56.6	1.4	17.0	.2	163.0	.8
Toshiba	186.2	2.0	71.2	1.7	190.1	2.3	447.5	2.1
Other Non-U.S.	5.1	.1	40.5	1.0	211.8	2.6	257.4	1.2
Non-U.S. Total	1,186.4	12.6	1,008.4	24.3	938.5	11.5	3,133.3	14.4
WORLDWIDE TOTAL	9,418.1	100.0	4,153.3	100.0	8,158.4	100.0	21,729.8	100.0

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

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

Codes: 1.8 = 1.8" C = Captive
2 = 2.5" P = PCM
3 = 3.5" O = OEM
5 = 5.25"
8 = 6.5"-9.5"
10 = 10.5"-10.8"

TABLE 13

CURRENT PRODUCT LINES
MANUFACTURERS OF RIGID MAGNETIC DISK DRIVES

U.S. Manufacturers (19)	DISK/TREND PRODUCT GROUP Type	1 Disk Cartridge Drives	2 Fixed Disk Drives <100 MB	3 Fixed Disk Drives 100-200 MB	4 Fixed Disk Drives 200-300 MB	5 Fixed Disk Drives 300-500 MB	6 Fixed Disk Drives 500 MB-1 GB	7 Fixed Disk Drives 1 GB-2 GB	8 Fixed Disk Drives 2 GB-3 GB	9 Fixed Disk Drives >3 GB
Areal Technology	O			2	2	2	2			
Aura Associates	P,O		1.8	1.8						
Avatar Systems	O	2								
Conner Peripherals	P,O				2,3	2,3	2,3	3	3	3
Digital Equipment	C						3	3	3	3,5
Hewlett-Packard	C,P,O						3	3	3	3,5
IBM	C,P,O			2,3	2,3	2,3,5	2,3,5	3,5	3	3,10
Integral Peripherals	P,O		1.8	1.8	1.8	1.8				
JTS	P,O				3	3	3			
Maxtor	P,O		1.8	1.8,3	3	3	3	3		
MFM Technology	O	5								
Micropolis	P,O						3	3	3,5	3,5
MiniStor Peripherals	P,O		1.8	1.8		2	2			
Quantum	P,O			2,3	2,3	2,3	2,3	3	3	3
Raymond Engineering	O		3			3				
Seagate Technology	P,O		1.8,2	2,3	2,3	2,3	2,3	3,5	3,5	3,5
Sequel	O		5	5,8	8	5	5			5
SyQuest Technology	P,O	1.8,3,5								
Western Digital	P,O			2,3	2,3	3	3	3		
Asian Manufacturers (9)										
Alps Electric	O				3		3			
Fuji Electric	O		2,3	2	3	3				
Fujitsu	C,P,O		2,3	2,3	2,3	2,3,5	2,3,5,8,10	3,5,8,10	3,5,8	
Hitachi	C,P,O		1.8,5	1.8,5	3	2,3,5,8	2,3,5,8	3,5,8	5,8	5
NEC	C,O		1.8,3	1.8,3	3	2,3		3		
Samsung Electronics	C,P,O				3	3	3			
TEAC	P,O				3	3	3			
Toshiba	C,P,O		2	2	2	2	2			
Zentek	P,O			2	2,3	2,3	3	3		
European Manufacturers (2)										
Calluna Technology	P,O		1.8	1.8	1.8					
Sagem	O				5					

TECHNICAL REVIEW

Competing technologies

Rapid technological improvement continues to be the hallmark of the rigid disk drive industry. Manufacturers continue to provide smaller, faster, more reliable, higher capacity, less expensive disk drives, well supported by a magnetic storage industry infrastructure. The disk drive industry is consistently able to increase areal density, provide thinner disk substrates, greater functionality chips, smaller heads, lower flying heights, smaller motors and many other improvements in disk drive and recording technology. If all of the projected improvements occur, a ten-fold expansion of capacities within existing form factors by the end of the decade appears likely.

Developers of alternatives to magnetic disk recording find it increasingly difficult to keep pace. While "disk replacement" products are frequently announced, system manufacturers buy only those that fit specialized requirements. Even if substitutes with performance and price equal to current disk drives existed today, most system designers would elect to use the familiar magnetic disk drives and their known system integration requirements, rather than risk the unknown. In order to displace rigid disk drives, the proposed substitute must be significantly better, faster, smaller, less expensive or demonstrate some other overwhelming advantage.

Those few technologies which do provide competition to magnetic disk drives in applications where characteristics such as speed, removability, or environmental tolerance give them unique advantages, are discussed in the following sections.

* Semiconductor memory -- applications and trends: Semiconductor memory offers fast response time and high reliability, characteristics that have won it a secondary data storage role in both large and small computer systems. When very fast access to data or programs is required, semiconductor memory can serve as an effective, though expensive, substitute for rigid drives. Larger systems frequently have large auxiliary semiconductor storage units performing as virtual disk drives or as cache between the host processor and disk storage. Personal computer operating systems allow part of main memory to be designated for use as a fast virtual disk.

Fast semiconductor memory is expensive, ranging from a few hundred to a few thousand dollars per megabyte, which limits its use to situations where its high speed or lack of moving parts are vitally necessary to meet system requirements. The least expensive semiconductor memories are volatile, and require the continuous availability of power to avoid loss of data. Nonvolatile semiconductor memory is usually more expensive, usually slower, and usually does not match the capacity per chip of DRAM, the most common form of volatile semiconductor memory. Some companies package semiconductor memory in disk drive form factors, typically using 4 megabit chips as the active storage elements. For instance, Hitachi offers 320 megabytes in a full height 5.25" disk drive form factor.

Aside from its role in system memory, it is likely that the greatest impact of semiconductor memory will be to augment disk drive functionality rather than to compete with it. Added to a disk drive, semiconductor memory can serve as a fast, low power cache that significantly improves system performance. The use of semiconductor memory in a cache can extend portable system battery life, because the disk drive can be shut down after data needed by the current application is loaded into the cache. If the cache memory (and some system memory) is nonvolatile, the system can be turned off and on, returning to the point where operation was halted without expending power on the disk drive.

The packaging of memory modules is evolving rapidly, especially memories used with portable systems. The Personal Computer Memory Card International Association (PCMCIA) has standardized the interface for plug-in cards used to expand system memory, emulate a disk drive, or provide other peripheral functions.

Specialized portable computers can use removable semiconductor memory packaged in a flat "credit card" format with PCMCIA interfaces. Pin interconnect and packaging standards have been worked out, with the final result being a 68 pin connector and a family of package heights: 3.3 millimeters (Type I), 5 millimeters (Type II) and 10.5 millimeters (Type III). The cards are available with a variety of memory forms, including disk drives, PROM, ROM, SRAM, DRAM, and flash memory.

The PCMCIA effort has been a major factor in promoting the acceptance of plug-in semiconductor memory as a disk drive alternative, although some disk drives, including 1.8" drives from several sources, have been packaged as PCMCIA cards with the capability to be plugged into a PCMCIA Type III card slot. Disk drives packaged in PCMCIA Type II format will be available in 1995. Some issues regarding software support of the PCMCIA interface are not yet fully worked out, and the use of the PCMCIA interface does not yet fully guarantee functional interchange among devices that are electrically and physically PCMCIA compliant, but compatibility, especially between newer PCMCIA products is improving.

Will semiconductor memory technology improve during the rest of the decade at the same rate exhibited in the last 20 years? As the complexity, packaging problems, and performance requirements of semiconductor memory have increased, so also have the investments in time and capital required to produce succeeding generations of chips. The pace of semiconductor memory price decreases is consequently expected to slow, and the high investment costs have already inspired an increasing number of companies to pool resources in order to contain development expenses.

* Volatile semiconductor memories: DRAM is the most commonly employed form of semiconductor memory. It is used in systems of all sizes for general purpose system memory, video memory, and other applications where its volatility is not a major handicap. It is also used on large systems as a supplement to magnetic storage to provide fast mass storage. DRAM chips are readily available in 4 megabit configurations and production of 16 megabit configurations has started. Large quantity production of 64 megabit DRAM chips is not expected until after 1995.

  SRAM memory chips are in volume production in 1 megabit and 4 megabit configurations. Power requirements are less than DRAM requires and speed is high, permitting SRAM to be used as a memory add-on in portable, power limited equipment. SRAM is sometimes used in removable memory cards that contain a small battery which provides the power needed by SRAM memories to retain data. However, SRAM is more expensive than DRAM and flash memory.

* Nonvolatile semiconductor memories: Flash memory, a form of EEPROM in which a block of memory cells can be erased by an electrical signal, is nonvolatile and can be used as fixed or removable storage. Flash memory can provide adequate mass storage where capacity need be only a few megabytes, power limitations are severe, a hostile environment exists, and product price is not a paramount factor.

  Flash memory is often discussed as a major competitor to rotating memory, but its more significant applications will be for program storage and as a reprogrammable BIOS in computer systems. In this role, flash memory can provide obsolescence protection by allowing periodic code updates, and provide functionality changes in printers, fax machines, and other electronic equipment.

  While flash memories are rugged, portable, reliable and use little power, they have some functional disadvantages. When rewriting, it is not possible to change only a few bits; an entire block must be erased and rewritten, and this can take from 10 milliseconds to as long as half a second for the equivalent of a disk sector in some flash memories. Whatever is in the cell block must be saved to RAM and restored after the erase/write cycle on the flash memory chip. As a result, read operations can be very fast

compared to a magnetic drive, but writing may be slower. There is also a limit to the number of times the memory device can be rewritten. At present, most flash memory devices are specified for 100,000 write/erase cycles. Some chips are specified at only 10,000 cycles. Some flash memories still require 12 volt power, but more recent products operate on 5 volts and development on 3.3 volt chips is under way at several companies. A 512K 3.3 volt chip became available from Atmel in 1993.

Flash memories using 1, 4, and 8 megabit chips are currently in production. They are being manufactured by Intel, AT&T, SunDisk, Seeq Technology, Toshiba and other firms. SunDisk offers a card with 20 megabytes of capacity that mimics the 512 byte sector organization of a magnetic disk drive and includes an IDE interface, appearing as a disk drive to the host system. This card uses 8 megabit chips. Future generations of flash memory chips are expected at 16 megabit and 64 megabit densities. 80 megabyte flash memory cards are expected to be available in 1994.

The price range for flash memory remained at about $40 to $60 per megabyte in 1992 and 1993 due to production roadblocks, but declined to the $30 per megabyte range in 1994. The most realistic projections for flash memories suggest OEM prices in the range of 10 to 20 dollars per megabyte in 1995, still much higher than anticipated for magnetic disk drives. Where only a few megabytes of storage are required and the rate of rewrites is not too high, flash memory can be economically attractive. Some disk drive producers, including Seagate, Conner and Quantum, have formed alliances with flash memory producers with the expectation of bringing flash memory modules organized as low capacity disk drives to market. These alliances also provide drive manufacturers with an early opportunity to assess and react to flash memory as a competitor to magnetic storage and to profit in either case.

Ferroelectric (FRAM) memories use the electrically reversible polarization of ferroelectric materials to form a capacitor, which is required in the circuitry of semiconductor memories. Proper design can produce a nonvolatile memory cell that can be fabricated with conventional planar processes but has smaller dimensions than cells made with silicon dioxide capacitor dielectrics. Submicrosecond access times are possible. The number of write/erase cycles possible exceeds a trillion cycles for the best materials, and a billion cycles may eventually be routinely achieved. Operating speed is equivalent to that of typical DRAM, but not quite as fast as conventional SRAM. FRAM does not have the limitations on write speed characteristic of flash memory. The fabrication techniques required to construct ferroelectric chips are substantially the same as used for CMOS, which is a well understood technology, although some process changes may be needed to accommodate the different materials used.

Ramtron, which has been the most visible developer of ferroelectric memory technology, has licensed it to NMB Semiconductor Company, ITT

and Seiko. Ramtron and Hitachi are jointly developing 256 kilobit, 1 megabit and 4 megabit ferroelectric memory chips. National Semiconductor also has a ferroelectric memory development effort. Ramtron, currently in production on 4 kilobit chips, hopes to produce 16 kilobit and 64 kilobit chips in the near future. 4 kilobit chips are currently being sold for a variety of applications, including electronic games, where they can provide a "save game" function.

Supporters of ferroelectric memories project that in the 1995-1996 time frame, chips with 1 to 4 megabit capacity could be available selling at $30 to $60 per megabyte. 16 megabit chips, possibly available in 1997, could sell in the $15 to $25 per megabyte range. Additional packaging and system costs will be incurred to fabricate the equivalent of a disk drive.

Ferroelectric and flash memories will contend for acceptance in portable computers, "smart cards" and in applications where loss of memory due to a power lapse is a critical problem. Ferroelectric memory will probably compete with magnetic drives in applications where the environment is stressful and rapid access is required. This includes military, industrial, and some high value commercial applications, but does not embrace the broader classes of nonvolatile memory requirements served by rotating memory. Development of ferroelectric memory is lagging that of flash memory, and it isn't clear that both can succeed.

* Holographic storage: Holographic storage is a type of optical storage in which an array of bits, usually representing an image, is stored in an optically sensitive medium in either two or three dimensions. When the medium is illuminated, the image can be seen or projected upon a detector. Storage media can be fixed or removable, and both write-once and rewritable forms are possible. Early attempts to develop holographic storage for use in computer memories were unsuccessful due to technical difficulties, such as a tendency of read operations to degrade the stored data, and inability to meet cost and performance constraints. But the very high storage densities and fast access times theoretically achievable have encouraged continuing research and development efforts by many organizations worldwide.

  Because holographic storage systems have no moving mechanical parts, they have applications in military, industrial, and other applications where ruggedized storage is essential. If practical, holographic storage can virtually eliminate the current limitations on throughput caused by mechanical drives, and must be considered as having the potential to compete with magnetic and optical rotating disk drives for selected applications in the late 1990s.

  One of the more ambitious holographic storage programs was conducted by MCC (Microelectronics and Computing Corporation), a research consortium sponsored by major U.S. technology firms. Among the sup-

porters of the MCC effort have been DEC, NCR, Eastman Kodak, General Dynamics and E-Systems. MCC demonstrated working prototypes of holographic memories in a 5.25" form factor in 1992 and established a subsidiary corporation, Tamarack Storage Devices, to commercialize the technology. MCC's devices had targeted capacities in the range of 200 megabytes to 10 gigabytes, average access times in the 1 to 10 microsecond range and data transfer rates in the gigabyte per second range. The storage medium, once written, can be read billions of times without significant degradation. However, the storage medium is a write-once medium. The specifications of Tamarack's first product will not be quite so impressive: It will include a jukebox holding up to 30 memory "tiles", with each tile containing 914 megabytes of storage. Once loaded, a tile is mechanically moved to center the appropriate area under a read/write head. Because of the positioning required, average access time is likely to be in the 30 to 50 millisecond range plus exchange time, if necessary. The data transfer rate is likely to be in the 1 to 1.5 megabyte per second range.

Tamarack has projected the cost per megabyte of its holographic storage at 2 to 4 times the cost of magnetic storage of equivalent unit capacity. Pilot line production of a 30-50 gigabyte device occupying a 5.25" form factor is expected in early 1995.

IBM has revealed research efforts using holographic storage techniques in conjunction with inexpensive organic amorphous media. However, this material, and similar materials announced by other researchers, must be used at very low temperatures.

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

* Optical disk drives: Optical drives range from 2.5" units with 140 megabyte capacity to 14" drives with several gigabytes of capacity. With track densities of 18,000 tracks per inch and linear bit densities of 30,000 bits per inch or more, optical disk drives have been capable of higher areal densities than magnetic disk drives now in use, although magnetic disk drives now exceeding 500 megabits per square inch areal density have all but closed the gap.

  Development of blue diode lasers capable of room temperature operation could quadruple capacity to the multiple gigabit per square inch range, but such a device is not expected to be available for several years. (IBM has projected availability of magnetic disk drives operating at a gigabit per

square inch in 1996.) However, slightly shorter wavelength lasers are expected to provide a 40 percent improvement in areal density within the next two years. The ultimate limit of optical areal density may be much higher. In mid-1992, Bell Laboratories reported they had written data in the laboratory at 45 billion bits per square inch using fiber optics to replace conventional optical elements.

While the areal density of optical drives is high, the volumetric density is inferior to that of magnetic drives because optical media is thick, head assemblies are large, only one disk is typically present, and typically only one head is present in the drive. Current optical drive technologies cannot provide performance equivalent to current magnetic disk technology, nor can optical drives yet compete on a product cost basis. Therefore, optical disk drives are preferred only where removability of the media is an advantage, such as use in an automated library or for security concerns. Even in some removable applications, magnetic disk cartridge drives such as SyQuest's 270 megabyte 3.5" drive compete strongly with 3.5" optical drives, offering better performance, lower price and higher capacity. Optical drives seem more likely to complement rigid magnetic disk drives rather than replace them, serving as vehicles for backup, software distribution, and off-line or library storage.

Manufacturers of optical disk media now claim that their disks will provide archival lives which equal or exceed those of magnetic media, with 10 to 30 years being commonly encountered specifications for archival life of the media. Lifetime is limited by the gradual appearance of defects on the recording layer due to the corrosive effects of water and oxygen on the metal films used in the recording layers of the media. The termination point of media lifetime occurs when the error correction capability of the drive can no longer cope with the gradually increasing media defect density. Media using organic dyes as the recording material have no metallic films and may offer improved stability.

Despite strong historical evidence that storage devices using noninterchangeable removable media achieve only limited success, optical drive producers have been slow to agree upon standards except for read-only drives. Write-once drives remain largely nonstandardized, but 5.25" and 3.5" rewritable drives have reached a higher, although incomplete degree of standardization.

Large automated libraries that provide random access to many disks make the use of large-scale optical storage attractive for users such as governmental agencies, banks, insurance companies and other organizations with massive records that must be easily accessed. Library systems coupled with operating system support make optical storage practical in a larger system environment. IBM now supports its model 3995 optical library as a virtual 3390 disk drive under system managed storage, although performance is very slow compared to a 3390 drive.

* Nonreversible optical disks: The first optical disk recording systems to enter the market were "nonreversible" or "write-once" systems. The initial products manufactured were 12" in diameter, but the trend is to 5.25" or smaller diameter drives. 12 centimeter (4.72") CD-ROM compatible write-once drives for professional use were introduced by Yamaha in 1989 and by Sony in 1990, and lower cost 12 cm. write-once drives from Philips, Sony and JVC entered the market in 1992. 12 cm. drives became the dominant form of write-once drives in 1994 as a result of the displacement of 5.25" write-once drives by multifunction and rewritable optical disk drives. Because individual manufacturers have championed their own approaches, write-once recording is poorly standardized, with the exception of 12 cm. drives, for which de facto standards exist as the result of strong standards for CD-ROM drives.

  The market for "pure" write-once optical disk systems is limited to the niches which emphasize nonreversibility. In some applications, the ability of write-once storage systems to maintain an audit trail or indicate whether or not stored data has been modified is perceived as a significant benefit.

  Virtually no displacement of magnetic disk drives by nonreversible optical storage will occur in the foreseeable future, and the growth of write-once technology is being capped by competition from rewritable or multifunctional optical drive technology.

* Rewritable optical disks: As cost-effective rewritable drives with improved performance become available, the possibility for eventual inroads into the market for magnetic disk drives exists. Some rewritable optical drives have reached performance levels typical of small rigid magnetic drives in the mid-1980s, but cost, capacity, power consumption and packaging improvements have lagged.

  Magneto-optical (MO) recording has seen development activity for more than twenty years, and rewritable phase change optical recording emerged as a competitor in 1990. The performance of magneto-optical drives exceeds that of write-once drives. Because it takes somewhat less laser power to change the state of a bit than required by write-once drives, the drive can rotate faster at a given laser power, reducing latency and improving data transfer rate. However, most magneto-optical drives now in production do not yet overwrite in place: A complete sector must be erased before the sector can be rewritten. The industry has been working on this problem for many years, and current industry expectations are for some models of magneto-optic drives without overwrite latencies to be available in 1995.

  Recent rewritable drives have reached 3,600 RPM spin rates and Fujitsu has announced a 5,400 RPM model. However, average seek times are just beginning to breach the 30 millisecond mark, and it will be years

before rewritable optical performance can approach the best magnetic drive technology. Improving optics, shorter wavelength, higher power lasers and other improvements will gradually permit closing the performance gap.

Today's 5.25" MO drives typically offer 652 megabytes per side, and a further advance to over 1.3 gigabyte per side is anticipated in 1995. IBM, Sony, Maxoptix, Hewlett-Packard and others currently produce the 652 megabyte version, and Hitachi put a nominal gigabyte per side drive in production in 1993. The 1.3 gigabyte per side issues are currently under consideration in several standards technical subcommittees.

The ISO standard 3.5" drives have 128 or 230 megabytes per side, and one 384 megabyte drive using a different format is also available. A general increase to the 650 megabyte per side range is anticipated in the 1995 time frame, as 3.5" drives with over 600 megabytes per side are being actively considered by a number of firms. Sony has announced a 140 megabyte 2.5" drive. Production is expected in second half, 1994.

Phase change optical recording involves a different type of amorphous coating, in which individual spots on the disk are changed by polarized light from a crystalline state, during which light is reflected, to a noncrystalline state, during which light is absorbed. Phase change recording is capable of a limited number of write/erase cycles before the signal to noise ratio from the written area degrades excessively. Matsushita Electric has reported achieving over a million cycles in the laboratory and has announced media with 100,000 cycles. Phase change erasable media can be directly overwritten. The first rewritable phase change drive was introduced by Matsushita Electric in 1990. It is backward compatible with previous write-once drives from the same firm. Several other firms now appear positioned to introduce phase change optical drives in the next year.

A third possibility, potentially the least expensive to manufacture, is erasable dye-based technology. While developers have not been able to demonstrate an adequately high number of write/erase cycles for general use, there are applications, such as backup, where this is not a major disadvantage.

Individual firms working on other proposed reversible optical recording technologies have yet to overcome all of the technical problems, which have included: Slow completion of the reversal cycle, sensitivity to ambient light, limitations on the number of reversals before degradation, expensive optical or laser components, poor shelf life, limited lifetime of stored data, and low recording density.

* Read-only optical disks: The read-only optical disk category is dominated by the CD-ROM, which has capacities of 550 to 600 megabytes, but slow access times. In 1992, NEC, Sony, Pioneer and others introduced CD-

ROM drives operating at doubled or quadrupled RPM, improving average access time and data transfer rate. It is technically feasible to develop read-only media for read/write drives, and a few firms are producing read-only media for 3.5" optical disk drives. 3.5" drive standards include definitions of read-only capability, which is expected to eventually become important in software distribution and multimedia related applications.

Because they do not have recording capability, no significant displacement of magnetic disk drives by read-only optical drives is anticipated. They will retain a specialized role as a form of electronic publishing and will appear on computer systems as an adjunct to a rigid disk drive rather than as a replacement device.

Despite improvements in recent years, optical drives lag rigid drives substantially in terms of performance, packaging, and price, and are not considered threats to magnetic rigid drives in the near term.

* High capacity flexible disk drives: It is within the capabilities of today's technology to fabricate a 3.5" floppy disk drive offering over 40 megabytes of storage capacity, and drives with 20 megabyte capacity are already in volume production. 3.5" drives with over 100 megabytes capacity are being considered for mid-decade announcement. The 5.25" Bernoulli disk drives offered by Iomega have now reached 230 megabytes in capacity and compete with removable 5.25" rigid cartridge disk drives. Where aggressively priced, these high capacity floppy drives could compete in the very low end of magnetic and optical disk drive markets and against tape drives for backup applications. However, their low capacities, thick form factors and relatively slow performance make them unlikely to displace rigid drives.

  10 and 20 megabyte 5.25" flexible disk drives available in the market over the past several years achieved only marginal success. However, the 3.5" drives with capacity in the 20 megabyte range which have been produced by Insite Peripherals (now a subsidiary of Ocean Radio) and Iomega (licensed by Insite) achieved a degree of acceptance, especially in the aftermarket. Several Japanese floppy drive producers have considered a standard for high capacity drives, including 10, 20 megabyte and higher capacity models, but none have initiated a significant production program.

  Unfortunately, none of the 3.5" high capacity flexible disk drive formats are compatible with each other, although each approach provides read and write downward compatibility with one and two megabyte 3.5" floppy disks. The 3.5" drives produced by Insite and Iomega use barium ferrite magnetic media with an optical servo pattern on the disk surface, combined with optical tracking methods. The companies in the Japanese standards group plan to use conventional embedded servo technology with metal particle media.

Disk drive enhancements

The original RAMAC, the first moving head rigid magnetic disk drive, was first shipped by IBM in 1956, giving birth to a highly competitive industry characterized by continuous and rapid improvement in product technology. IBM provided disk drive technology leadership until the late 1970s, at which time IBM was displaced from its leading position by aggressive competitors manufacturing small diameter drives. IBM reemerged as a technology leader in the late 1980s, introducing a 320 megabyte 3.5" drive with 8 disks, an 857 megabyte 5.25" drive with 12 disks, and a 2.5" 40 megabyte drive only 12.7 millimeters high introduced in 1991. IBM also introduced the first disk drives using magnetoresistive heads in 1991. As of mid-1994, IBM continues to reinforce its position, with the "Starfire" family of 3.5" disk drives, offering capacities from 1.1 gigabyte to 5.2 gigabytes and an areal density of over 560 megabits per square inch -- with much more to come. Other manufacturers are expected to follow IBM's lead and move to higher areal densities based on magnetoresistive heads and improved data channels. The critical technologies being addressed by IBM and others are discussed below.

* Head flying height: Because head flying height determines the achievable areal density, reductions are of critical importance. Head flying height is below the 4 microinch range for an increasing number of drives, and several firms are attempting to design drives in which there is no measurable flying height.

  As flying height decreases, maintaining a constant flying height becomes critical to reliable performance. Developers of conventional sliders are adding slots to the outer rails or contouring the edges of the rails. Both approaches show promise in controlling flying height and stabilizing the head position, although they add cost. A few firms are working on negative pressure sliders, a design which forms a partial vacuum under the head. The head can stably fly very close to the disk surface, although there is a risk of debris accumulating in the negative pressure cavity on the underside of the head.

  Each reduction of flying height requires a new level of sophistication in the preparation of disk substrates, coatings, overcoatings, heads and test equipment. For instance, it appears that glass or other alternative substrates may be necessary to obtain the required smoothness and flatness for the lowest flying and glide heights. Determining reliable processes for manufacturing, coating, texturing and testing disk media using alternative substrates are major challenges, especially as glide heights decrease below 2 microinches in coming years. A few drive manufacturers have

begun using glass substrates even where not absolutely required in order to gain experience and prepare for more exacting future demands.

Several approaches to contact recording are being developed. Censtor is developing an unusual low mass, low contact area head design in which the head is normally in contact with the disk. While wear does occur, the rate of wear of the critical parts of the head is low enough to permit head lifetimes to exceed expected drive lifetimes. The head area and loading is small enough to control stiction effects, and the in-contact thin film head is capable of operating at 200,000 to 300,000 BPI. VISqUS Technology, acquired by Conner Peripherals in 1991, developed a "waterskiing" technique in which the friction of head/disk contact is controlled by floating a head on a continually refreshed liquid bearing surface. Lubricant that spins off the disk due to centrifugal force is filtered and recirculated back to the disk surface. IBM has publicly discussed a "tail dragging" approach that suspends a small head from a larger flying head. The large area of the flying head keeps the head at a stable height and orientation while positioning the smaller active head at the surface of the disk. Recent patent applications also reveal that IBM has been working on designs in which heads would "fly" on a liquid bearing on the disk surface, using an approach different from the VISqUS technique. Censtor and Conner are closest to having manufacturable designs, and Censtor is working with several drive manufacturers to adapt its designs to specific disk drive development efforts.

* Recording heads: Monolithic ferrite heads patterned after IBM's 3350 designs were dominant in early Winchester disk drive designs. In following years, PCM drives using heads with 3370 contours (minisliders) designed to compete against IBM's 3370, 3375, 3380, and other new drives with ferrite heads became common. The avalanche of small diameter disk drives from multiple OEM sources since the early 1980's has required smaller head contours and continues to drive the demand for higher performance smaller heads. These pressures have driven the development of composite, metal-in-gap ferrite heads, inductive thin film heads, and magnetoresistive thin film heads.

  Sliders have continued to decline in size under the pressure to make ever smaller HDAs. The 70% form factor microslider (70% of the volume of a minislider) is being used in thin 3.5" and 2.5" diameter drives and the 50% form factor nanoslider will see wide use in 3.5", 2.5", and 1.8" diameter drives. As spacing between disks diminished, use of the smaller sliders became mandatory. Additional advantages of the small sliders include less mass to inhibit rapid positioner movement or to cause damaging head/disk interference. The smaller size also relieves stiction problems, although some new drive designs also utilize ramp loaded heads, eliminating the possibility of stiction and reducing power requirements for starting drive motors. The 70% sliders are in large volume production currently, while 50% sliders entered general production during 1992, although the

IBM 1 gigabyte, 3.5" drive that began to ship in the last half of 1991 also uses 50% sliders. The industry is looking ahead to 30% and 15% sliders for advanced product development.

Ferrite head designs are phasing out and thin film heads are taking over as areal densities increase, although less expensive MIG (metal-in-gap) heads are sometimes able to substitute for thin film heads in 3.5" and 2.5" midrange drive applications. Drive manufacturers often perform a disk drive product launch using thin film heads to insure performance, and then retrofit the drive with highly customized MIG heads to reduce cost. Still, thin film heads are probably the technology of choice for most 3.5" drives with capacities of 500 megabytes and above.

Metal-in-gap heads were first used by Japanese firms in the late 1970's for video tape applications, and are now used in DAT recorders as well as small, high performance disk drives. They can compete effectively with thin film heads in many of today's applications, although thin film heads are capable of performance extensions that metal-in-gap heads are unlikely to reach. The choice of head type depends upon the flying height, desired areal density, the characteristics of the media, and cost.

The ability of thin film heads to operate at areal densities well above those achievable by other head technologies guarantees them a role in future high capacity, high performance designs. 1984 saw the beginning of thin film head shipments for small diameter OEM disk drives. Production is large and increasing as more vendors master the process and gain control of process yields. Current major producers include IBM, Seagate, Applied Magnetics, Yamaha and Read-Rite.

Still making their debut are magnetoresistive heads, which have appeared in both high performance and small form factor drives. IBM introduced the first disk drives using MR heads in 1991 and uses them in 3.5" and 2.5" disk drives, as well as in the 3390-9. A few other drive manufacturers have introduced drives with MR heads in 1994, and many more are expected to follow in 1995.

While internally generated noise and low yield remain challenges to be overcome before MR heads are widely available from multiple vendors, MR heads are needed to achieve the gigabit per square inch areal density targeted for later in this decade. IBM, which has been developing MR heads for many years, first shipped them in a 1 gigabyte 3.5" drive that began production in late 1991. The first 2.5" drive with MR heads followed in 1993. Seagate, Fujitsu, Digital Equipment and Hitachi have also announced drives using MR heads.

In August, 1993, IBM published information suggesting that advanced MR heads using "giant magnetoresistance", which enhances head sensitivity, will be a key factor in moving recording density beyond 1 gigabit per square inch in 1996, to 10 gigabits per square inch areal density by the

end of the decade. Giant magnetoresistance is still in the laboratory stage at IBM and other firms. Utilization in a production disk drive is probably at least three years away. There appear to be several possible methods of constructing multilayer heads exhibiting enhanced magnetoresistance, with the more promising designated as the multilayer granular alloy approach and the spin valve, also a multilayer structure. The challenge is to fabricate a structure highly responsive to the lower field strengths typically seen by read heads.

MR heads are usually fabricated in an assembly including an inductive thin film head for writing and the MR head for readback of data. The width of the write head is usually greater than the width of the read head to provide some protection against off track positioning and noise from adjacent tracks. Because these head assemblies are complex and yields are not yet high, the near term use of MR heads is expected to be limited to situations requiring their unique capabilities, and it is not clear that the supply of MR heads can be ramped fast enough to meet anticipated demand in the next few years.

* Recording disks: Disk media production processes have undergone continuing refinement to achieve ever-thinner applications of more uniform recording layers. Progress in improving media surface lubricants and protective overcoatings has been equally impressive, if at times uneven. Fluorocarbon based lubricants are typically used in current drive designs. Carbon and silicon dioxide overcoatings have been getting thinner to reduce head-recording layer separation. The thinnest are now down to about .2 microinch. Carbon is the most favored material.

  Substrate smoothness has been a critical issue for several years as flying heights have diminished. Aluminum substrates require a layer, usually plated, of very smooth material to serve as a surface for the deposition of the magnetic recording layer. A typical layer is 300 to 400 microinches thick, and is textured to provide protection against stiction. The depth of the texturing is decreasing as flying heights decrease, but the texturing patterns are becoming more complex, increasing the sophistication and expense of texturing equipment. Zoned recording (requiring zoned texturing) and the expansion of the active recording area closer to the outer edge of the disk are also increasing the complexity of the texturing process. The increasing complexity of the processes required to create good aluminum substrates are encouraging the use of glass and glass/ceramic hybrid materials as substrates, as the surface is inherently smooth and texturing can be obtained in the process of making the basic substrate.

  The oxide coated media of early disk drives has largely been displaced by thin film media, because oxide coated media was unable to satisfy increasing areal density requirements. Even IBM, a longtime oxide champion, has abandoned oxide coated media in all drives introduced since 1989. While barium ferrite might be able to extend the areal density capabilities

of coated disks, the surface roughness of barium ferrite is too great for reliable operation at today's lower flying heights.

Plating was the primary method used to produce early generations of thin film disks, but plating has been supplanted by sputtering as the preferred production technique. The sputtering process is more capable of producing the higher coercivities, thin layers and tight tolerances required by disk drives operating at high areal densities and low flying heights.

Media producers find the sputtering process easier to control and capable of substantially higher yields than the plating process. Sputtering is also less subject to water contamination. Sputtered disk producers are concentrating on 5.25", 3.5", and 2.5" media because the bulk of the near term demand is in those sizes, and some are manufacturing 1.8" media. Media with coercivity in the 1,400 to 1,800 oersted range is routinely produced, and some companies have demonstrated fabrication of media up to 2,300 oersted coercivity on production quality sputtering systems. Media with coercivities exceeding 1,800 oersteds is expected to increasingly appear in new drive designs in 1994 and thereafter.

While most thin film media production has been from independent producers, some drive manufacturers, such as IBM, Conner, Western Digital and Seagate also produce some of their media needs, and appear to be in the process of substantially upgrading internal production capabilities. The effect is to reduce external disk purchases by these drive manufacturers, although the effect on the independent disk media manufacturers has been mitigated by the very strong demand for 3.5" and 2.5" drives. However, it is possible that an overcapacity situation may be developing in the thin film media industry.

As flying heights have declined below 4 microinches, glass and ceramic substrates have begun to displace aluminum. Producers of aluminum substrates have continued to improve their technology, but are finding it increasingly difficult to maintain adequate flatness as substrate thickness declines. The stresses produced when very thin disks are clamped to the spindle appear to cause more deformation in aluminum disks than in glass disks. Alternative substrates offer other advantages as well: They are typically harder than aluminum and less vulnerable to shock induced head slap damage. Texturing may also be easier to control in alternative substrates.

Some high capacity 2.5" disk drives, such as those of IBM, Areal Technology and Toshiba, use glass or glass/ceramic as a substrate material, and 1.8" drives also make use of glass media. Glass substrates are potentially smoother and flatter (especially in very thin substrates) than aluminum, have fewer impurities that can cause defects, and can be made very thin. These characteristics allow for lower flying heights and the inclusion of more disks in a stack, both highly desirable features. Because glass is more resistant to damage from shock induced head slap, glass substrates

are attractive in drives for mobile systems. However, because of lower production volume, glass disks still cost significantly more than aluminum substrates and industry production capacity is limited at present. In 1993, Seagate Technology and Corning announced that Seagate had agreed to use Corning's canasite glass/ceramic substrates in volume production, and the company has added substantial disk substrate production capacity, although technical difficulties delayed full production, and a technical problem involving degradation of the magnetic coating by substrate contamination have delayed utilization in production drives. Other alternative substrate materials have been proposed, including carbon, plastic, titanium and silicon carbide, but none of these have yet won acceptance.

Disk substrate thickness is declining in order to allow placement of more disks in small diameter drive HDAs. In 1989, 50 mil substrates were standard practice for 3.5" diameter drives, but 31.5 mil substrates have seen increasing use since IBM introduced them in the "Lightning" 3.5" drive introduced in 1989. The next step has been a move to 20-25 mil substrates in current drives. 2.5" drive substrates, now at 35 mils, are also migrating to 25 mils and will probably have begun a further migration to 15 mil substrates by mid-decade. The 1.3" Kittyhawk drive used 15 mil thick substrates. Some disk drive designers believe that 7 mil glass substrates will be in use within a few years.

* Areal density: Drives using MR heads and having areal densities exceeding 560 million bits per square inch went into production in 1994. Areal density for leading edge drives is expected to increase to 1 gigabit per square inch in late 1995 or early 1996, and 10 gigabits per square inch might be reached by the end of the decade. Increasing areal density reduces the number of disks and heads needed to achieve a given capacity in a specific form factor, which in turn lowers product costs for that configuration.

  TPI in excess of 2,000 is common and some of the newest small drives operate at over 6,000 TPI. IBM's "Bolero" 2.5" drive operates at 6,350 TPI, and some firms are investigating the use of optical tracking techniques to obtain even higher TPI. IBM has shown the feasibility in the laboratory of creating media with very narrow tracks with submicron dimensions. However, considerable work will have to be done to develop heads capable of working with such narrow track widths. Hitachi's 2.3 gigabit per square inch demonstration featured 17,000 TPI, a figure that may not be seen in a production drive for a long time. New materials and designs being developed to improve vibration suppression damping in head gimbal assemblies and positioning mechanisms should assist in reaching higher track densities.

  IBM's 1 gigabit per square inch demonstration operated at 158,000 bits per inch, which was exceeded slightly by Hitachi at 165,000 BPI. IBM's Bolero operates at 101,400 BPI, and many of today's small drives operate

with bit densities between 50,000 and 70,000 BPI, and an increasing number have BPI in excess of 80,000. IBM's Starfire operates with BPI up to 128,900, not too distant from the IBM demonstration BPI.

* Perpendicular recording: Today's rigid disk drives all use longitudinal recording, making use of magnetic domains oriented parallel to the surface of the recording medium. Higher linear densities could theoretically be resolved by recording heads if magnetization were oriented in a plane perpendicular to the recording surface, and TPI could also be sharply increased, provided that head to disk spacing is minimized. In general, perpendicular recording is superior to longitudinal recording only at very low head flying heights or contact recording.

  Intensive development efforts in perpendicular recording have occurred in Japan since 1977, with application objectives in video and audio recording, as well as for data storage. In the United States, IBM and other manufacturers have development programs, but the first drive using perpendicular recording, introduced by Northern Telecom in 1989 with heads and disks developed by Censtor, was withdrawn when the firm decided to discontinue disk drive operations.

  Early developers of perpendicular recording discovered that the high bit densities implicit in perpendicular recording resulted in very high data transfer rates that available controllers for small disk drives couldn't handle. Censtor avoided this problem by improving track density as well as bit density, permitting the use of current controller technology. This approach required Censtor to develop both heads and media and to completely manage the head/disk interface.

* Multiple spindle arrays: A single high capacity drive can be replaced with an array of smaller capacity drives having aggregate equivalent capacity and a file organization that appears to the host system to be similar to that of the larger drive. Data, plus parity information, is typically striped, mirrored, or both, across each drive in the array. In some array configurations, the drives operate with the drive rotation rate and phase synchronized to minimize the skew between related bits. Arrays are usually implemented with specialized controllers and supporting software, but some arrays achieve low cost by using software to control array functionality and minimizing the hardware content. This approach lowers cost, but performance usually suffers. Arrays are available for a variety of systems, ranging from personal computers serving as file servers to large mainframes and supercomputers.

  The term RAID (Redundant Array of Independent Disks) denotes multiple drive configurations generically, with specific configurations ranging from multiple, uncoordinated disk drives to striped, synchronized drives defined within the RAID designation as RAID-0, RAID-1, RAID-2, etc., through RAID-5. The RAID nomenclature, which derives from papers published by

the University of California, Berkeley, has been formally defined only up to the RAID-5 level, but various firms offer advanced redundant architectures informally defined as RAID-6 or RAID-7. The RAID Advisory Board, an industry association, is attempting to develop a standardized nomenclature.

The multispindle array can offer significant advantages compared to drives limited by a single actuator. Depending upon the way the array is configured and upon the degree of sophistication of associated subsystems, it can provide fault tolerance, very high data transfer rates, or volumetric efficiencies, compared to single large drives. Options such as cache and multiple data paths can also improve performance. Disk arrays, except for the RAID-0 (striping only) type, improve fault tolerance. However, optimizing for performance means less than optimum reliability and cost, while optimizing for fault tolerance or cost may degrade performance significantly. Several companies provide array products that operate simultaneously in several RAID modes, providing users with operational flexibility. Arrays are more costly than single large disks, and require that each drive in the array have superior reliability to provide an acceptable service rate for the array. Furthermore, while arrays can improve the fault tolerance of the system, data availability is not assured unless every portion of the system is made redundant so that a failure of a controller, a power supply or a cable can not disable the array.

Disk array markets have grown to a significant size. While product complexity and proliferation, lack of standardization, customer confusion and ignorance of array capabilities would be expected to suppress market development, the array market is actually on a healthy growth pattern and has already passed the billion dollar level.

* Performance: Significant improvements in data transfer rates and average access times are expected during the next few years. The single most important factor in initiating these improvements will be the increase in disk rotation rate, which both decreases latency and increases data transfer rate, albeit at the expense of a higher performance read/write channel. A secondary technique may be the use of multiple heads per surface and/or multiple heads per slider to permit parallel access to large amounts of data without head movement. Conner Peripherals, borrowing from the mainframe world, offered a multiple actuator 3.5" drive, but the product was not successful in the market.

  After many years of 3,600 RPM specifications, drive rotation rates leaped in 1989 when Imprimis announced a family of high capacity 5.25" drives operating at 5,400 RPM. Most of the 1 gigabyte 3.5" drives announced to date offer 4,300 RPM or faster spin rates, and Seagate's Barracuda series, introduced in late 1992, pioneered at 7,200 RPM. Some firms are even considering the use of motors operating in the 9,000 to 10,000 RPM range for use with disk drives having disk diameters under 2.5". The heat, power

consumption and bearing wear problems generated by these higher spin rates present a significant challenge to both disk drive and system designers. These faster spin rates are being supported by changes in the SCSI and PC AT interface specifications to accommodate faster bus data transfer rates.

The use of parallel transfer from multiple heads to achieve data rates of 12 megabytes or more per second has been a practice for many years, with such drives typically used for supercomputers and high-end imaging applications. Drives with data transfer rates of 24 megabytes per second or more are in demand for supercomputing applications. 27 megabytes per second is achieved by Seagate's Sabre PTD, an 8" 2.4 gigabyte 9 head parallel transfer drive introduced in 1990.

Average seek times have now dipped down to the 6 millisecond range for the fastest drives, and sub-10 millisecond seek times are becoming more common in high performance 3.5" drives. Higher energy magnetic materials used in actuators and lower mass heads are contributing to the improved performance. In some cases, special alloys permitting lighter positioning mechanisms that help reduce seek time are being considered. Some drives are specified with read seek times that are a millisecond or two faster than the write seek time as a result of drive intelligence permitting usable readback signals to be acquired before the head has fully settled after a seek.

The requirements of digital audio and digital video based systems require a different view of performance. While data processing systems can specify performance in terms of average response times and throughput, multimedia oriented systems require specification of the maximum sustained performance in terms of throughput and response times so that system designers can obtain the smooth flow of audio/video content required by end users. The continuity of output requirement has implications as to how intelligent drive controllers manage potentially disruptive operations such as periodic recalibration, head degaussing, and other internal, and usually invisible, housekeeping functions.

* Form factor: Sub-3.5" drives are an increasingly significant part of the market as manufacturers of notebook computers require small footprint, low height, low power drive designs. Drive height has steadily declined, and competition in providing higher capacity and thinner sub-3.5" disk diameter drives is keen. 15 to 19 millimeter heights are available for new low-end drives for desktop computers, so that half of an existing "half high" disk drive bay can be free for other peripheral devices. 2.5" drives are already in the 10 to 12.7 millimeter high range, to allow maximum volume for batteries in notebook computers. 1.8" drives conforming to the 10.5 millimeter PCMCIA Type III height requirement are in production. In 1994, announced native capacities for 1.8" drives in the PCMCIA Type III form factor reached 420 megabytes, and 1.8" drive manufacturers are

preparing even higher capacity designs and even thinner packages. Several drive manufacturers intend to offer 1.8" drives in the 5 millimeter high PCMCIA Type II card format, with delivery in 1995.

Technologically, form factor reduction is being driven by improvements in areal density, smaller heads, thinner media, greater IC functionality, and higher energy magnetic materials that permit fabrication of smaller motors and actuators without reducing performance. One of the most critical factors is the reduction in the surface area required to mount electronics needed by the drive. An increasing degree of functional integration in chips is needed and is being provided. In some drive designs, fewer than 7 chips are needed and some drive designs requiring only 5 chips (or less) on the circuit board will be announced in 1994.

Another issue related to form factor concerns patents on drive media diameter. While Rodime, PrairieTek and Conner Peripherals were able to obtain such patents, many other drive suppliers dispute the validity of form factor patents. A group of manufacturers has specifically requested that the U.S. Patent Office review and invalidate the size related patents.

* Power reduction: Another aspect of form factor reduction is the need to operate the drive at low power to conserve battery life in portable systems or to meet the requirements of energy efficient desktop systems. Smaller form factor drives typically need less power to rotate the disks and move the heads. Portable systems require the drive to have several operating modes to conserve power when not in use. Typically, the drive does not spin when data is not being transferred and other power consuming functions may also be shut down when the drive is inactive. A related need is for the drive to quickly come up to operating speed when needed. A few designs incorporate ramp loading of heads, enabling removal of the heads from disk contact when the drive spins down. The removal of head drag on the disk enables the drive to spin up faster with less power demand and lessens the danger of a stiction caused malfunction.

  The voltage required by the drive is also a factor. In 1995, some drives for portable systems (such as Maxtor's PCMCIA Type II drive) will be capable of operating within specification over a range of voltage from 3 to 5 volts. 3 volt operation permits the drive to be operated directly from a battery supply without incurring the cost and power dissipation of a voltage regulator. While concerns exist about the performance of drives operating at 3 volt levels, the performance requirements of the portable computers most likely to employ 3 volt drives may not demand the highest levels of disk drive performance. 3 volt chips and chip sets are gradually becoming available, with various functions such as controllers and read/write channels available from Cirrus Logic, IMP, Allegro, Zilog and others.

* Interfaces and controllers: The majority of small disk drives have intelligent embedded controllers and are able to communicate directly with a

host system data bus or host bus adaptor. Embedded SCSI and PC/AT (IDE) controllers are widely used in drives for personal computer applications, and embedded SCSI is also used with the majority of drives used with workstations, servers and equivalent applications. SCSI is also used as an interface to other types of peripheral products, including tape drives, optical drives, libraries, scanners and others.

While the IDE interface (more formally known as the ATA, or AT Attachment interface in standards committees) was originally limited to rigid drives with 528 megabytes or less, the Enhanced IDE (EIDE) specification sponsored by Western Digital and other firms supports drives with capacities to 8.4 gigabytes, provides 1 or 2 data channels, and also accommodates other devices such as CD-ROMs and tape drives. Higher data transfer rates in processor I/O mode and DMA mode are also supported, allowing EIDE to substitute for SCSI if only a few peripheral devices are needed in a system. EIDE incorporates ATA-2, the second generation ATA specification establishing the higher data transfer rates and additional transfer modes. Shipments of disk drives incorporating EIDE and ATA-2 began in 1994.

SCSI interfaces are most frequently encountered in workstations, file servers (especially those using disk drive arrays) and Apple Macintosh and IBM personal computers. PC/AT interfaces far outnumber SCSI interfaces in the IBM compatible personal computer market, though most IBM PS/2 models use SCSI drives. For 1.8" and smaller drives, the standards for pin connections used for ATA (AT Attachment) cards that fit physically into PCMCIA sized slots and connectors exist but various manufacturers have implemented them in ways leading to incompatibility between cards. However, some companies have agreed to informal interchange standards: In September of 1993, IBM, Maxtor, Seagate, SunDisk and Toshiba announced that mass storage cards using the PCMCIA interface and supplied by those companies would be interchangeable and would also comply with the ATA standard.

The SCSI interface continues to evolve, with the SCSI-2 command set now in general use. SCSI-3, the next version, is currently being discussed in various standards groups. (However, SCSI is implemented in different ways by different peripheral manufacturers, and is not the ironclad standard that many would prefer.) SCSI is also being upgraded to accommodate 20 megahertz bus clock rates, permitting 20 megabyte per second byte wide transfers (Fast-20) or 40 megabyte per second transfers (Fast-40) if two bytes are transmitted at a time.

Serial interfaces make up a new family of small drive interfaces. Three interfaces designs are vying for drive maker and OEM acceptance: SSA (Serial Storage Architecture), Fibre Channel and the IEEE sponsored P1394 interface, more familiarly known as Firewire. The serial interface proposals have some common features, including SCSI command sets,

ability to hot plug drives, smaller connectors and cables, and data transfer rates exceeding EIDE and SCSI rates, but differ in their efficiency with different size data blocks, number of drives or other devices, physical size of storage subsystem and other factors.

SSA has been supported by IBM and Micropolis, is in the process of formal review by the ANSI X3T10.1 subcommittee, and seems destined for a role in large and midrange systems. Fibre channel has been championed by Seagate and many supporters of open systems (but still has some standards issues to be resolved), while Apple and video equipment producers have been the most visible supporters of P1394. It seems likely that all three interfaces will appear in production equipment in 1995, with the choice made by the system integrator dependent upon the application and processing platform selected.

Intelligent interfaces and embedded controllers provide disk drive suppliers with an opportunity to add value, but more importantly give engineers freedom to design the drive to meet various needs while maintaining a common interface to the host system. Embedded intelligent interfaces permit the varying bit density by zones over the band of recording tracks and advanced data coding transparent to the host system. Other features, such as on-board error monitoring and diagnostics, error correction, digital servos, segmented caching, zero latency read/write and multiport buffering can be included and also made transparent to the using system. However, there is a delicate balance between overall system performance and the design of the intelligent controller. For instance, the use of too large a buffer can slow data retrieval if all of the buffer contents must be examined to service each request for data from the system.

* Digital servos: Digital servos are increasingly popular as VLSI density improves, track density increases, and smaller disk drive form factors make printed circuit board space a scarcer commodity. The ability to incorporate programmable servo functions in a single chip or chip set provides both functional and economic advantages. Typical servo control chips employ digital signal processors coupled with a standard microprocessor. By the mid-1990s, it is probable that well over 80% of the rigid disk drives produced will incorporate digital servos. Digital servo chips are expected to include motor power control functions as well as servo functions.

* Encoding and error correction: Effective linear bit density can be improved beyond the raw flux change density by the use of appropriate data encoding schemes. Run-length-limited codes such as 2,7 RLL and 1,7 RLL are the most often used currently, but the Probable Response Maximum Likelihood (PRML) code introduced by IBM on its 9336 model 5.25" and 1 gigabyte and up 3.5" drives may be used more widely once it is well understood by the rest of the industry and appropriate chips are available from independent semiconductor vendors. Cirrus Logic has

already announced a PRML chip set. Companies understood to be working on digital read channels include GEC Plessey, Silicon Systems, Philips Semiconductor and others.

In-line error correction of the read-back data stream will also become increasingly common, because as areal density becomes higher, the size of a media defect required to cause an error becomes smaller and the number of error causing defects per unit area increases. The Reed-Solomon codes used in optical disk drives to perform error correction are migrating to the rigid disk drive world, permitting the reliable use of media that would otherwise have to be discarded. The effective improvement in media yield provides an incentive to adopt error correction techniques.

If other in-line processing of data within the drive is performed, data compression within the drive might also be incorporated as an internal drive capability. In addition to improving capacity, the internal data transfer rate may be improved. The degree of compression obtainable is highly influenced by the format of the data and the degree of processing allowable by real-time requirements on drive performance. In any event, the compression algorithms used will be restricted to lossless compression techniques.

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 manufacturers use them.

Market classification

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

Captive: Disk drives manufactured internally or by a subsidiary of a computer manufacturer, and sold or leased primarily for use with systems offered by the manufacturer. Note that the term is used to describe the products, not the manufacturer; drives sold to PCM/Reseller or OEM/Integrator market classes are classified accordingly. Most DISK/TREND statistics separate data between IBM captive and "other captive", but the term still pertains to the disk drives involved, not the manufacturer.

Examples:

* Drives sold by Hewlett-Packard, IBM or Fujitsu to computer system end users are considered captive, if internally manufactured.

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

Examples:

* Shipments by Hitachi are noncaptive, except for drives sold with systems made by the parent company or other subsidiaries.

* Shipments made by Quantum or Seagate Technology are noncaptive.

PCM/Reseller: Disk drives sold or leased by "plug compatible manufacturers" or their distributing organizations directly to end users for use with systems sold by another manufacturer. Also includes drives sold in the "aftermarket" -- shipments by drive manufacturers to subsystem producers, 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 drives sold as add-on devices by distributors and dealers.

Examples:

* Disk drives sold by Western Digital or Maxtor through distributors or major retailers to computer end users.

* On an arbitrary basis, disk drives manufactured by Fujitsu or Hitachi and resold in the PCM/Reseller market by other companies are included in PCM/Reseller totals, to avoid distortion of total industry PCM activity.

OEM/Integrator: Drives sold by the original producer to system manufacturers which resell them as part of complete computer systems. Also includes sales to system integrators or value-added resellers which combine finished system components and software to provide complete systems for specific applications. Sales by a disk drive manufacturer to a second drive manufacturer for resale are included only in shipment totals for the originating manufacturer, except when drives are produced on a contract manufacturing basis with a design supplied by the disk drive manufacturer which finally sells the drive to a third party.

Examples:

* Drives produced by Western Digital or Conner Peripherals for sale to system manufacturers.

* Drives sold by Quantum Corporation to system manufacturers but manufactured to Quantum designs by Matsushita-Kotobuki Electronics.

Geographic classification

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

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

Examples:

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

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

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

Example:

* Seagate is considered a U.S. manufacturer, even though the firm manufactures many of its disk drives 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 unit totals are counted in spindles. In order to avoid distortion of shipment information for large fixed disk drives used with mainframe systems, certain plug compatible models have been arbitrarily counted on the basis that two or more physical spindles are equivalent to a single IBM spindle.

Revenue: Based on sales of disk drives 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 disk drive models include integral control functions, such as may be required for the first drive on a string of drives, the actual value of the complete unit is used. Sale prices are estimated public sale transaction prices, whether at captive end user, PCM/Reseller or OEM/Integrator levels. All prices are in 1994 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 double density versions of existing single density 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 are classified by the following computer applications:

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

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

Networks/mini/multiuser computers: Drives attached to network file servers, minicomputers, video-on-demand servers and other midrange multiuser systems. Examples: IBM System AS/400, Hewlett-Packard 3000, Compaq Systempro, Data General CLARiiON series.

Personal computers: Drives used with a desktop or portable personal computer intended primarily for nonconsumer applications. Examples: IBM PS/2, IBM ValuePoint, Apple Macintosh, Compaq DeskPro, Toshiba Satellite series.

Workstations: Attached to 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 and hobby computers: Used in general purpose or dedicated applications systems sold primarily to consumers for nonbusiness purposes. Examples: All computers intended for home use and all computer games. Multimedia systems for home use, such as the Tandy Sensation, are also included in this category.

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

1994 DISK/TREND REPORT

DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter	
MFM Technology	11/11, 5/5
SyQuest Technology	SQ555, SQ5110, SQ5200C
3.5" disk diameter	
SyQuest Technology	SQ3105A/S, SQ3270A/S
2.5" disk diameter	
Avatar Systems	ASR-2085N, ASR-3085N
1.8" disk diameter	
SyQuest Technology	SQ1080

All types of disk drives using removable media in the form of rigid disk cartridges have been included in this product group. During recent years 5.25" drives have provided most of the shipments in the disk cartridge drive product group. However, shipments of SyQuest's 3.5" drives have been under way since 1992, and the 3.5" drives are now challenging the 5.25" form factor for shipment leadership.

Avatar Systems' 2.5" disk cartridge drives, including models combining removable disk drives with floppy drives or with fixed disk drives, went into production in 1993. SyQuest also initiated a 2.5" disk cartridge drive program, with initial shipments in 1993, but has since discontinued the product. Instead, SyQuest has emphasized development of an 80 megabyte drive in a PCMCIA Type III card format, which uses 1.8" disks in a cartridge which may be removed from the removable drive.

Market status

Shipments of disk cartridge drives grew only 18% in 1993, a relatively small increase for this product group, but a strong resurgence in shipment growth is projected for 1994. 552,400 disk cartridge drives are forecasted for 1994, up

47.3%, and 1994 sales revenues are estimated at $132.7 million, an increase of 53.3%. New SyQuest drives with increased capacity in both 5.25" and 3.5" models have made the difference in 1994 shipments and revenues.

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 the active upgrading from 44 megabyte to 88 megabyte drives which was under way during 1992/93, the overall market growth for 5.25" disk cartridge drives slowed down, as customers' appetites for even higher capacities became stronger. During 1994, SyQuest responded to this demand with a 200 megabyte 5.25" drive which maintains backward media compatibility with the lower capacity models, and a slight increase in overall 5.25" drive shipments is now expected for 1994. However, after several years of complete dominance by 5.25" disk cartridge drives, the product mix in the disk cartridge drive group is now starting the expected transition to smaller diameters.

The most aggressive competition for SyQuest's rigid disk cartridge drives is provided by manufacturers of optical disk drives and by Iomega, maker of the high capacity Bernoulli floppy disk drive. Iomega's 44 megabyte 5.25" drive was supplemented in 1991 with a 90 megabyte model and in 1992 with a new 150 megabyte model, with the result that SyQuest and Iomega are competing directly in both the Macintosh and IBM personal computer markets for the same graphics and desktop publishing applications. 3.5" optical disk drives have also sold into the same markets, in both the standard 128 megabyte models and the newer 230 megabyte drives available from some of the same manufacturers. However, the sales efforts for optical drives have been handicapped by high drive prices and lower performance, leaving SyQuest in a leadership role.

SyQuest's first shipments of its 105 megabyte 3.5" drives began in 1992, and the 270 megabyte drive went into production at the end of 1993. The 105 megabyte model captured 20.8% of 1993 total unit shipments for the product group, but the market response to the 270 megabyte model has been even stronger. 1994 shipments of 3.5" disk drives are expected to provide over 39% of the overall disk cartridge drive unit shipment total for the year. In addition to

extensive shipments through PCM/Reseller channels for usage as add-on drives with Macintosh and IBM compatible personal computers, the 3.5" drives are also expected to capture significant OEM sales to system manufacturers -- a market in which 5.25" disk cartridge drives had only a minor role in recent years.

Older 14" and 8" captive disk cartridge drive programs by Digital Equipment, Control Data and other companies have long since been phased out, accounting for the absence of captive revenues. The growth expectations of several years ago for 14" and 8" drives were largely unfulfilled, due to the arrival in the market of more cost-effective smaller 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 an 85 megabyte 2.5" rigid disk cartridge drive 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 is one of the most unusual disk drive designs to date. It uses a disk cartridge which can be removed from the drive, which, like all drives in a PCMCIA card format, is removable from the host system. This drive has an interesting potential future market, since the removable disk cartridge will have a much lower cost than a complete drive unit. The relatively low media cost will be important in applications requiring multiple media units, and may 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, especially as the continuing improvements in the areal density of rigid disk drives make it possible to increase drive capacity.

SyQuest Technology captured 98.9% of the worldwide unit shipments of disk cartridge drives in 1993, with 371,000 drives. In 1993 all disk cartridge drives were shipped in noncaptive market channels.

Marketing trends

Based on the surge in demand now under way for SyQuest's 270 megabyte 3.5" drives, it is forecasted that growth for 3.5" drives will continue and they will take over shipment leadership in this product group in 1995. Through 1997, SyQuest's 3.5" drives are expected to be locked in a continuing contest with Iomega's Bernoulli drives and various 3.5" magneto-optical drives for dominance

in the graphics and "prepress" interchange markets. Increased storage capacities for 3.5" MO drives are expected next year, with two different camps predicting drives in the mid-600 megabyte range, and further increases in Bernoulli drive capacity are anticipated. However, it is likely that SyQuest will benefit from the rigid disk drive components being developed to maintain the 60% per year average increases in areal density now considered normal in rigid disk drive technology, and availability of these components will probably enable SyQuest to equal or better the currently planned capacity improvements envisioned for optical disk drives.

The PCM/Reseller sales channel will continue to dominate rigid disk cartridge drive shipments. In recent years, the personal computer aftermarket has provided most of the sales opportunity for disk cartridge drives, with the largest proportion of drives moving through independent resellers marketing disk subsystems designed as add-ons to be used with existing computers. Given the earlier background of technical difficulties, shaky financial status of some manufacturers, lack of media interchange standards and excellent competition from fixed disk drives, it is easy to understand why a majority of the computer industry's system manufacturers are no longer using disk cartridge drives.

However, the availability of the new smaller drives may erode some of the current dominance of the aftermarket distribution channel for disk drives in this product group. SyQuest's 3.5" drives and the Avatar Systems 2.5" model have an interesting opportunity in OEM markets -- the first time in the last ten years that disk cartridge drives have had this opportunity. Both drives' smaller sizes are consistent with the industry's current physical formats, and with many end users already sold on the use of removable media for selected applications, the time for renewed growth of OEM shipments for disk cartridge drives may have arrived. DISK/TREND data indicates that 97.2% of all disk cartridge drive 1993 unit shipments were sold through PCM/Reseller channels, but forecasts a drop to 85.8% in 1997, with the balance sold to OEM/Integrators.

SyQuest's 1.8" "removable/removable" drive may have even greater potential in both PCM/Reseller and OEM/Integrator channels. The PCMCIA standards for removable devices in the card format is clearly destined for very wide usage in the computer industry, for desktop personal computers, notebook and subnotebook computers and for a variety of mobile computing devices intended for indi-

vidual use. Since it is not yet clear which applications will survive the market introduction phase, forecasting the specific usage patterns for the storage devices which will be available is still very speculative. However, it is now obvious that there will be innumerable PCMCIA slots offered with new notebook and desktop PCs -- and this market alone will provide a major sales opportunity for 1.8" drives offering the added feature of removable media.

Technical trends

It is possible to increase density in removable disk drives. The major difference in high density recording between disk cartridge drives and fixed disk drives is the higher probability of particulate contamination in removable disk drives. At the higher areal densities already in use with fixed disk drives, heads must fly at lower altitudes, increasing the need for reduced contamination levels. But advanced disk cartridge drives will continue to take advantage of the disk drive industry's many improvements in heads, filtration systems and seals, and thin film disks will continue to be used because of improved surface durability.

The basic recording technologies now in use for products in this group will continue to predominate for years. The smaller drives now going into quantity production embody the mechanical design lessons accumulated during years of production of larger removable disk drives, but will be able to take advantage of the rapid design advancements in recent years in recording heads, disks, head positioning and electronic components originally intended for fixed disk drives. The 3.5" and 2.5" disk cartridge drives now available, plus the 1.8" drives now going into production, may be expected to increase continually in capacity during the coming years, following closely the rapid improvements in areal density expected with higher capacity fixed disk drives.

Forecasting assumptions

1. Significant shipment increases of 3.5" disk cartridge drives will continue, with further increases in drive capacity available next year, with successful sales to both system manufacturers and the aftermarket.
2. Production for 5.25" disk cartridge drives will peak in 1994, to be followed with a migration of graphics and desktop publishing applications to smaller disk cartridge drives.

TABLE 14

CARTRIDGE DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	46.8	81.6	74.7	123.0	96.9	152.5	122.2	188.6	122.6	190.2
OEM/Integrator	2.5	3.0	7.1	9.7	16.0	21.3	18.7	27.8	22.5	33.5
TOTAL U.S. NONCAPTIVE	49.3	84.6	81.8	132.7	112.9	173.8	140.9	216.4	145.1	223.7
TOTAL U.S. REVENUES	49.3	84.6	81.8	132.7	112.9	173.8	140.9	216.4	145.1	223.7
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	.3	1.9	--	--	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	.3	1.9	--	--	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	49.6	86.5	81.8	132.7	112.9	173.8	140.9	216.4	145.1	223.7
OEM Average Price ($000)		.408		.299		.264		.252		.239

TABLE 15

CARTRIDGE DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993		Forecast							
	Shipments		1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	205.0	363.0	308.0	520.0	410.0	659.6	505.0	795.0	535.0	845.0
OEM/Integrator	7.0	9.0	23.4	32.4	60.4	80.4	75.0	110.0	95.0	140.0
TOTAL U.S. NONCAPTIVE	212.0	372.0	331.4	552.4	470.4	740.0	580.0	905.0	630.0	985.0
TOTAL U.S. SHIPMENTS	212.0	372.0	331.4	552.4	470.4	740.0	580.0	905.0	630.0	985.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	.5	3.0	--	--	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	.5	3.0	--	--	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	212.5	375.0	331.4	552.4	470.4	740.0	580.0	905.0	630.0	985.0
Total Capacity (Terabytes)	19.5	33.0	56.7	90.1	95.9	148.2	154.7	236.6	205.3	315.1
Cumulative Shipments (Units in thousands)										
IBM	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0
Non-IBM	1,851.5	2,983.0	2,182.9	3,535.4	2,653.3	4,275.4	3,233.3	5,180.4	3,863.3	6,165.4
WORLDWIDE TOTAL	1,904.8	3,062.0	2,236.2	3,614.4	2,706.6	4,354.4	3,286.6	5,259.4	3,916.6	6,244.4

TABLE 16

CARTRIDGE DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues			Forecast															
				1994				1995				1996				1997			
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																			
PCM/Reseller	61.4	18.9	1.3	63.6	56.6	--	2.8	56.0	84.8	--	11.7	39.4	113.5	--	35.7	23.7	115.7	--	50.8
OEM/Integrator	.8	2.1	.1	.5	6.4	2.8	--	.5	10.6	10.2	--	--	16.3	11.5	--	--	19.5	14.0	--
TOTAL U.S. REVENUES	62.2	21.0	1.4	64.1	63.0	2.8	2.8	56.5	95.4	10.2	11.7	39.4	129.8	11.5	35.7	23.7	135.2	14.0	50.8
NON-U.S. MANUFACTURERS																			
OEM/Integrator	1.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	1.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WORLDWIDE RECAP																			
PCM/Reseller	61.4	18.9	1.3	63.6	56.6	--	2.8	56.0	84.8	--	11.7	39.4	113.5	--	35.7	23.7	115.7	--	50.8
	-21.0%	--	--	+3.6%	+199.5%	--	--	-11.9%	+49.8%	--	+317.9%	-29.6%	+33.8%	--	+205.1%	-39.8%	+1.9%	--	+42.3%
OEM/Integrator	2.7	2.1	.1	.5	6.4	2.8	--	.5	10.6	10.2	--	--	16.3	11.5	--	--	19.5	14.0	--
	-35.7%	+950.0%	--	-81.5%	+204.8%	--	--	--	+65.6%	+264.3%	--	--	+53.8%	+12.7%	--	--	+19.6%	+21.7%	--
Total Revenues	64.1	21.0	1.4	64.1	63.0	2.8	2.8	56.5	95.4	10.2	11.7	39.4	129.8	11.5	35.7	23.7	135.2	14.0	50.8
	-21.7%	--	--	--	+200.0%	+100.0%	--	-11.9%	+51.4%	+264.3%	+317.9%	-30.3%	+36.1%	+12.7%	+205.1%	-39.8%	+4.2%	+21.7%	+42.3%
ANNUAL SHARE, BY DIAMETER	74.2%	24.3%	1.5%	48.4%	47.5%	2.1%	2.0%	32.6%	54.9%	5.9%	6.6%	18.2%	60.1%	5.3%	16.4%	10.6%	60.5%	6.3%	22.6%

TABLE 17

CARTRIDGE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments			Forecast															
				1994				1995				1996				1997			
	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																			
PCM/Reseller	288.0	70.0	5.0	315.0	195.0	--	10.0	294.6	320.0	--	45.0	220.0	420.0	--	155.0	140.0	445.0	--	260.0
OEM/Integrator	.8	8.0	.2	.4	22.0	10.0	--	.4	40.0	40.0	--	--	60.0	50.0	--	--	75.0	65.0	--
TOTAL U.S. SHIPMENTS	288.8	78.0	5.2	315.4	217.0	10.0	10.0	295.0	360.0	40.0	45.0	220.0	480.0	50.0	155.0	140.0	520.0	65.0	260.0
NON-U.S. MANUFACTURERS																			
OEM/Integrator	3.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	3.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WORLDWIDE RECAP																			
PCM/Reseller	288.0	70.0	5.0	315.0	195.0	--	10.0	294.6	320.0	--	45.0	220.0	420.0	--	155.0	140.0	445.0	--	260.0
	-7.4%	--	--	+9.4%	+178.6%	--	--	-6.5%	+64.1%	--	+350.0%	-25.3%	+31.3%	--	+244.4%	-36.4%	+6.0%	--	+67.7%
OEM/Integrator	3.8	8.0	.2	.4	22.0	10.0	--	.4	40.0	40.0	--	--	60.0	50.0	--	--	75.0	65.0	--
	-35.6%	+900.0%	--	-89.5%	+175.0%	--	--	--	+81.8%	+300.0%	--	--	+50.0%	+25.0%	--	--	+25.0%	+30.0%	--
Total Shipments	291.8	78.0	5.2	315.4	217.0	10.0	10.0	295.0	360.0	40.0	45.0	220.0	480.0	50.0	155.0	140.0	520.0	65.0	260.0
	-7.9%	--	--	+8.1%	+178.2%	+92.3%	--	-6.5%	+65.9%	+300.0%	+350.0%	-25.4%	+33.3%	+25.0%	+244.4%	-36.4%	+8.3%	+30.0%	+67.7%
ANNUAL SHARE, BY DIAMETER	77.9%	20.8%	1.3%	57.2%	39.3%	1.8%	1.7%	40.0%	48.6%	5.4%	6.0%	24.3%	53.1%	5.5%	17.1%	14.2%	52.9%	6.6%	26.3%
TOTAL CAPACITY (Terabytes)	21.1	11.7	.2	34.0	54.4	.9	.8	44.2	97.2	3.2	3.6	44.0	168.0	6.0	18.6	35.0	218.4	9.8	52.0

TABLE 18

CARTRIDGE DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	354.2	94.5	955.5	97.0
WORKSTATIONS Engineering and office, single user	20.8	5.5	29.5	3.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	375.0	100.0	985.0	100.0

TABLE 19

CARTRIDGE DISK DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1993	Forecast 1994	1995	1996	1997
Captive					
5.25"	--	--	--	--	--
3.5"	--	--	--	--	--
2.5"	--	--	--	--	--
1.8"	--	--	--	--	--
Captive Average	--	--	--	--	--
PCM/Reseller					
5.25"	2.92	1.87	1.26	.89	.67
3.5"	1.80	1.15	.98	.77	.61
2.5"	6.25	--	--	--	--
1.8"	--	3.43	3.25	1.91	.97
PCM/Reseller Average	2.57	1.47	1.13	.89	.69
OEM/Integrator					
5.25"	27.28	--	26.00	--	--
3.5"	1.80	1.13	.98	.77	.61
2.5"	--	3.05	3.18	1.91	1.43
1.8"	--	--	--	--	--
OEM/Integrator Average	3.80	1.48	1.52	1.02	.81

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 20

CARTRIDGE DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 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	150.0	56.0	5.0	211.0	99.3	288.0	78.0	5.0	371.0	98.9
Other U.S.	.8	--	.2	1.0	.5	.8	--	.2	1.0	.3
Other Non-U.S.	.5	--	--	.5	.2	3.0	--	--	3.0	.8
TOTAL	151.3	56.0	5.2	212.5	100.0	291.8	78.0	5.2	375.0	100.0

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Hitachi	DK522-10*
Sequel	XT-1085

3.5" disk diameter

Fuji Electric	FK314S-90R**
Fujitsu	M2612ES*
NEC	D3735**, D3835**

2.5" disk diameter

Fuji Electric	FK202S-80R***
Fujitsu	M2633S/T***
Seagate Technology	ST9080A****, ST9100A****
Toshiba	MK-14224FCv****

1.8" disk diameter

Aura Associates	AU1085P-III*****
Calluna Technology	CT-80MC*****
Hitachi	DK110A-8****
Integral Peripherals	1841PA*****, 1882PA****
Maxtor	MobileMax Lite 85******
MiniStor Peripherals	MiniPORT 42P*****, MiniPORT 85A****
NEC	D1632*****, D1731***
Seagate Technology	ST7050P*****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****PCMCIA Type III (10.5 mm height).
******PCMCIA Type II (5 mm height).

Shipments of rigid disk drives in the lower capacity ranges are continuing to decline, and the two DISK/TREND product groups with capacities less than 100 megabytes used in last year's report have been combined into a single group for this year's edition.

Although numerous manufacturers shipped fixed disk drives in this capacity range with 14" disks in the 1970's and with 8" disks in the late 1970's and early

1980's, followed by 5.25" disks in the 1980's, the industry's continuing improvement in recording densities have forced the withdrawal of drives with larger disks from the market. Even 3.5" and 2.5" drives are finding rapidly shrinking markets below 100 megabytes, due to the current demand for higher capacities for most applications. 1995 is expected to be the last year of shipments for all disk drives in this product group except for 1.8" disk drives, and the market for those drives in this capacity range is forecasted to end in 1996. The Hewlett-Packard 1.3" "Kittyhawk" disk drives are being discontinued and are not included in the above listings.

Market status

Disk drive shipments in the product groups now combined in this section were once larger than those in any other DISK/TREND Report product group, but the passage of time has changed that drastically. The storage demands of new software and changing user operating practices have moved the typical capacities required by personal computers out of this product group's range for most applications.

Worldwide revenues for disk drives with less than 100 megabytes capacity are now collapsing to negligible levels, as are unit shipments. 1993's sales revenues of $1.1 billion are forecasted to drop to only $132 million in 1994. Worldwide unit shipments were 7.4 million drives in 1993, but are expected to reach only 259,100 units in 1994.

The personal computer market consumed most of the production of 3.5" drives with capacities less than 100 megabytes during the last decade, but software and application requirements have resulted in a demand for more capacity. As a result, 3.5" drive shipments in this product group declined 57.2% in 1993 and are expected to decline another 93.2% in 1994. A similar trend is occurring in the notebook computer market, with capacities rapidly moving to higher levels, and reduced demand for 2.5" drives. Shipments of 2.5" drives were down 64.1% in 1993 and are forecasted to drop 91.5% in 1994.

The 1993 leader in noncaptive shipments for disk drives with less than 100 megabytes capacity was Quantum with 2.3 million units, 35.6% of the worldwide total. Conner Peripherals held 28.3% of the shipment total and led in 2.5" drive

shipments, although at a much lower level than in the previous year. Seagate Technology was third with 22.3%.

Marketing trends

As the long-standing markets for disk drives in this product group with desktop personal computers and with notebook computers move to capacities at higher levels, it is clear that there is no future for drives in this capacity range. 1995 is expected to be the last year for shipments of 2.5" and 3.5" drives, and 1.8" drives are expected to survive only until 1996.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
5.25"	60.1	15.0	1.5	--	--
	.8%	2.3%	1.7%	--	--
3.5" 1.625" high	163.0	74.6	16.5	--	--
	2.2%	11.4%	18.8%	--	--
3.5" 1" high or less	5,644.7	322.2	11.0	--	--
	76.2%	49.4%	12.5%	--	--
2.5" more than .5" high	970.7	60.0	3.0	--	--
	13.1%	9.2%	3.4%	--	--
2.5" .5" high or less	411.5	57.4	2.0	--	--
	5.6%	8.8%	2.3%	--	--
1.8" PCMCIA Type II/III	78.7	24.2	29.0	14.0	--
	1.1%	3.7%	33.0%	93.3%	--
1.8" or less, other formats	75.0	98.6	25.0	1.0	--
	1.0%	15.1%	28.4%	6.7%	--
Total	7,403.7	652.0	88.0	15.0	--

Shipments of 1.3" disk drives have been combined in the 1.8" drive totals for statistical purposes. With the withdrawal of Hewlett-Packard's 1.3" disk drive program in 1994, the end of production and sales activity for this drive format is expected this year. No other disk drive manufacturer is known to be currently developing 1.3" disk drives.

1.8" drives are forecasted to stay in production into 1996, but shipments by that year will be nominal. At one time, it was envisioned that there would be continuing markets for 1.8" drives with lower capacity levels, but those markets have been illusory. Storage capacities required by personal digital assistants and many other mobile systems are apparently relatively small, and will be provided primarily by flash memory, both internal and in PCMCIA card form. The most significant market for 1.8" drives has become the subnotebook market, with most users demanding disk drive capacities well above 100 megabytes, a capacity range in which flash memory's high price does not compete effectively with disk drives.

Technical trends

The challenges of large production volume and low cost requirements have been the key engineering targets for the older disk drives in this group. The problem was to achieve high production volumes despite use of continually higher recording densities. The challenge of higher areal densities became even more acute with the movement to 2.5" disks, followed by 1.8" disks. Competitive cost targets have pushed drives of 100 megabytes or less in capacity toward single disk configurations, in order to help reduce the parts count in each drive, and thus the cost.

Packaging techniques developed for 2.5" drives and 1" high 3.5" drives with lower capacities were also adapted to this product group, taking advantage of the availability of miniaturized drive motors, head positioning mechanisms and electronic components. Considerable activity continues in development of even smaller form factors, but the target markets are in higher capacity ranges.

In addition to lower costs, higher areal density has also had the effect of speeding the transition to intelligent embedded controllers. Higher recording densities mean higher transfer rates, and frequently are used with multiple recording bands, each with different densities. In order to mask individual drive peculiarities, all drives now offer embedded controllers, some with the choice of either SCSI or PC/AT (IDE) interfaces.

A different set of requirements has guided the development work on 1.3" and

1.8" drives in this capacity range. The objective has been to increase capacity significantly without increasing the parts count, and cost. Even with the rapid increases in areal density the industry has achieved in recent years, the capacity currently available in the 1.3" disk drive format proved to be inadequate to develop a major market. The greater amount of disk surface area in 1.8" drives, with the resulting larger capacity levels, made the difference in finding markets, but the industry's appetite for even larger capacities has moved the market to capacity levels above this product group.

Forecasting assumptions

1. IBM will cease production of all disk drives with capacities below 100 megabytes in 1994.

2. Shipments of 3.5" and 2.5" drives with capacities below 100 megabytes peaked in 1992, and the last shipments of both 3.5" and 2.5" drives will be in 1995.

3. 1.8" drive shipments in this product group will continue to decline, displaced by similar drives with higher capacities, with final shipments in 1996.

TABLE 21

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	150.8	222.4	23.6	35.4	--	--	--	--	--	--
Other U.S. Captive	.1	.1	.1	.1	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	150.9	222.5	23.7	35.5	--	--	--	--	--	--
PCM/Reseller	92.9	204.4	15.1	23.6	3.5	4.7	.5	.8	--	--
OEM/Integrator	275.8	498.7	8.6	22.3	3.7	6.0	.7	1.3	--	--
TOTAL U.S. NONCAPTIVE	368.7	703.1	23.7	45.9	7.2	10.7	1.2	2.1	--	--
TOTAL U.S. REVENUES	519.6	925.6	47.4	81.4	7.2	10.7	1.2	2.1	--	--
Non-U.S. Manufacturers										
Captive	3.5	51.0	--	15.7	--	2.0	--	.6	--	--
PCM/Reseller	3.8	14.8	--	--	--	--	--	--	--	--
OEM/Integrator	30.3	142.3	4.0	35.1	--	4.7	--	--	--	--
TOTAL NON-U.S. REVENUES	37.6	208.1	4.0	50.8	--	6.7	--	.6	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	557.2	1,133.7	51.4	132.2	7.2	17.4	1.2	2.7	--	--
OEM Average Price ($000)		.136		.188		.182		.144		--

TABLE 22

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast							
	1994		1995		1996		1997			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	535.5	790.8	100.0	150.0	--	--	--	--	--	--
Other U.S. Captive	.1	.1	.2	.2	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	535.6	790.9	100.2	150.2	--	--	--	--	--	--
PCM/Reseller	765.2	1,697.2	79.6	150.9	19.0	25.0	3.0	5.0	--	--
OEM/Integrator	2,262.9	4,062.6	58.0	140.8	18.1	28.5	5.0	9.0	--	--
TOTAL U.S. NONCAPTIVE	3,028.1	5,759.8	137.6	291.7	37.1	53.5	8.0	14.0	--	--
TOTAL U.S. SHIPMENTS	3,563.7	6,550.7	237.8	441.9	37.1	53.5	8.0	14.0	--	--
Non-U.S. Manufacturers										
Captive	10.0	130.4	--	45.5	--	4.5	--	1.0	--	--
PCM/Reseller	30.0	102.7	--	.1	--	--	--	--	--	--
OEM/Integrator	143.6	619.9	21.3	164.5	--	30.0	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	183.6	853.0	21.3	210.1	--	34.5	--	1.0	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,747.3	7,403.7	259.1	652.0	37.1	88.0	8.0	15.0	--	--
Total Capacity (Terabytes)	256.2	496.2	17.0	41.9	1.4	3.8	.3	.6	--	--
Cumulative Shipments (Units in millions)										
IBM	9.6	14.2	9.7	14.4	9.7	14.4	9.7	14.4	9.7	14.4
Non-IBM	63.5	117.3	63.7	117.8	63.7	117.9	63.7	117.9	63.7	117.9
WORLDWIDE TOTAL	73.2	131.6	73.4	132.2	73.5	132.3	73.5	132.3	73.5	132.3

TABLE 23

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues				Forecast 1994				Forecast 1995				Forecast --1996--	1997
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	<=1.8"	All Dia.
U.S. MANUFACTURERS														
IBM Captive	.9	137.5	84.0	--	--	26.4	9.0	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	.1	--	--	--	.1	--	--	--	--	--	--
PCM/Reseller	6.5	181.2	11.8	4.9	3.0	4.3	1.5	14.8	--	--	--	4.7	.8	--
OEM/Integrator	7.3	370.5	90.9	30.0	2.0	3.2	3.8	13.3	1.2	--	--	4.8	1.3	--
TOTAL U.S. REVENUES	14.7	689.2	186.7	35.0	5.0	33.9	14.3	28.2	1.2	--	--	9.5	2.1	--
NON-U.S. MANUFACTURERS														
Captive	.7	33.2	14.1	3.0	.4	13.6	--	1.7	--	.7	--	1.3	.6	--
PCM/Reseller	--	8.8	5.7	.3	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	.5	68.4	72.2	1.2	.1	27.7	6.9	.4	--	4.1	.6	--	--	--
TOTAL NON-U.S. REVENUES	1.2	110.4	92.0	4.5	.5	41.3	6.9	2.1	--	4.8	.6	1.3	.6	--
WORLDWIDE RECAP														
Captive	1.6	170.7	98.1	3.1	.4	40.0	9.0	1.8	--	.7	--	1.3	.6	--
	-78.4%	-76.6%	-77.1%	--	-75.0%	-76.6%	-90.8%	-41.9%	--	-98.3%	--	-27.8%	-53.8%	--
PCM/Reseller	6.5	190.0	17.5	5.2	3.0	4.3	1.5	14.8	--	--	--	4.7	.8	--
	-75.5%	-74.8%	-65.8%	--	-53.8%	-97.7%	-91.4%	+184.6%	--	--	--	-68.2%	-83.0%	--
OEM/Integrator	7.8	438.9	163.1	31.2	2.1	30.9	10.7	13.7	1.2	4.1	.6	4.8	1.3	--
	-46.9%	-66.3%	-71.0%	+447.4%	-73.1%	-93.0%	-93.4%	-56.1%	-42.9%	-86.7%	-94.4%	-65.0%	-72.9%	--
Total Revenues	15.9	799.6	278.7	39.5	5.5	75.2	21.2	30.3	1.2	4.8	.6	10.8	2.7	--
	-67.3%	-71.3%	-73.3%	+581.0%	-65.4%	-90.6%	-92.4%	-23.3%	-78.2%	-93.6%	-97.2%	-64.4%	-75.0%	--
ANNUAL SHARE, BY DIAMETER	1.4%	70.6%	24.6%	3.4%	4.2%	57.0%	16.0%	22.8%	6.9%	27.7%	3.4%	62.0%	100.0%	--

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

TABLE 24

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments				Forecast 1994				Forecast 1995				Forecast --1996--	1997
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	<=1.8"	All Dia.
U.S. MANUFACTURERS														
IBM Captive	.8	550.0	240.0	--	--	120.0	30.0	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	.1	--	--	--	.2	--	--	--	--	--	--
PCM/Reseller	36.0	1,562.1	78.1	21.0	9.5	65.4	11.0	65.0	--	--	--	25.0	5.0	--
OEM/Integrator	21.6	3,292.5	624.6	123.9	5.0	47.3	35.0	53.5	1.5	--	--	27.0	9.0	--
TOTAL U.S. SHIPMENTS	58.4	5,404.6	942.7	145.0	14.5	232.7	76.0	118.7	1.5	--	--	52.0	14.0	--
NON-U.S. MANUFACTURERS														
Captive	.4	85.1	40.0	4.9	.2	42.5	--	2.8	--	2.5	--	2.0	1.0	--
PCM/Reseller	--	70.0	32.0	.7	--	--	--	.1	--	--	--	--	--	--
OEM/Integrator	1.3	248.0	367.5	3.1	.3	121.6	41.4	1.2	--	25.0	5.0	--	--	--
TOTAL NON-U.S. SHIPMENTS	1.7	403.1	439.5	8.7	.5	164.1	41.4	4.1	--	27.5	5.0	2.0	1.0	--
WORLDWIDE RECAP														
Captive	1.2	635.1	280.0	5.0	.2	162.5	30.0	3.0	--	2.5	--	2.0	1.0	--
	-74.5%	-63.1%	-67.2%	--	-83.3%	-74.4%	-89.3%	-40.0%	--	-98.5%	--	-33.3%	-50.0%	--
PCM/Reseller	36.0	1,632.1	110.1	21.7	9.5	65.4	11.0	65.1	--	--	--	25.0	5.0	--
	-76.7%	-63.0%	-54.9%	--	-73.6%	-96.0%	-90.0%	+200.0%	--	--	--	-61.6%	-80.0%	--
OEM/Integrator	22.9	3,540.5	992.1	127.0	5.3	168.9	76.4	54.7	1.5	25.0	5.0	27.0	9.0	--
	-63.5%	-52.4%	-64.0%	+490.7%	-76.9%	-95.2%	-92.3%	-56.9%	-71.7%	-85.2%	-93.5%	-50.6%	-66.7%	--
Total Shipments	60.1	5,807.7	1,382.2	153.7	15.0	396.8	117.4	122.8	1.5	27.5	5.0	54.0	15.0	--
	-72.9%	-57.2%	-64.1%	+608.3%	-75.0%	-93.2%	-91.5%	-20.1%	-90.0%	-93.1%	-95.7%	-56.0%	-72.2%	--
ANNUAL SHARE, BY DIAMETER	.8%	78.5%	18.7%	2.0%	2.3%	61.0%	18.0%	18.7%	1.7%	31.4%	5.7%	61.2%	100.0%	--
TOTAL CAPACITY (Terabytes)	2.8	386.1	101.1	6.2	.6	26.5	9.0	5.8	.1	1.1	.2	2.4	.7	--

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

TABLE 25

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	7,238.6	97.8	--	--
WORKSTATIONS Engineering and office, single user	48.9	.7	--	--
CONSUMER, GAME AND HOBBY COMPUTERS	69.6	.9	--	--
OTHER APPLICATIONS	46.6	.6	--	--
Total	7,403.7	100.0	--	--

TABLE 26

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1993	Forecast 1994	1995	1996	1997
Captive					
5.25"	--	--	--	--	--
3.5"	3.53	3.41	5.53	--	--
2.5"	4.34	3.75	--	--	--
1.8" or less	7.72	9.57	7.64	7.05	--
Captive Average	3.83	3.58	6.80	7.05	--
PCM/Reseller					
5.25"	4.32	7.62	--	--	--
3.5"	1.92	.78	--	--	--
2.5"	2.41	1.88	--	--	--
1.8" or less	5.18	6.17	4.91	4.04	--
PCM/Reseller Average	2.02	2.62	4.91	4.04	--
OEM/Integrator					
5.25"	6.03	10.40	11.42	--	--
3.5"	1.83	3.28	4.05	--	--
2.5"	2.29	1.84	2.83	--	--
1.8" or less	6.47	4.26	3.68	3.33	--
OEM/Integrator Average	2.02	3.08	4.06	3.33	--

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 27

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	3.5"	2.5"	<=1.8"	Total		5.25"	3.5"	2.5"	<=1.8"	Total	
Quantum	--	1240.0	74.0	--	1314.0	41.1	--	2120.0	190.0	--	2310.0	35.6
Conner Peripherals	--	850.5	82.4	--	932.9	29.1	--	1554.8	281.3	--	1836.1	28.3
Seagate Technology	48.0	581.0	41.0	--	670.0	20.9	56.0	1169.0	221.0	--	1446.0	22.3
Toshiba	--	--	48.0	--	48.0	1.5	--	15.0	230.0	--	245.0	3.8
Other U.S.	1.3	10.3	9.9	89.7	111.2	3.5	1.6	10.8	10.4	144.9	167.7	2.6
Other Non-U.S.	.1	63.5	60.9	1.1	125.6	3.9	1.3	303.0	169.5	3.8	477.6	7.4
TOTAL	49.4	2745.3	316.2	90.8	3201.7	100.0	58.9	5172.6	1102.2	148.7	6482.4	100.0

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

FIXED DISK DRIVES, 100 - 200 MEGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, 100 - 200 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Hitachi	DK524C-20*
Sequel	XT-2190, XT-4230E

3.5" disk diameter

Fujitsu	M2614ES*, M2617T**
IBM	H3171-A2**
Maxtor	7131A**
NEC	D3861*, D3765**
Quantum	170AT LPS**
Seagate Technology	ST3144A**
Western Digital	WDAC1170**

2.5" disk diameter

Areal Technology	A130****, A175***
Fuji Electric	FK204S-160Z***
IBM	H2172***
Maxtor	25128A***
Quantum	120A Daytona****, 170S GRS***
Seagate Technology	ST9144A***, ST9190AG****
Toshiba	MK-1522FCV****
Western Digital	WDAL2170***
Zentek	ZQ 2140***

1.8" disk diameter

Aura Associates	AU1126I***, AU1170P-III*****
Calluna Technology	CT-170*****
Hitachi	DK120P-13*****
Integral Peripherals	8105PA*****, 8170PA*****
Maxtor	MobileMax 171*****M'Max Lite 121*******
MiniStor Peripherals	MiniPORT 128A****, MP170P3*****
NEC	D1741****

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.
*****PCMCIA Type III (10.5 mm height).
******PCMCIA Type II (5 mm height).

Dominated in sequence by 14", 8" and 5.25" drives, the majority of disk drive

shipments in the 100-200 megabyte capacity range are now 3.5" models, but substantial shipments of 2.5" drives started in 1992, and the first production drives with 1.8" disks were shipped in 1993.

Market forces created one of the greatest surges in shipments in the history of the disk drive industry during 1992 for 3.5" drives in the 100-200 megabyte product group. Combined with continually improving areal density, the very large 3.5" drive shipments resulted in aggressive efforts by most disk drive manufacturers to reduce parts count, resulting in lower costs. 120 megabyte drives using a single disk became common, and 1993 saw the broad scale introduction of single platter drives with 170 megabytes capacity. However, the inevitable annual increases in areal density have continued, and shipments of 3.5" drives in the 100-200 megabyte range are now in a rapid decline.

Growth in 2.5" shipments has followed the same pattern, with the first 126 megabyte 2.5" drive using a single disk introduced in 1993. However, users'appetites for higher capacities have also affected the market for 2.5" drives in this product group, and shipments are declining in 1994. 1.8" drives, on the other hand, have been the beneficiary of the industry's improvements in areal densities, and now that drives are available in the PCMCIA Type III format with capacities over 100 megabytes, significant growth is under way. First shipments of PCMCIA Type II disk drives, only 5 millimeters thick, are expected in 1995.

Market status

20 million drives in the 100-200 megabyte capacity range were shipped worldwide in 1993, making this DISK/TREND product group the annual leader by a wide margin. However, glory is fleeting in the disk drive industry, and disk drives in this capacity range are experiencing an estimated 53.6% decline in shipments for 1994, down to 9.3 million units. 170 megabyte single platter 3.5" drives became the dominant product in this group during 1993, but by the end of the year, monthly shipments were already in decline, impacted by the continuously increasing demand for more disk drive capacity for desktop personal computers.

Prices have fallen in this product group even more rapidly than for most other disk drives, pushing down total sales revenues. While unit shipments were

increasing 14.4% in 1993, revenues were down 22.5%, yielding a total just below $4 billion. With unit shipments declining an estimated 53.6% in 1994, total revenues will drop 61%, cutting the total for the year to $1.6 billion. It is clear that the major problem with 1993 sales revenues, and with the 1993 profitability of most of the participating drive manufacturers, was the faster than normal drop in selling prices. For example, the worldwide OEM/Integrator average selling price per megabyte for 3.5" disk drives in this product group was $2.74 in 1991, dropping to $1.93 in 1992, then to $1.06 in 1993. A further reduction to $.78 is forecasted for 1994.

Quantum took the lead in noncaptive shipments for 100-200 megabyte drives in 1993 with 30.3% of the worldwide total, a combined total of 5,220 3.5" and 2.5" drives. Conner Peripherals held second position with 26.4% and Seagate Technology dropped to third place with 19.1%.

Marketing trends

Further rapid decline in shipments for 100-200 megabyte drives is inevitable, as software requirements and patterns of usage for personal computers continue to change. The average annual decline in worldwide unit shipments in the 1995-97 period is forecasted at 59.9%, with 1997 total shipments for the product group placed at only 590,000. 1997 sales revenues for the product group are projected to be only $98 million.

The decline in demand for 3.5" drives in this product group for desktop personal computers is also being matched by the movement to higher disk capacities for notebook computers, with the expected negative effect on 2.5" drive shipments. 1994 is seeing a sharp increase in shipments of 12.7 millimeter high 2.5" drives, but sales of even the thinner models are expected to decline rapidly during the next few years, with all 2.5" drives in the group ending production in 1996.

For the last few years, there has been a general expectation in the industry that 1.8" drives would enjoy a large market when drives with adequate capacity for general notebook computer applications became available. In 1994 a combination of developments has started an upward growth pattern for 1.8" drives. Drive capacities over 100 megabytes in PCMCIA Type III format became avail-

able, shipments of subnotebook computers are increasing and numerous notebook computers with PCMCIA slots have become available. Shipments of 1.8" drives, especially those in the PCMCIA formats, are expected to increase through 1996, but are forecasted to decline in 1997, as typical capacities used on portable computers increase beyond the level offered by the disk drives in this product group.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
5.25"	22.0 .1%	6.7 .1%	3.4 .1%	-- --	-- --
3.5" 1.625" high	186.2 .9%	65.0 .7%	-- --	-- --	-- --
3.5" 1" high or less	16,424.6 82.0%	6,243.0 67.2%	2,210.0 54.8%	660.0 38.9%	165.0 28.0%
2.5" more than .5" high	3,098.0 15.5%	1,447.4 15.6%	745.0 18.5%	80.0 4.7%	-- --
2.5" .5" high or less	292.4 1.5%	1,202.0 12.9%	395.0 9.8%	150.0 8.8%	-- --
1.8" PCMCIA Type II/III	3.5 --	308.0 3.3%	660.0 16.4%	805.0 47.5%	425.0 72.0%
1.8", other formats	--	14.1 .2%	20.0 .5%	-- --	-- --
Total	20,026.7	9,286.2	4,033.4	1,695.0	590.0

Technical trends

Most of the product development activity for drives in the 100-200 megabyte range is now concentrated on 1.8" drives in the PCMCIA formats. The PCMCIA Type III disk drives in the 105, 130 and 170 megabyte capacity groups are currently leading in 1.8" drive shipments, but developments under way will cause significant changes.

As noted above, shipments of 1.8" disk drives in this product group are expected to peak in 1996, as the momentum passes to higher capacity 1.8" drives made possible by inevitable areal density improvements. However, those same improvements in recording density which will make possible PCMCIA Type III drives with capacities much higher than the drives in this product group will

also have other benefits. For example, higher areal densities will also make possible single platter 1.8" drives in the 100-200 megabyte range -- thus making the PCMCIA Type II format an attractive possibility.

The PCMCIA Type III format defines cards which are 10.5 millimeters thick, but the Type II format cards are only 5 millimeters thick, presenting an entirely new set of miniaturization challenges to disk drive designers. Some of the major problems involve drive motors, reduction of disk thickness, head assemblies and semiconductor packaging. However, solutions for most of the technical problems have already been worked out, and the major remaining difficulties in starting production for Type II drives involve establishing reliable production for critical new components. The first shipments of PCMCIA Type II disk drives are expected in 1995.

Forecasting assumptions

1. IBM's shipments of both 3.5" and 2.5" drives in this group will end in 1995.
2. 3.5" drives will continue to dominate noncaptive drive shipments through 1995 due to their wide acceptance in the personal computer market, but will continue to decline in shipments.
3. 2.5" drives used for notebook computer applications will decline in shipments starting in 1994 and will end production in 1996. The 1.8" drives in the 100-200 megabyte capacity range which became available in 1993 will significantly displace 2.5" in portions of the low-end notebook computer market by 1996, but 1.8" drive shipments will also start to decline in 1997, due to the transition of market demand to higher capacities.

TABLE 28

FIXED DISK DRIVES, 100 - 200 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	648.8	953.0	175.8	262.1	28.8	45.2	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	648.8	953.0	175.8	262.1	28.8	45.2	--	--	--	--
PCM/Reseller	352.7	736.9	107.1	216.6	48.8	96.8	29.0	52.7	20.5	34.6
OEM/Integrator	1,031.6	1,780.7	408.7	707.6	200.9	330.7	95.6	144.4	25.0	36.8
TOTAL U.S. NONCAPTIVE	1,384.3	2,517.6	515.8	924.2	249.7	427.5	124.6	197.1	45.5	71.4
TOTAL U.S. REVENUES	2,033.1	3,470.6	691.6	1,186.3	278.5	472.7	124.6	197.1	45.5	71.4
Non-U.S. Manufacturers										
Captive	26.6	265.4	30.0	190.3	7.8	26.5	1.7	16.7	--	12.0
PCM/Reseller	17.7	48.5	19.3	44.6	7.8	19.3	6.5	15.0	3.7	8.8
OEM/Integrator	45.2	211.3	42.6	135.6	13.3	36.6	9.2	21.1	3.4	6.5
TOTAL NON-U.S. REVENUES	89.5	525.2	91.9	370.5	28.9	82.4	17.4	52.8	7.1	27.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,122.6	3,995.8	783.5	1,556.8	307.4	555.1	142.0	249.9	52.6	98.7
OEM Average Price ($000)		.164		.140		.127		.137		.142

TABLE 29

FIXED DISK DRIVES, 100 - 200 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,645.3	2,420.5	615.0	920.0	115.0	180.0	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,645.3	2,420.5	615.0	920.0	115.0	180.0	--	--	--	--
PCM/Reseller	2,285.0	4,794.0	856.2	1,759.6	390.2	790.4	200.0	375.0	125.0	215.0
OEM/Integrator	6,499.6	11,131.1	2,957.1	5,233.6	1,557.0	2,638.0	680.0	1,065.0	175.0	265.0
TOTAL U.S. NONCAPTIVE	8,784.6	15,925.1	3,813.3	6,993.2	1,947.2	3,428.4	880.0	1,440.0	300.0	480.0
TOTAL U.S. SHIPMENTS	10,429.9	18,345.6	4,428.3	7,913.2	2,062.2	3,608.4	880.0	1,440.0	300.0	480.0
Non-U.S. Manufacturers										
Captive	38.0	395.6	50.0	318.8	20.0	65.0	5.0	35.0	--	20.0
PCM/Reseller	113.0	313.3	126.0	287.0	50.0	125.0	35.0	85.0	20.0	50.0
OEM/Integrator	217.8	972.2	246.1	767.2	85.0	235.0	55.0	135.0	20.0	40.0
TOTAL NON-U.S. SHIPMENTS	368.8	1,681.1	422.1	1,373.0	155.0	425.0	95.0	255.0	40.0	110.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	10,798.7	20,026.7	4,850.4	9,286.2	2,217.2	4,033.4	975.0	1,695.0	340.0	590.0
Total Capacity (Terabytes)	1,519.7	2,795.6	732.3	1,392.7	313.7	567.4	146.2	252.0	55.2	95.2
Cumulative Shipments (Units in millions)										
IBM	4.2	6.0	4.8	6.9	4.9	7.1	4.9	7.1	4.9	7.1
Non-IBM	24.3	44.5	28.6	52.9	30.7	56.7	31.7	58.4	32.0	59.0
WORLDWIDE TOTAL	28.6	50.5	33.4	59.8	35.6	63.9	36.6	65.6	36.9	66.2

TABLE 30

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues				Forecast												
	1994				1995				1996			1997	
	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	1.8"
U.S. MANUFACTURERS																	
IBM Captive	.9	479.5	472.6	--	--	150.1	112.0	--	--	22.5	22.7	--	--	--	--	--	--
PCM/Reseller	.5	707.5	28.4	.5	.8	191.5	18.1	6.2	.4	65.1	8.1	23.2	19.1	2.4	31.2	4.6	30.0
OEM/Integrator	9.0	1,414.5	356.6	.6	4.2	418.0	216.5	68.9	2.6	139.2	105.0	83.9	40.0	19.3	85.1	9.5	27.3
TOTAL U.S. REVENUES	10.4	2,601.5	857.6	1.1	5.0	759.6	346.6	75.1	3.0	226.8	135.8	107.1	59.1	21.7	116.3	14.1	57.3
NON-U.S. MANUFACTURERS																	
Captive	5.4	171.2	88.8	--	2.2	85.1	103.0	--	--	3.5	19.5	3.5	--	6.9	9.8	--	12.0
PCM/Reseller	--	43.7	4.7	.1	--	18.0	24.4	2.2	--	6.2	3.4	9.7	2.0	--	13.0	.5	8.3
OEM/Integrator	5.2	105.9	100.2	--	.1	23.3	101.3	10.9	--	6.9	14.3	15.4	2.6	2.3	16.2	.5	6.0
TOTAL NON-U.S. REVENUES	10.6	320.8	193.7	.1	2.3	126.4	228.7	13.1	--	16.6	37.2	28.6	4.6	9.2	39.0	1.0	26.3
WORLDWIDE RECAP																	
Captive	6.3	650.7	561.4	--	2.2	235.2	215.0	--	--	26.0	42.2	3.5	--	6.9	9.8	--	12.0
	-76.8%	-41.4%	+148.6%	--	-65.1%	-63.9%	-61.7%	--	--	-88.9%	-80.4%	--	--	-83.6%	+180.0%	--	+22.4%
PCM/Reseller	.5	751.2	33.1	.6	.8	209.5	42.5	8.4	.4	71.3	11.5	32.9	21.1	2.4	44.2	5.1	38.3
	-96.2%	-46.0%	+1.8%	--	+60.0%	-72.1%	+28.4%	--	-50.0%	-66.0%	-72.9%	+291.7%	-70.4%	-79.1%	+34.3%	-75.8%	-13.3%
OEM/Integrator	14.2	1,520.4	456.8	.6	4.3	441.3	317.8	79.8	2.6	146.1	119.3	99.3	42.6	21.6	101.3	10.0	33.3
	-54.0%	-26.9%	+85.5%	--	-69.7%	-71.0%	-30.4%	--	-39.5%	-66.9%	-62.5%	+24.4%	-70.8%	-81.9%	+2.0%	-76.5%	-67.1%
Total Revenues	21.0	2,922.3	1,051.3	1.2	7.3	886.0	575.3	88.2	3.0	243.4	173.0	135.7	63.7	30.9	155.3	15.1	83.6
	-70.6%	-36.2%	+108.4%	--	-65.2%	-69.7%	-45.3%	--	-58.9%	-72.5%	-69.9%	+53.9%	-73.8%	-82.1%	+14.4%	-76.3%	-46.2%
ANNUAL SHARE, BY DIAMETER	.5%	73.2%	26.3%	--	.5%	57.0%	37.0%	5.5%	.5%	43.9%	31.2%	24.4%	25.6%	12.4%	62.0%	15.3%	84.7%

TABLE 31

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments				Forecast												
					1994				1995				1996			1997	
	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	1.8"
U.S. MANUFACTURERS																	
IBM Captive	.5	1,370.0	1,050.0	--	--	600.0	320.0	--	--	100.0	80.0	--	--	--	--	--	--
PCM/Reseller	.5	4,663.9	128.3	1.3	.8	1,629.0	107.8	22.0	.4	620.0	60.0	110.0	195.0	20.0	160.0	50.0	165.0
OEM/Integrator	11.7	9,452.8	1,664.7	1.9	4.6	3,644.0	1,332.0	253.0	3.0	1,365.0	830.0	440.0	420.0	170.0	475.0	105.0	160.0
TOTAL U.S. SHIPMENTS	12.7	15,486.7	2,843.0	3.2	5.4	5,873.0	1,759.8	275.0	3.4	2,085.0	970.0	550.0	615.0	190.0	635.0	155.0	325.0
NON-U.S. MANUFACTURERS																	
Captive	2.7	266.0	126.9	--	1.2	146.0	171.6	--	--	10.0	50.0	5.0	--	20.0	15.0	--	20.0
PCM/Reseller	--	292.0	21.0	.3	--	139.0	140.0	8.0	--	55.0	25.0	45.0	20.0	--	65.0	5.0	45.0
OEM/Integrator	6.6	566.1	399.5	--	.1	150.0	578.0	39.1	--	60.0	95.0	80.0	25.0	20.0	90.0	5.0	35.0
TOTAL NON-U.S. SHIPMENTS	9.3	1,124.1	547.4	.3	1.3	435.0	889.6	47.1	--	125.0	170.0	130.0	45.0	40.0	170.0	10.0	100.0
WORLDWIDE RECAP																	
Captive	3.2	1,636.0	1,176.9	--	1.2	746.0	491.6	--	--	110.0	130.0	5.0	--	20.0	15.0	--	20.0
	-71.2%	+24.1%	+323.3%	--	-62.5%	-54.4%	-58.2%	--	--	-85.3%	-73.6%	--	--	-84.6%	+200.0%	--	+33.3%
PCM/Reseller	.5	4,955.9	149.3	1.6	.8	1,768.0	247.8	30.0	.4	675.0	85.0	155.0	215.0	20.0	225.0	55.0	210.0
	-97.2%	-16.4%	+43.6%	--	+60.0%	-64.3%	+66.0%	--	-50.0%	-61.8%	-65.7%	+416.7%	-68.1%	-76.5%	+45.2%	-74.4%	-6.7%
OEM/Integrator	18.3	10,018.9	2,064.2	1.9	4.7	3,794.0	1,910.0	292.1	3.0	1,425.0	925.0	520.0	445.0	190.0	565.0	110.0	195.0
	-61.4%	+11.7%	+150.1%	--	-74.3%	-62.1%	-7.5%	--	-36.2%	-62.4%	-51.6%	+78.0%	-68.8%	-79.5%	+8.7%	-75.3%	-65.5%
Total Shipments	22.0	16,610.8	3,390.4	3.5	6.7	6,308.0	2,649.4	322.1	3.4	2,210.0	1,140.0	680.0	660.0	230.0	805.0	165.0	425.0
	-71.3%	+2.4%	+180.8%	--	-69.5%	-62.0%	-21.9%	--	-49.3%	-65.0%	-57.0%	+111.1%	-70.1%	-79.8%	+18.4%	-75.0%	-47.2%
ANNUAL SHARE, BY DIAMETER	.1%	83.0%	16.9%	--	.1%	68.0%	28.5%	3.4%	.1%	54.9%	28.3%	16.7%	39.0%	13.6%	47.4%	28.1%	71.9%
TOTAL CAPACITY (Terabytes)	3.5	2,328.1	463.7	.3	1.1	987.2	362.5	41.9	.6	310.7	155.6	100.6	91.7	31.4	128.9	22.9	72.3

TABLE 32

FIXED DISK DRIVES, 100 - 200 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS Business and professional, single user	19,468.0	97.2	460.2	78.0
WORKSTATIONS Engineering and office, single user	222.3	1.1	70.8	12.0
CONSUMER, GAME AND HOBBY COMPUTERS	318.4	1.6	41.3	7.0
OTHER APPLICATIONS	10.0	.1	17.7	3.0
Total	20,026.7	100.0	590.0	100.0

TABLE 33

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1993	Forecast 1994	1995	1996	1997
Captive					
5.25"	15.75	22.00	--	--	--
3.5"	3.05	1.94	1.41	--	--
2.5"	3.22	2.77	2.08	2.65	--
1.8"	--	--	4.11	3.82	3.52
Captive Average	3.14	2.27	1.81	3.23	3.52
PCM/Reseller					
5.25"	4.50	3.60	4.85	--	--
3.5"	1.09	.78	.65	.61	.57
2.5"	1.58	1.28	1.00	.85	--
1.8"	3.34	2.06	1.43	1.22	1.07
PCM/Reseller Average	1.10	.85	.80	.92	.97
OEM/Integrator					
5.25"	4.76	5.26	4.85	--	--
3.5"	1.06	.73	.62	.58	.55
2.5"	1.69	1.26	.96	.82	--
1.8"	5.94	2.11	1.28	1.12	1.00
OEM/Integrator Average	1.17	.94	.84	.87	.84

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 34

FIXED DISK DRIVES, 100 - 200 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	3.5"	2.5"	1.8"	Total		5.25"	3.5"	2.5"	1.8"	Total	
Quantum	--	2900.0	158.0	--	3058.0	33.6	--	4830.0	390.0	--	5220.0	30.3
Conner Peripherals	--	2150.4	260.3	--	2410.7	26.4	--	4012.7	525.1	--	4537.8	26.4
Seagate Technology	--	1312.0	214.0	--	1526.0	16.7	--	2719.0	571.0	--	3290.0	19.1
Maxtor	--	1084.9	125.5	2.0	1212.4	13.3	--	1723.0	158.9	2.6	1884.5	10.9
Western Digital	--	483.0	84.0	--	567.0	6.2	--	832.0	148.0	--	980.0	5.7
Toshiba	--	--	56.0	--	56.0	.6	6.0	11.0	254.0	--	271.0	1.6
NEC	--	62.5	--	--	62.5	.7	--	234.3	--	--	234.3	1.4
Other U.S.	10.2	--	--	.3	10.5	.1	12.2	--	--	.6	12.8	.1
Other Non-U.S.	--	155.0	57.3	--	212.3	2.4	.6	612.8	166.5	.3	780.2	4.5
TOTAL	10.2	8147.8	955.1	2.3	9115.4	100.0	18.8	14974.8	2213.5	3.5	17210.6	100.0

FIXED DISK DRIVES, 200 - 300 MEGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, 200 - 300 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Sequel	807

5.25" disk diameter

Sagem	MSA 252-200

3.5" disk diameter

Alps Electric	DR312C/D**
Conner Peripherals	CFS-210A**, CFS-270A**
Fuji Electric	FK317S-240R**
Fujitsu	M2618T**
Hitachi	DK312C-25*
IBM	H3256-A3**, DSAA/S-3270**
JTS	P3270****
Maxtor	7213S/A**, 7270AV**
NEC	D3766**
Quantum	270A/S Maverick**
Samsung Electronics	SHD-3122A**
Seagate Technology	ST3250A**, ST3295A**
TEAC	SD-3250N****
Western Digital	WDAC1210**, WDAC1270**
Zentek	ZM 3272**

2.5" disk diameter

Areal Technology	A260***, A265****
Conner Peripherals	CFN-250S/A***
Fujitsu	M2637S/T***
IBM	H2258***, DHAA/S-2270***
Quantum	255A/S Daytona****
Seagate Technology	ST9235AG***, ST9300AG****
Toshiba	MK-2224FC***, MK-1724FCV****
Western Digital	WDAL2200***
Zentek	ZQ 2260***

1.8" disk diameter

Calluna Technology	CT-210

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.

During most of the 1980's, there was little activity in this capacity range, with most 14", 8" and 5.25" drive capacities jumping to higher levels when the pace of the technology allowed. However, the personal computer market's continually increasing requirements for higher storage capacities created a new market for 200-300 megabyte drives at the beginning of the 1990's. This market is served by 3.5" drives, while the notebook computer market stimulated the introduction of 2.5" drives in this capacity range in 1992.

Although 8" and 5.25" 200-300 megabyte drives are at the end of their production lives, the increasing demand for 3.5" and 2.5" drives is inspiring continual refinements in product design for small form factor drives. One inch height has become the standard for 3.5" drives, and the improved areal density developed initially for drives in higher capacity ranges has made possible regular reductions in the parts count for mainstream 200-300 megabyte 3.5" drives. Most major drive manufacturers offered 3.5" drives using two disks in this capacity range until the past year, and many drives available in 1994 use a single disk for up to 270 megabytes. Most of the many 2.5" drives introduced in this capacity range during 1993-94 use two or three disks, but the first of the expected wave of single platter 2.5" drives in the 200-300 megabyte range have been introduced.

Market status

200-300 megabyte drives achieved the highest growth rate of any DISK/TREND Report product group in 1993, and in 1994 the group has become the industry's leader in both unit shipments and sales revenues. An estimated 21.5 million 200-300 megabyte drives will be shipped in 1994, an increase of 53.6% over the previous year. Sales revenues are expected to reach $3.9 billion, up only 13.3%, with the size of the increase dampened by falling average unit prices.

3.5" drives produced 92.4% of 1993's unit shipment total, almost 13 million drives, a direct result of the growing demand for more disk storage on the typical desktop personal computer. The 3.5" share of 1994 shipments is expected to fall to 84.9% during 1994, however, even though the unit shipment total will increase to 18.3 million drives, due to expanding 2.5" drive shipments. The evolving usage patterns for notebook computers, plus expanded software requirements, created

significant shipments of 2.5" drives in 1993, which are increasing sharply in 1994. The 1.1 million 2.5" drives shipped in 1993 are forecasted to increase to 3.3 million drives in 1994.

The high shipment levels for this product group have brought extremely competitive pricing. The worldwide average OEM/Integrator price per megabyte of $1.60 for 3.5" disk drives in 1992 dropped to $.92 in 1993, and is forecasted at $.61 for 1994. Similar pricing declines are accompanying the rapid growth in shipments of 2.5" drives. The 1992 OEM/Integrator average price per megabyte for 2.5" drives was $2.02, declined to $1.13 in 1993, and is projected at $.85 for 1994.

Personal computers, including notebook computers, produced 97.6% of 1993's worldwide unit shipments, trailed by nominal shipments for workstations, consumer and network applications. The personal computer market, including portable system applications, is expected to consume 90% of 1997's shipments. The balance is scattered among workstation, consumer and other applications, which will use the 1.8" drives which are expected to provide a major share of future shipments for this product group.

Seagate assumed noncaptive shipment leadership in this product group in 1993, with 22.9% of the worldwide total, for 2.9 million drives. Quantum dropped to second place with 21.5%, followed by Conner Peripherals with 17.2%.

Marketing trends

It is clear that 200-300 megabyte drives will have only a one-year tenure as the leading product group in worldwide shipments, destined to be displaced by the inevitable industry march to higher capacities. It is projected that 1994's shipment peak will be followed by continuing declines in total unit shipments, dropping to only 3.7 million drives in 1997. Total sales revenues are projected at only $682.5 million in 1997. By 1997 slightly more than half of all unit shipments are expected to be 1.8" disk drives, at higher average prices than 3.5" or 2.5" drives.

2.5" drives in this capacity group, which started to ship in 1992, are also are benefiting from the impact of personal computer software on the notebook

computer market, with 2.5" drive shipments forecasted to increase to 4.4 million in 1995. However, 1995 is expected to be the peak year for 2.5" drives in this capacity range, with shipments dropping to only 930,000 in 1997. The same appetite for increased disk capacity that is cutting off growth for 3.5" drives in this capacity range for desktop PC markets will also affect the market for 2.5" drives in notebook computer applications.

The industry's continual improvements in areal densities are expected to make possible the production of 1.8" drives in this capacity range starting in early 1995. 1.9 million 1.8" drives are forecasted for shipment in 1997, with the major markets expected mostly in subnotebook computer applications. By 1997, 1.8" drives are forecasted to provide 52.2% of the product group's worldwide unit shipments.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
8"	.8	.1	--	--	--
	--	--	--	--	--
3.5" 1.625" high	41.9	6.6	1.5	--	--
	.3%	--	--	--	--
3.5" 1" high or less	12,937.5	18,269.5	6,735.0	3,425.0	855.0
	92.0%	84.8%	58.0%	40.8%	22.9%
2.5" more than .5" high	1,076.8	2,059.0	1,415.0	455.0	45.0
	7.7%	9.6%	12.2%	5.4%	1.2%
2.5" .5" high or less	10.0	1,210.0	2,980.0	3,120.0	885.0
	.1%	5.6%	25.7%	37.2%	23.7%
1.8" PCMCIA Type II/III	--	--	485.0	1,390.0	1,950.0
	--	--	4.2%	16.6%	52.2%
Total	14,067.0	21,545.2	11,616.5	8,390.0	3,735.0

Technical trends

Even though 1994 is the peak year for shipments of 200-300 megabyte 3.5" drives, increasing shipments of drives with smaller diameter disks will induce disk drive manufacturers to continue to concentrate their product development efforts on specific cost reduction targets. In this type of product, cost reduction frequently requires significant advances in the technology and the assumption of considerable risk.

Single disk 3.5" drives in the 200-300 megabyte capacity range are now common, and single disk 2.5" drives have appeared. The major reduction in parts count represented by the drive with a single disk will stimulate drive manufacturers to use high density magnetoresistive thin film heads as soon as they are in high volume production for the noncaptive market, as well as continue to drive disk coercivities to higher levels. If contact, or near-contact, recording becomes a production reality in the next few years, it will probably be used in this capacity range early in its life, due to the significant cost reduction opportunity offered. Other cost reductions will be derived from continued simplification of mechanical subassemblies and combination of more functions on fewer semiconductor chips.

The initial shipments of 1.8" drives with 200-300 megabyte capacities expected within the next year will require high areal densities, but in a range thought to be attainable in high volume production. It is expected that the experience with PCMCIA Type III drives already in production for lower capacities will smooth out most of the mechanical and packaging difficulties. The first of the 5 millimeter thick PCMCIA Type II disk drives will probably appear well before the end of this report's forecast period.

Forecasting assumptions

1. Shipments of IBM's 3.5" and 2.5" drives in this capacity group will decline starting in 1995 and will end in 1996. IBM will start 1.8" drive shipments in 1995.
2. 3.5" total drive shipments will peak in 1994, with continuous declines thereafter, due to the personal computer markets continuing evolution to higher disk capacities.
3. Total shipments of 2.5" drives will decline after 1995, even though shipments of 12.7 millimeter high models will increase through 1996.
4. Significant shipments of PCMCIA Type III drives will start in 1995, with Type II drives probably also available by 1997.

TABLE 35

FIXED DISK DRIVES, 200 - 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	384.4	573.4	483.8	727.6	234.4	356.0	133.9	208.1	75.6	122.4
Other U.S. Captive	--	--	.4	.4	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	384.4	573.4	484.2	728.0	234.4	356.0	133.9	208.1	75.6	122.4
PCM/Reseller	424.1	824.9	506.7	964.2	205.8	370.4	161.5	280.5	103.6	178.4
OEM/Integrator	1,068.7	1,785.2	1,013.7	1,846.1	532.4	937.9	417.6	708.3	170.3	273.4
TOTAL U.S. NONCAPTIVE	1,492.8	2,610.1	1,520.4	2,810.3	738.2	1,308.3	579.1	988.8	273.9	451.8
TOTAL U.S. REVENUES	1,877.2	3,183.5	2,004.6	3,538.3	972.6	1,664.3	713.0	1,196.9	349.5	574.2
Non-U.S. Manufacturers										
Captive	13.6	133.9	26.5	143.6	34.1	136.8	24.5	99.6	6.9	33.5
PCM/Reseller	12.4	40.1	16.0	45.3	12.1	34.3	10.5	29.4	8.2	18.8
OEM/Integrator	21.5	126.5	59.9	219.7	76.8	205.4	65.5	164.9	24.8	56.0
TOTAL NON-U.S. REVENUES	47.5	300.5	102.4	408.6	123.0	376.5	100.5	293.9	39.9	108.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,924.7	3,484.0	2,107.0	3,946.9	1,095.6	2,040.8	813.5	1,490.8	389.4	682.5
OEM Average Price ($000)		.220		.160		.152		.153		.151

TABLE 36

FIXED DISK DRIVES, 200 - 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993		Forecast							
	Shipments		1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	845.3	1,260.5	1,295.0	1,950.0	735.0	1,120.0	385.0	600.0	210.0	340.0
Other U.S. Captive	--	--	.2	.2	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	845.3	1,260.5	1,295.2	1,950.2	735.0	1,120.0	385.0	600.0	210.0	340.0
PCM/Reseller	1,951.4	3,795.2	3,261.2	6,213.2	1,365.0	2,520.0	970.0	1,735.0	595.0	1,035.0
OEM/Integrator	4,847.8	8,147.2	6,482.6	11,827.3	3,545.0	6,335.0	2,705.0	4,695.0	1,115.0	1,825.0
TOTAL U.S. NONCAPTIVE	6,799.2	11,942.4	9,743.8	18,040.5	4,910.0	8,855.0	3,675.0	6,430.0	1,710.0	2,860.0
TOTAL U.S. SHIPMENTS	7,644.5	13,202.9	11,039.0	19,990.7	5,645.0	9,975.0	4,060.0	7,030.0	1,920.0	3,200.0
Non-U.S. Manufacturers										
Captive	17.0	153.8	40.0	211.0	65.0	256.5	50.0	200.0	15.0	75.0
PCM/Reseller	70.0	202.0	102.0	256.0	71.0	200.0	55.0	160.0	45.0	105.0
OEM/Integrator	95.8	508.3	312.0	1,087.5	442.0	1,185.0	393.0	1,000.0	155.0	355.0
TOTAL NON-U.S. SHIPMENTS	182.8	864.1	454.0	1,554.5	578.0	1,641.5	498.0	1,360.0	215.0	535.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	7,827.3	14,067.0	11,493.0	21,545.2	6,223.0	11,616.5	4,558.0	8,390.0	2,135.0	3,735.0
Total Capacity (Terabytes)	1,824.3	3,284.0	2,806.7	5,259.0	1,520.3	2,831.6	1,113.5	2,046.9	517.0	904.5
Cumulative Shipments (Units in millions)										
IBM	1.2	1.7	2.5	3.7	3.2	4.8	3.6	5.4	3.8	5.8
Non-IBM	10.9	19.1	21.1	38.7	26.6	49.2	30.8	57.0	32.7	60.4
WORLDWIDE TOTAL	12.2	20.9	23.6	42.5	29.9	54.1	34.4	62.5	36.6	66.2

TABLE 37

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues			Forecast											
				1994			1995			1996			1997		
	8"	3.5"	2.5"	8"	3.5"	2.5"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS															
IBM Captive	1.8	553.6	18.0	--	525.0	202.6	236.0	108.0	12.0	82.6	33.5	92.0	--	--	122.4
Other U.S. Captive	--	--	--	--	.4	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	813.2	11.7	--	930.8	33.4	281.9	37.5	51.0	132.6	31.5	116.4	31.0	8.9	138.5
OEM/Integrator	.3	1,609.9	175.0	.1	1,508.1	337.9	459.6	405.5	72.8	238.0	332.3	138.0	63.9	78.1	131.4
TOTAL U.S. REVENUES	2.1	2,976.7	204.7	.1	2,964.3	573.9	977.5	551.0	135.8	453.2	397.3	346.4	94.9	87.0	392.3
NON-U.S. MANUFACTURERS															
Captive	--	79.9	54.0	--	48.8	94.8	26.6	110.2	--	10.8	83.3	5.5	--	23.0	10.5
PCM/Reseller	--	29.1	11.0	--	30.5	14.8	11.2	18.4	4.7	4.1	14.0	11.3	1.9	3.9	13.0
OEM/Integrator	--	79.7	46.8	--	80.1	139.6	27.9	171.8	5.7	13.2	137.6	14.1	2.9	38.3	14.8
TOTAL NON-U.S. REVENUES	--	188.7	111.8	--	159.4	249.2	65.7	300.4	10.4	28.1	234.9	30.9	4.8	65.2	38.3
WORLDWIDE RECAP															
Captive	1.8	633.5	72.0	--	574.2	297.4	262.6	218.2	12.0	93.4	116.8	97.5	--	23.0	132.9
	-55.0%	+51.4%	+900.0%	--	-9.4%	+313.1%	-54.3%	-26.6%	--	-64.4%	-46.5%	+712.5%	--	-80.3%	+36.3%
PCM/Reseller	--	842.3	22.7	--	961.3	48.2	293.1	55.9	55.7	136.7	45.5	127.7	32.9	12.8	151.5
	--	+64.6%	+497.4%	--	+14.1%	+112.3%	-69.5%	+16.0%	--	-53.4%	-18.6%	+129.3%	-75.9%	-71.9%	+18.6%
OEM/Integrator	.3	1,689.6	221.8	.1	1,588.2	477.5	487.5	577.3	78.5	251.2	469.9	152.1	66.8	116.4	146.2
	-89.3%	+104.2%	--	-66.7%	-6.0%	+115.3%	-69.3%	+20.9%	--	-48.5%	-18.6%	+93.8%	-73.4%	-75.2%	-3.9%
Total Revenues	2.1	3,165.4	316.5	.1	3,123.7	823.1	1,043.2	851.4	146.2	481.3	632.2	377.3	99.7	152.2	430.6
	-69.1%	+80.1%	--	-95.2%	-1.3%	+160.1%	-66.6%	+3.4%	--	-53.9%	-25.7%	+158.1%	-79.3%	-75.9%	+14.1%
ANNUAL SHARE, BY DIAMETER	.1%	91.0%	8.9%	--	79.2%	20.8%	51.2%	41.7%	7.1%	32.4%	42.4%	25.2%	14.6%	22.4%	63.0%

TABLE 38

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments			Forecast											
				1994			1995			1996			1997		
	8"	3.5"	2.5"	8"	3.5"	2.5"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS															
IBM Captive	.5	1,230.0	30.0	--	1,500.0	450.0	800.0	300.0	20.0	300.0	100.0	200.0	--	--	340.0
Other U.S. Captive	--	--	--	--	.2	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	3,754.7	40.5	--	6,052.2	161.0	2,120.0	230.0	170.0	1,060.0	200.0	475.0	265.0	60.0	710.0
OEM/Integrator	.3	7,445.0	701.9	.1	10,074.2	1,753.0	3,535.0	2,540.0	260.0	1,935.0	2,160.0	600.0	555.0	540.0	730.0
TOTAL U.S. SHIPMENTS	.8	12,429.7	772.4	.1	17,626.6	2,364.0	6,455.0	3,070.0	450.0	3,295.0	2,460.0	1,275.0	820.0	600.0	1,780.0
NON-U.S. MANUFACTURERS															
Captive	--	86.3	67.5	--	68.0	143.0	46.5	210.0	--	20.0	170.0	10.0	--	50.0	25.0
PCM/Reseller	--	154.0	48.0	--	186.0	70.0	80.0	105.0	15.0	30.0	85.0	45.0	15.0	25.0	65.0
OEM/Integrator	--	309.4	198.9	--	395.5	692.0	155.0	1,010.0	20.0	80.0	860.0	60.0	20.0	255.0	80.0
TOTAL NON-U.S. SHIPMENTS	--	549.7	314.4	--	649.5	905.0	281.5	1,325.0	35.0	130.0	1,115.0	115.0	35.0	330.0	170.0
WORLDWIDE RECAP															
Captive	.5	1,316.3	97.5	--	1,568.2	593.0	846.5	510.0	20.0	320.0	270.0	210.0	--	50.0	365.0
	-50.0%	+221.1%	--	--	+19.1%	+508.2%	-46.0%	-14.0%	--	-62.2%	-47.1%	+950.0%	--	-81.5%	+73.8%
PCM/Reseller	--	3,908.7	88.5	--	6,238.2	231.0	2,200.0	335.0	185.0	1,090.0	285.0	520.0	280.0	85.0	775.0
	--	+198.7%	+883.3%	--	+59.6%	+161.0%	-64.7%	+45.0%	--	-50.5%	-14.9%	+181.1%	-74.3%	-70.2%	+49.0%
OEM/Integrator	.3	7,754.4	900.8	.1	10,469.7	2,445.0	3,690.0	3,550.0	280.0	2,015.0	3,020.0	660.0	575.0	795.0	810.0
	-66.7%	+238.8%	--	-66.7%	+35.0%	+171.4%	-64.8%	+45.2%	--	-45.4%	-14.9%	+135.7%	-71.5%	-73.7%	+22.7%
Total Shipments	.8	12,979.4	1,086.8	.1	18,276.1	3,269.0	6,736.5	4,395.0	485.0	3,425.0	3,575.0	1,390.0	855.0	930.0	1,950.0
	-57.9%	+223.9%	--	-87.5%	+40.8%	+200.8%	-63.1%	+34.4%	--	-49.2%	-18.7%	+186.6%	-75.0%	-74.0%	+40.3%
ANNUAL SHARE, BY DIAMETER	--	92.4%	7.6%	--	84.9%	15.1%	58.1%	37.8%	4.1%	40.9%	42.6%	16.5%	23.0%	24.9%	52.1%
TOTAL CAPACITY (Terabytes)	.2	3,047.3	236.5	--	4,496.9	762.1	1,650.7	1,064.6	116.4	838.9	874.4	333.6	208.9	227.5	468.0

TABLE 39

FIXED DISK DRIVES, 200 - 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MINI/MULTIUSER				
Midrange systems and network servers	22.5	.2	--	--
PERSONAL COMPUTERS				
Business and professional, single user	13,728.0	97.6	3,361.5	90.0
WORKSTATIONS				
Engineering and office, single user	220.8	1.6	186.8	5.0
CONSUMER, GAME AND HOBBY COMPUTERS	95.7	.6	112.0	3.0
OTHER APPLICATIONS	--	--	74.7	2.0
Total	14,067.0	100.0	3,735.0	100.0

TABLE 40

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1993	Forecast 1994	1995	1996	1997
Captive					
8"	17.50	--	--	--	--
5.25"	--	--	--	--	--
3.5"	2.17	1.46	1.24	1.16	--
2.5"	3.24	1.96	1.70	1.78	2.00
1.8"	--	--	2.50	1.93	1.51
Captive Average	2.25	1.60	1.43	1.57	1.57
PCM/Reseller					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.91	.63	.54	.51	.48
2.5"	1.15	.92	.70	.65	.61
1.8"	--	--	1.25	1.02	.81
PCM/Reseller Average	.92	.64	.61	.67	.71
OEM/Integrator					
8"	3.60	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.92	.61	.54	.51	.47
2.5"	1.13	.85	.67	.63	.59
1.8"	--	--	1.16	.96	.75
OEM/Integrator Average	.94	.65	.62	.62	.62

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 41

FIXED DISK DRIVES, 200 - 300 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	8"	3.5"	2.5"	Total		8"	3.5"	2.5"	Total	
Seagate Technology	--	1189.0	460.0	1649.0	23.7	--	2292.0	606.0	2898.0	22.9
Quantum	--	1520.0	5.0	1525.0	21.9	--	2710.0	10.0	2720.0	21.5
Conner Peripherals	--	908.4	78.6	987.0	14.2	--	2075.1	102.3	2177.4	17.2
Maxtor	--	1448.5	12.1	1460.6	21.0	--	2090.4	23.9	2114.3	16.7
Western Digital	--	1161.0	.2	1161.2	16.7	--	2002.0	.2	2002.2	15.8
Toshiba	--	--	58.0	58.0	.8	--	--	223.0	223.0	1.8
Other U.S.	.2	16.2	--	16.4	.2	.3	30.2	--	30.5	.2
Other Non-U.S.	--	99.3	8.5	107.8	1.5	--	463.4	23.9	487.3	3.9
TOTAL	.2	6342.4	622.4	6965.0	100.0	.3	11663.1	989.3	12652.7	100.0

FIXED DISK DRIVES, 300 - 500 MEGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, 300 - 500 MEGABYTES

Coverage

Examples of disk drives in this group include:

9" disk diameter

Hitachi	DK815-5

5.25" disk diameter

Fujitsu	M2249, M2262
Hitachi	DK514-38
IBM	9336-10
Sequel	XT-4380E/S

3.5" disk diameter

Conner Peripherals	CFS-420A**
Fuji Electric	FK319A/S**
Fujitsu	M2622S/T*, MK2682S/T**
Hitachi	DK314C-41*
IBM	H3342-A4**, DSAA/S-3360**
JTS	P3420****
Maxtor	7345A/S**, 7420AV**
NEC	D3872*, D3713**
Quantum	340S/A LPS**, 420A LPS**
Samsung Electronics	SHD-3212A**
Seagate Technology	ST3550A/N**
TEAC	SD-3360N****
Western Digital	WDAC2340**, WDAC2420**
Zentek	ZM 3480**

2.5" disk diameter

Areal Technology	A340***, A345****
Conner Peripherals	CFN-340A***, CFL-420A****
Fujitsu	M2705S/T***
IBM	H2344***, DHAA/S-2405***
MiniStor Peripherals	MP340A****
NEC	D2713****
Quantum	341A/S Daytona***
Seagate Technology	ST9385AG***, ST9550AG***
Toshiba	MK-2326***, MK-1824****
Zentek	ZQ 2390***

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.

The original disk drives in this group were patterned after IBM's 3350 -- typically 317.5 megabyte floor-standing drives intended for use with mainframes. These drives, and the rack-mounted 14", 10.5", 9" and 8" drives which followed, are now mostly gone, as improving areal density has continually reduced drive packaging to smaller sizes.

A wave of 380 megabyte 5.25" drives, following the lead of Maxtor, provided major shipments for many producers for several years, with more than 20 companies active, at various times, in the market. The half high Wren 5.25" drives (pioneered by Control Data, now part of Seagate's product line), were followed with half high 5.25" models from only Micropolis and Digital Equipment, but all half high 5.25" drive shipments have now ceased.

In 1989, IBM became the first company to announce and ship 3.5" drives in this capacity range, but numerous other drive manufacturers also introduced 3.5" drives in 1990. In 1991, Seagate announced 426 megabyte models only 1" high, and in late 1992 Western Digital started shipments of a 1" high 340 megabyte 3.5" drive using only two disks, followed by a 425 megabyte model in early 1993. The higher areal densities now practical for high volume production subsequently made it possible for several other disk drive manufacturers to follow the Western Digital initiative, but time passes and the first of the 3.5" single disk configurations have been announced in this product group. With the start of 2.5" drive shipments in the 300-500 megabyte range in 1993, there has been an active race during the last year among drive manufacturers to establish a presence in the notebook computer market, and several manufacturers have introduced drives only 12.7 millimeters high, or slightly less.

Market status

More than 90 percent of the disk drives in the 300-500 megabyte capacity range are now used for personal computers, a transition which occurred during the last few years. Until 1992, the majority of disk drives in this product group were used with workstations and midrange computer systems. In 1994, a surge of increased usage for personal computers has created a movement to new product lines from most drive manufacturers, with low cost and reduced parts count becoming prime objectives.

1993 worldwide unit shipments for the product group were up 152.1% to 4.5 million drives, and 1994 shipments are expected to jump to over 14 million units, a 207.5% increase. Rapidly declining prices are expected to hold down the percentage increase in sales revenues. 1993 revenues were $1.7 billion, a 1% decrease, and the projected 1994 revenue of $3.4 billion will provide an increase of only 94.4%.

Advances in recording density, the rapid increase in unit shipments and an overheated 1993 competitive environment have pushed down average prices more rapidly than previously expected. The worldwide OEM/Integrator average price per megabyte for the key 3.5" drive format was $1.69 in 1992, $.79 in 1993, and is projected at $.49 for 1994. With the transition to single platter drives now under way in this capacity range, future efforts to reduce parts count, and cost, will become more difficult. In addition, the 5.25" drives which previously were an important part of the product group's shipments, at relatively high average unit prices, shrunk to only 1.3% of 1993 unit shipments, with insignificant shipments expected in 1994.

3.5" drive shipments currently dominate the 300-500 megabyte range, growing from 1993's 4.1 million drives to 12.2 million in 1994, and now provide 87% of the unit shipment total for the product group. Shipments of 3.5" drives in this product group are primarily through noncaptive channels, with captive drives providing only 10.3% of the worldwide total, mostly from IBM.

Increasing demand for more disk capacity for notebook computers has boosted 2.5" drive shipments in the 300-500 megabyte range, following initial shipments in 1993 by both Toshiba and IBM. The 1993 total of 423,300 drives is forecasted to rise to 1.8 million in 1994, with about one third expected to be captive drives, also mostly from IBM. Users of notebook computers have come to expect to be able to do everything that can be done on their office computers, and the result has been a rapid increase in typical capacities for 2.5" disk drives.

Personal computer applications, including portable computers, sharply increased their shipment leadership in this product group in 1993, advancing to 91.7% of the worldwide unit shipment total, as the expanding range of sophisticated applications and continually more complex software programs forced many users to add disk capacity. Further growth to 94% is forecasted for 1997.

Workstation applications fell to 4.7% of the 1993 total, with a decline to 4% projected in 1997 despite an increase in unit shipments, as PC sales volumes overpower other unit shipment totals. Network/Minicomputer/Multiuser applications sank to 3.5% in 1993, and are expected to be down to 1% in 1997, as disk capacity requirements grow beyond those offered by this product group.

Western Digital assumed noncaptive shipment leadership in the 300-500 megabyte range in 1993, with 38.5% of worldwide shipments, a total of 1.5 million 3.5" drives, after providing industry leadership in developing the market for two platter 340 megabyte 3.5" drives. Seagate held second place in total unit shipments with 22.1%, and Maxtor was third with 14.1%.

Marketing trends

Another year of growth is forecasted for the 300-500 megabyte capacity range, making it the largest DISK/TREND product group in 1995, as the average disk capacity demanded for personal computer applications continues to rise. However, the movement to higher PC disk capacities has acquired a momentum which will carry beyond the range offered by this product group, and declining shipments for the group are expected starting in 1996.

1995's total shipments of 300-500 megabyte drives are forecasted at 23.7 million units, up 68.9% over 1994. However, it is expected that this disk capacity range will have a rather long life as the "entry level" for desktop personal computers, and the 1997 total is forecasted to decline modestly to 17.1 million drives. 1995 sales revenues are projected to reach $5 billion, falling to $3.4 billion in 1997.

As 8" and 5.25" drives approach end of life, 3.5" drives now dominate the group's shipments, with 87% of the 1994 total. 1" high models provide most of the current 3.5" drive shipments, and have become the standard configuration for the worldwide desktop personal computer market. 1" high 3.5" drives were shipped for the first time in 1992, but are expected to provide shipments of 19.4 million drives in 1995. This demand is driven by the storage requirements of a variety of operating systems, graphics applications and data base management programs, combined with a pattern of typical user practices which involve keeping a large amount of data continually on-line. 1" high drives make it possible for

system manufacturers to offer disk upgrade options in this capacity range without physical changes to existing systems, and they make it relatively easy for dealers and end users to upgrade existing systems.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
8"	4.4	3.0	--	--	--
	.1%	--	--	--	--
5.25"	58.1	12.3	4.5	--	--
	1.3%	.1%	--	--	--
3.5" 1.625" high	515.6	49.5	5.0	--	--
	11.3%	.4%	--	--	--
3.5" 1" high	3,557.5	12,126.0	19,389.0	12,005.0	8,520.0
	78.0%	86.5%	81.9%	65.9%	49.9%
2.5" more than .5" high	423.3	1,221.8	2,000.0	1,410.0	520.0
	9.3%	8.7%	8.4%	7.7%	3.0%
2.5" .5" high or less	--	605.1	2,145.0	4,330.0	6,270.0
	--	4.3%	9.1%	23.8%	36.7%
1.8" PCMCIA Type II/III	--	--	130.0	475.0	1,760.0
	--	--	.5%	2.6%	10.3%
Total	4,558.9	14,017.7	23,673.5	18,220.0	17,070.0

As expected, the first 2.5" drives in this capacity group were shipped in 1993, for a total of 423,300 units, and shipments are projected to grow to 6.8 million drives in 1997. Many 2.5" drives in this capacity range will be used in high-end notebook computers and portable engineering workstations, but 2.5" drives will also find a market with array applications. The small form factor of these drives will make it possible to offer arrays in the 1-2 gigabyte range using a total package size no larger than a 5.25" drive, opening entirely new markets to fault tolerant array subsystems. It is expected that 2.5" drives in the newer heights of 12.7 millimeter or less will assume leadership in 2.5" drive shipments starting in 1995.

A newcomer to this disk drive product group will be 1.8" disk drives in PCMCIA card formats expected to be shipped for the first time in 1995. 130,000 PCMCIA Type III drives are forecasted for shipment in 1995, with total shipments growing to 1.8 million in 1997, which will include a mix of Type III format and the 5 millimeter thick Type II format. The challenge for producers of 1.8" drives will be

to achieve lowest possible cost as early as possible, by utilizing the latest advances in areal density, in order to compete with 2.5" drives for notebook computer applications. It is expected that 2.5" drives will maintain a healthy lead in shipments for notebook computer applications through 1997, but that the size and interchange convenience inherent in the PCMCIA format drives will create a significant market for 1.8" models.

Technical trends

The demand for more capacity in small spaces will continue. Expect to see extensive use of MIG and thin film heads, sputtered disks using thinner substrates, advanced encoding methods, intelligent interfaces, and smaller semiconductor chip sets. The startling rate of progress in packing growing disk drive capacities in shrinking form factors will continue.

IBM's Lightning drive was a 1989 pathfinder for the industry in disk substrate thickness and in drive packaging. It was an impressive usage of 8 disks in the standard 41.3 millimeter height for 3.5" drives, a design made possible by reducing the normal 50 mil disk substrate thickness to only 31.5 mils, which became a de facto standard. Western Digital's two disk 1" high 3.5" drive delivered in late 1992 with a capacity of 340 megabytes, was the pathfinder for the rest of the industry in moving to two platter 3.5" drives in the 300-500 megabyte range. It fits the most preferred form factor, and the usage of only two disks makes possible a low parts count, and the lowest possible price. 2 disks became the standard for 3.5" drives in the 300-500 megabyte range, and single disk models have been introduced in 1994.

Competitive market forces will keep up the pressure on disk drive manufacturers' development organizations to cut product costs and to package drives in smaller form factors. The name of the game is to minimize the parts count in each type of drive.

Most of the advanced product development activity in this capacity range has already moved on to smaller drives. 2.5" drives are rapidly moving to half inch high formats, and the race to utilize higher recording densities to further cut production costs is well under way. The packaging challenges for 1.8" drives in the 300-500 megabyte capacity range are even more difficult, but have already

been successfully met for the two disk PCMCIA Type III drives now offered with lower capacities. It will be more difficult to package three disks in the Type III 10.5 millimeter thick card format, but it is expected to be done in the near future, in an attempt to expand the capacity range for 1.8" drives as rapidly as possible. By the end of the 1997 forecast period covered by this report, 5 millimeter thick Type II drives in this product group will probably also be in production, stretching advances in areal density to the limit.

Forecasting assumptions

1. Shipments of 8" drives will end in 1994, and 5.25" drives will be shipped for the last time in 1995.
2. Sustained growth for high-end personal computers, technical workstations, LANs, and specialized systems will continue to create significant growth for 3.5" drives.
3. Expanding demand for disk drive capacity for notebook computers and several specialized markets will continue to produce major shipments of 2.5" drives in this capacity range.
3. Initial volume shipments in this capacity range of 1.8" drives in PCMCIA Type III format will start in 1995.

TABLE 42

FIXED DISK DRIVES, 300 - 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	210.4	312.0	574.5	846.2	737.0	1,098.6	625.3	945.5	440.4	678.1
Other U.S. Captive	35.9	48.1	5.9	8.4	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	246.3	360.1	580.4	854.6	737.0	1,098.6	625.3	945.5	440.4	678.1
PCM/Reseller	231.4	383.2	376.2	690.2	597.5	1,094.4	405.8	738.6	353.6	624.9
OEM/Integrator	466.7	718.0	809.5	1,484.4	1,252.7	2,262.5	885.5	1,587.6	808.9	1,426.9
TOTAL U.S. NONCAPTIVE	698.1	1,101.2	1,185.7	2,174.6	1,850.2	3,356.9	1,291.3	2,326.2	1,162.5	2,051.8
TOTAL U.S. REVENUES	944.4	1,461.3	1,766.1	3,029.2	2,587.2	4,455.5	1,916.6	3,271.7	1,602.9	2,729.9
Non-U.S. Manufacturers										
Captive	9.0	145.0	27.5	153.2	61.1	228.4	81.2	247.1	80.3	246.9
PCM/Reseller	9.6	33.0	11.1	41.6	19.9	68.2	22.5	67.0	24.2	72.7
OEM/Integrator	25.3	95.3	58.6	148.1	123.5	290.9	153.4	344.6	167.2	369.4
TOTAL NON-U.S. REVENUES	43.9	273.3	97.2	342.9	204.5	587.5	257.1	658.7	271.7	689.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	988.3	1,734.6	1,863.3	3,372.1	2,791.7	5,043.0	2,173.7	3,930.4	1,874.6	3,418.9
OEM Average Price ($000)		.313		.195		.178		.177		.171

TABLE 43

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	262.3	379.5	1,155.5	1,700.8	1,610.0	2,400.0	1,543.0	2,335.0	1,250.0	1,925.0
Other U.S. Captive	19.8	26.6	3.9	5.5	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	282.1	406.1	1,159.4	1,706.3	1,610.0	2,400.0	1,543.0	2,335.0	1,250.0	1,925.0
PCM/Reseller	805.3	1,336.9	1,977.7	3,611.9	3,420.0	6,270.0	2,315.0	4,245.0	2,090.0	3,765.0
OEM/Integrator	1,485.6	2,332.5	4,207.7	7,731.2	7,122.5	12,908.0	5,045.0	9,100.0	4,670.0	8,315.0
TOTAL U.S. NONCAPTIVE	2,290.9	3,669.4	6,185.4	11,343.1	10,542.5	19,178.0	7,360.0	13,345.0	6,760.0	12,080.0
TOTAL U.S. SHIPMENTS	2,573.0	4,075.5	7,344.8	13,049.4	12,152.5	21,578.0	8,903.0	15,680.0	8,010.0	14,005.0
Non-U.S. Manufacturers										
Captive	9.0	108.1	35.0	168.0	95.0	355.5	140.0	430.0	160.0	495.0
PCM/Reseller	37.0	113.0	60.0	185.0	100.0	340.0	110.0	340.0	120.0	395.0
OEM/Integrator	75.8	262.3	257.4	615.3	590.0	1,400.0	782.0	1,770.0	975.0	2,175.0
TOTAL NON-U.S. SHIPMENTS	121.8	483.4	352.4	968.3	785.0	2,095.5	1,032.0	2,540.0	1,255.0	3,065.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,694.8	4,558.9	7,697.2	14,017.7	12,937.5	23,673.5	9,935.0	18,220.0	9,265.0	17,070.0
Total Capacity (Terabytes)	985.0	1,671.7	2,843.1	5,187.3	4,722.8	8,645.4	3,844.5	7,066.0	3,763.9	6,956.2
Cumulative Shipments (Units in millions)										
IBM	1.3	1.8	2.4	3.5	4.0	5.9	5.6	8.2	6.8	10.1
Non-IBM	5.4	9.3	12.0	21.6	23.3	42.9	31.7	58.7	39.7	73.9
WORLDWIDE TOTAL	6.7	11.1	14.4	25.1	27.4	48.8	37.3	67.0	46.6	84.1

TABLE 44

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues				Forecast													
					1994				1995				1996			1997		
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	10.2	12.3	142.5	147.0	5.0	1.1	540.1	300.0	--	731.0	367.6	--	636.5	302.3	6.7	430.6	197.5	50.0
Other U.S. Captive	--	.4	47.7	--	--	--	8.4	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	6.0	377.2	--	--	.9	673.1	16.2	--	1,027.8	47.3	19.3	623.7	58.0	56.9	381.5	57.9	185.5
OEM/Integrator	--	37.1	680.8	.1	--	7.4	1,299.5	177.5	4.5	1,820.0	409.2	28.8	972.8	543.1	71.7	615.8	621.0	190.1
TOTAL U.S. REVENUES	10.2	55.8	1,248.2	147.1	5.0	9.4	2,521.1	493.7	4.5	3,578.8	824.1	48.1	2,233.0	903.4	135.3	1,427.9	876.4	425.6
NON-U.S. MANUFACTURERS																		
Captive	13.6	14.6	88.8	28.0	8.8	5.4	52.5	86.5	1.5	68.5	158.4	--	42.1	205.0	--	29.4	209.2	8.3
PCM/Reseller	--	--	15.0	18.0	--	--	26.5	15.1	--	40.9	27.3	--	24.7	34.0	8.3	16.0	35.0	21.7
OEM/Integrator	--	7.7	40.3	47.3	--	3.1	44.1	100.9	--	72.2	218.7	--	39.6	295.7	9.3	25.9	316.7	26.8
TOTAL NON-U.S. REVENUES	13.6	22.3	144.1	93.3	8.8	8.5	123.1	202.5	1.5	181.6	404.4	--	106.4	534.7	17.6	71.3	560.9	56.8
WORLDWIDE RECAP																		
Captive	23.8	27.3	279.0	175.0	13.8	6.5	601.0	386.5	1.5	799.5	526.0	--	678.6	507.3	6.7	460.0	406.7	58.3
	-66.2%	-68.8%	-54.4%	--	-42.0%	-76.2%	+115.4%	+120.9%	-76.9%	+33.0%	+36.1%	--	-15.1%	-3.6%	--	-32.2%	-19.8%	+770.1%
PCM/Reseller	--	6.0	392.2	18.0	--	.9	699.6	31.3	--	1,068.7	74.6	19.3	648.4	92.0	65.2	397.5	92.9	207.2
	--	-89.4%	+64.0%	--	--	-85.0%	+78.4%	+73.9%	--	+52.8%	+138.3%	--	-39.3%	+23.3%	+237.8%	-38.7%	+1.0%	+217.8%
OEM/Integrator	--	44.8	721.1	47.4	--	10.5	1,343.6	278.4	4.5	1,892.2	627.9	28.8	1,012.4	838.8	81.0	641.7	937.7	216.9
	--	-61.9%	+28.0%	--	--	-76.6%	+86.3%	+487.3%	-57.1%	+40.8%	+125.5%	--	-46.5%	+33.6%	+181.3%	-36.6%	+11.8%	+167.8%
Total Revenues	23.8	78.1	1,392.3	240.4	13.8	17.9	2,644.2	696.2	6.0	3,760.4	1,228.5	48.1	2,339.4	1,438.1	152.9	1,499.2	1,437.3	482.4
	-68.6%	-70.1%	-1.6%	--	-42.0%	-77.1%	+89.9%	+189.6%	-66.5%	+42.2%	+76.5%	--	-37.8%	+17.1%	+217.9%	-35.9%	--	+215.5%
ANNUAL SHARE, BY DIAMETER	1.4%	4.5%	80.4%	13.7%	.4%	.5%	78.5%	20.6%	.1%	74.7%	24.4%	.8%	59.6%	36.6%	3.8%	44.0%	42.0%	14.0%

TABLE 45

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments				Forecast													
					1994				1995				1996			1997		
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	1.0	3.5	165.0	210.0	.5	.3	1,200.0	500.0	--	1,700.0	700.0	--	1,675.0	650.0	10.0	1,325.0	500.0	100.0
Other U.S. Captive	--	.1	26.5	--	--	--	5.5	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	5.9	1,331.0	--	--	.9	3,549.5	61.5	--	6,010.0	210.0	50.0	3,780.0	290.0	175.0	2,725.0	340.0	700.0
OEM/Integrator	--	38.2	2,294.0	.3	--	6.8	7,029.4	695.0	4.0	10,964.0	1,860.0	80.0	6,080.0	2,785.0	235.0	4,105.0	3,450.0	760.0
TOTAL U.S. SHIPMENTS	1.0	47.7	3,816.5	210.3	.5	8.0	11,784.4	1,256.5	4.0	18,674.0	2,770.0	130.0	11,535.0	3,725.0	420.0	8,155.0	4,290.0	1,560.0
NON-U.S. MANUFACTURERS																		
Captive	3.4	4.3	72.4	28.0	2.5	1.7	53.8	110.0	.5	115.0	240.0	--	85.0	345.0	--	70.0	410.0	15.0
PCM/Reseller	--	--	63.0	50.0	--	--	125.0	60.0	--	215.0	125.0	--	145.0	170.0	25.0	110.0	205.0	80.0
OEM/Integrator	--	6.1	121.2	135.0	--	2.6	212.3	400.4	--	390.0	1,010.0	--	240.0	1,500.0	30.0	185.0	1,885.0	105.0
TOTAL NON-U.S. SHIPMENTS	3.4	10.4	256.6	213.0	2.5	4.3	391.1	570.4	.5	720.0	1,375.0	--	470.0	2,015.0	55.0	365.0	2,500.0	200.0
WORLDWIDE RECAP																		
Captive	4.4	7.9	263.9	238.0	3.0	2.0	1,259.3	610.0	.5	1,815.0	940.0	--	1,760.0	995.0	10.0	1,395.0	910.0	115.0
	-30.2%	-67.5%	-16.1%	--	-31.8%	-74.7%	+377.2%	+156.3%	-75.0%	+44.1%	+54.1%	--	-3.0%	+5.9%	--	-20.7%	-8.5%	--
PCM/Reseller	--	5.9	1,394.0	50.0	--	.9	3,674.5	121.5	--	6,225.0	335.0	50.0	3,925.0	460.0	200.0	2,835.0	545.0	780.0
	--	-91.9%	+272.2%	--	--	-84.7%	+163.6%	+143.0%	--	+69.4%	+175.7%	--	-36.9%	+37.3%	+300.0%	-27.8%	+18.5%	+290.0%
OEM/Integrator	--	44.3	2,415.2	135.3	--	9.4	7,241.7	1,095.4	4.0	11,354.0	2,870.0	80.0	6,320.0	4,285.0	265.0	4,290.0	5,335.0	865.0
	--	-68.0%	+175.7%	--	--	-78.8%	+199.8%	+709.6%	-57.4%	+56.8%	+162.0%	--	-44.3%	+49.3%	+231.3%	-32.1%	+24.5%	+226.4%
Total Shipments	4.4	58.1	4,073.1	423.3	3.0	12.3	12,175.5	1,826.9	4.5	19,394.0	4,145.0	130.0	12,005.0	5,740.0	475.0	8,520.0	6,790.0	1,760.0
	-42.1%	-75.4%	+160.3%	--	-31.8%	-78.8%	+198.9%	+331.6%	-63.4%	+59.3%	+126.9%	--	-38.1%	+38.5%	+265.4%	-29.0%	+18.3%	+270.5%
ANNUAL SHARE, BY DIAMETER	.1%	1.3%	89.4%	9.2%	--	.1%	87.0%	12.9%	--	82.0%	17.5%	.5%	66.0%	31.5%	2.5%	50.0%	39.8%	10.2%
TOTAL CAPACITY (Terabytes)	1.9	20.2	1,504.7	144.9	1.3	4.3	4,536.4	645.3	1.6	7,141.9	1,457.8	44.2	4,718.3	2,168.2	179.5	3,485.7	2,758.9	711.7

TABLE 46

FIXED DISK DRIVES, 300 - 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	160.9	3.5	170.7	1.0
PERSONAL COMPUTERS Business and professional, single user	4,179.1	91.7	16,045.8	94.0
WORKSTATIONS Engineering and office, single user	214.3	4.7	682.8	4.0
CONSUMER, GAME AND HOBBY COMPUTERS	2.7	.1	170.7	1.0
OTHER APPLICATIONS	--	--	--	--
Total	4,558.9	100.0	17,070.0	100.0

TABLE 47

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1993	1994	1995	1996	1997
Captive					
8"	12.47	10.57	--	--	--
5.25"	10.48	9.27	9.31	--	--
3.5"	2.98	1.35	1.25	1.09	.93
2.5"	2.13	1.77	1.56	1.38	1.16
1.8"	--	--	--	1.97	1.49
Captive Average	2.80	1.52	1.36	1.20	1.05
PCM/Reseller					
8"	--	--	--	--	--
5.25"	3.18	2.83	--	--	--
3.5"	.77	.51	.46	.41	.33
2.5"	1.05	.73	.63	.52	.41
1.8"	--	--	1.13	.86	.64
PCM/Reseller Average	.79	.52	.47	.44	.40
OEM/Integrator					
8"	--	--	--	--	--
5.25"	2.84	3.17	3.14	--	--
3.5"	.79	.49	.45	.40	.35
2.5"	1.03	.72	.62	.51	.42
1.8"	--	--	1.05	.80	.61
OEM/Integrator Average	.84	.52	.48	.45	.41

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 48

FIXED DISK DRIVES, 300 - 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 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	
Western Digital	--	904.0	--	904.0	37.6	--	1560.0	--	1560.0	38.5
Seagate Technology	4.0	663.0	--	667.0	27.7	6.0	887.0	--	893.0	22.1
Maxtor	--	385.0	--	385.0	16.0	--	569.2	--	569.2	14.1
Conner Peripherals	--	260.9	.2	261.1	10.9	--	520.0	.3	520.3	12.9
Toshiba	--	--	80.0	80.0	3.3	--	--	185.0	185.0	4.6
Other U.S.	21.5	52.3	--	73.8	3.1	38.1	88.8	--	126.9	3.1
Other Non-U.S.	--	32.8	--	32.8	1.4	6.1	184.2	--	190.3	4.7
TOTAL	25.5	2298.0	80.2	2403.7	100.0	50.2	3809.2	185.3	4044.7	100.0

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

1994 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

10.5" disk diameter

Fujitsu	F6425G, M2361A

9-9.5" disk diameter

Hitachi	DKU-86I

8" disk diameter

Fujitsu	M2344K/KS, M2382K/P

5.25" disk diameter

Fujitsu	M2263
Hitachi	DK711S-60D, DK515-78
IBM	9336-020
Sequel	XT-8760SH

3.5" disk diameter

Alps Electric	DR322C/D**
Conner Peripherals	CFA-540S**, CFA-850A**
Fuji Electric	FK320A/S**
Fujitsu	M2624S/T*, M2684S/T**
Hewlett-Packard	C2244*
Hitachi	DK325C-57**
IBM	0662-508**, 9336-025**, DPEA-30540**
JTS	P3540****
Maxtor	7540AV**
Micropolis	2205S*, 2210A*
Quantum	540A/S Maverick**, 730A/S Lightning**
Samsung Electronics	SHD-30540A**
Seagate Technology	ST3600A/N**, ST5660A/N***
TEAC	SD-3540N****
Western Digital	WDAC2540**
Zentek	ZM 3560**, ZM 3870**

2.5" disk diameter

Areal Technology	A520***
Fujitsu	M2706S/T***
Hitachi	DK211A/C***
IBM	DBOA-2720****, DVAA/S-2810***
MiniStor Peripherals	MP510A***, MP680A***
Quantum	514A/S Daytona***

2.5" disk diameter (continued)

Seagate Technology	ST9655AG***
Toshiba	MK-2428***

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19.05 mm height, or less.
****Maximum 12.7 mm height, or less.

Until recent years, drives in this group consisted mostly of PCM, IBM and other captive 14" drives intended for use with mainframe systems. Control Data's 9" FSD was the pioneer among drives less than 10.5", but in the mid-1980's several 8" drives with capacities above 500 megabytes entered the market.

Maxtor's introduction of a 768 megabyte 5.25" drive precipitated a flurry of announcements from many of the same companies already competing for the 380 megabyte 5.25" market. In 1990, Maxtor was also the first company to announce a 3.5" drive in this product group, but the firm was quickly followed by several major competitors. Sixteen drive manufacturers have announced or are shipping 3.5" drives in this capacity range. Most of the leading drive manufacturers have also added 1" high models during the last two years, which have assumed market leadership for the product group.

Toshiba, which has provided much of the product leadership in 2.5" drives during recent years, announced 520 megabyte 2.5" models in 1993, the first 2.5" drives in this capacity range. Eight drive manufacturers now offer 2.5" drives in the 500 megabyte - 1 gigabyte capacity range.

Market status

The industry's inevitable annual increases in areal density and the growing demand for more disk storage capacity in personal computer and workstation applications have finally caught up with this product group. Barely a million drives in this capacity range were shipped in 1992, but 1993 worldwide shipments were up 112.6%, to 2.2 million drives, and the total for 1994 is forecasted at 7.6 million, an increase of 248.3%. As might be expected, however, the movement to smaller drives and rapidly declining prices have made the increase in sales revenues for the same periods less impressive. The $1.5 billion in 1993 revenue was actually a 26.6% decline, and the lowest revenue level since this

DISK/TREND Report product group was established in 1987. 1994 revenues of $3.6 billion represented an increase of only 137.7%.

Even though the first shipments of 1" high 3.5" drives with more than 500 megabytes capacity did not occur until 1992, with a modest 42,500 units, 1" high models are overwhelming the market for 3.5" drives. The 1993 shipment total for 1" high drives was 1.6 million, 71.9% of overall unit shipments for the product group, and 1994 shipments are projected at 6.1 million units, 80.2% of the total. The growing dominance of personal computer applications for drives in this capacity range is driving the product group's rapid growth. Today's PC markets require 1" high 3.5" drives, and the added bonus is a lower parts count than was used in the older full size 3.5" drives, with the corollary cost reductions. Another new development in 1994 is the availability of 2.5" drives from eight manufacturers, with a rapid build-up in shipments. 1.4 million 2.5" drives are forecasted for shipment in 1994.

Personal computers jumped into a strong lead in applications for disk drives in this capacity range in 1993, after holding only 19.2% of 1992 shipments. 63.2% of 1993 unit shipments were used with personal computers, and the level is expected to climb to 87% in 1997, utilizing 24.4 million drives. Engineering and office workstation applications held 17.7% of 1993 shipments and are expected to retain 9.5% of the 1997 market, for a total of 2.7 million drives. Networks/minicomputers/multiuser applications led this product group before 1993, but dropped to 18.2% in 1993, with a further decline to 3% projected for 1997, as the capacity requirements for these applications migrate to levels above this product group.

The leading manufacturers of disk drives for the personal computer market moved into leadership of noncaptive unit shipments for this product group in 1993. Conner Peripherals held the lead with 25.3% of worldwide shipments, all 3.5" drives. Seagate Technology was second with 23.1%, and Maxtor followed with 20.5%.

Marketing trends

Disk drives in the 500 megabyte - 1 gigabyte capacity range are destined to become the leading product group in overall shipments in 1996-97, after almost

doubling in unit shipments during 1995. Total shipments for the product group are forecasted at 15.1 million drives in 1995, growing to almost 28 million by 1997. 1995 sales revenues will climb to an estimated $5.5 billion, growing to $8.3 billion in 1997.

As this product group has become primarily oriented to the personal computer and workstation markets, the older large diameter drives which dominated shipments until the last few years are at end of life, and even the full size 3.5" drives are expected to end production next year.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
8"	8.6	4.9	--	--	--
	.4%	.1%	--	--	--
5.25"	121.5	23.4	13.9	--	--
	5.5%	.3%	.1%	--	--
3.5" 1.625" high	484.9	60.7	2.0	--	--
	22.1%	.8%	--	--	--
3.5" 1" high	1,575.3	6,121.0	12,685.0	20,127.0	20,520.0
	71.9%	80.2%	83.9%	81.4%	73.3%
2.5"	--	1,422.0	2,420.0	4,590.0	7,260.0
	--	18.6%	16.0%	18.6%	25.9%
1.8" PCMCIA Type III	--	--	--	--	210.0
	--	--	--	--	.8%
Total	2,190.3	7,632.0	15,120.9	24,717.0	27,990.0

1" high 3.5" drives dominate current shipments, due to the growing disk market with high-end personal computers. Shipments of 1" high 3.5" drives are expected to more than double in 1995, reaching a total of 12.7 million units, and by 1996 the total is projected at 20.1 million drives. That level, however, is expected to be close to the peak for 3.5" drives in this product group, with 1997 shipments rising to only 20.5 million, as the high-end of the PC disk drive market continues to move up in capacity.

Heavy demand is expected for 2.5" drives, primarily for notebook computers, but it is probable that the long-expected movement of 2.5" disk drives into the desktop computer market will be under way by 1997, absorbing part of the

forecasted total. By 1997, the first 1.8" PCMCIA Type III disk drives with over 500 megabytes capacity are expected, targeted at notebook computer applications.

Technical trends

This product group has benefited greatly from development work under way in other capacity ranges. Perhaps the greatest short-term benefits have been realized in the 1" high 3.5" drives and the new 2.5" drives now in quantity production.

Most of the industry's manufacturers of high capacity disk drives have devoted a large amount of resources to development of 3.5" drives in higher capacity ranges. It's a fact that most of the heads, disks, and semiconductors for those drives, plus many of the mechanical components, are also appropriate for usage in 1" high 3.5" drives designed for fewer disks -- many of which have capacities in this capacity range. So it is a safe assumption that many of the drive components and subassemblies which would be costly to design for drives in the 500 megabyte - 1 gigabyte range have already been developed for other drives, and can be utilized immediately.

Most major drive manufacturers will undoubtedly introduce single platter 3.5" drives with 540/550 megabytes in 1995, and many of the same components will be utilized in 2.5" drives. IBM is already shipping an 810 megabyte 2.5" drive using three disks, and next year's areal densities will probably reduce the disk count.

Forecasting assumptions

1. 8" drives will be produced for the last time in 1994, and the last production of 5.25" drives will be in 1995.
2. Shipments of 3.5" drives for personal computer markets and other applications will continue to increase through 1996, but will peak in the 1996-97 period.
3. Shipments of 2.5" drives in this product group will continue to increase rapidly through 1997.
4. The first shipments of 1.8" drives in this capacity range will start in 1997.

TABLE 49

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	80.2	126.3	858.3	1,261.6	1,325.5	1,995.6	1,745.3	2,687.2	1,901.4	2,958.4
Other U.S. Captive	47.4	88.6	7.5	13.5	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	127.6	214.9	865.8	1,275.1	1,325.5	1,995.6	1,745.3	2,687.2	1,901.4	2,958.4
PCM/Reseller	116.9	210.3	275.3	470.0	543.1	969.0	828.4	1,502.9	811.5	1,461.6
OEM/Integrator	640.5	837.7	857.0	1,348.8	1,289.4	2,110.1	1,770.0	2,929.4	1,749.3	2,888.2
TOTAL U.S. NONCAPTIVE	757.4	1,048.0	1,132.3	1,818.8	1,832.5	3,079.1	2,598.4	4,432.3	2,560.8	4,349.8
TOTAL U.S. REVENUES	885.0	1,262.9	1,998.1	3,093.9	3,158.0	5,074.7	4,343.7	7,119.5	4,462.2	7,308.2
Non-U.S. Manufacturers										
Captive	--	110.3	43.8	205.7	42.0	145.8	74.3	233.9	117.0	389.0
PCM/Reseller	--	--	4.1	24.6	7.7	39.7	15.1	68.2	26.4	102.5
OEM/Integrator	49.7	127.6	72.3	243.1	75.1	224.2	122.6	385.5	149.9	534.3
TOTAL NON-U.S. REVENUES	49.7	237.9	120.2	473.4	124.8	409.7	212.0	687.6	293.3	1,025.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	934.7	1,500.8	2,118.3	3,567.3	3,282.8	5,484.4	4,555.7	7,807.1	4,755.5	8,334.0
OEM Average Price ($000)		.550		.342		.279		.244		.231

TABLE 50

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	30.6	45.0	1,030.4	1,514.7	2,129.5	3,207.0	3,115.0	4,800.0	3,740.0	5,830.0
Other U.S. Captive	17.4	32.7	4.7	8.7	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	48.0	77.7	1,035.1	1,523.4	2,129.5	3,207.0	3,115.0	4,800.0	3,740.0	5,830.0
PCM/Reseller	188.7	345.9	753.0	1,291.6	1,810.3	3,230.4	3,180.0	5,770.0	3,565.0	6,435.0
OEM/Integrator	1,219.0	1,566.1	2,480.9	3,924.7	4,586.0	7,508.5	7,295.0	12,082.0	7,610.0	12,580.0
TOTAL U.S. NONCAPTIVE	1,407.7	1,912.0	3,233.9	5,216.3	6,396.3	10,738.9	10,475.0	17,852.0	11,175.0	19,015.0
TOTAL U.S. SHIPMENTS	1,455.7	1,989.7	4,269.0	6,739.7	8,525.8	13,945.9	13,590.0	22,652.0	14,915.0	24,845.0
Non-U.S. Manufacturers										
Captive	--	14.3	35.0	110.4	50.0	168.0	90.0	290.0	150.0	515.0
PCM/Reseller	--	--	10.0	60.0	30.0	155.0	60.0	275.0	105.0	420.0
OEM/Integrator	78.7	187.7	242.8	723.1	290.0	852.0	485.0	1,500.0	637.0	2,210.0
TOTAL NON-U.S. SHIPMENTS	78.7	202.0	287.8	893.5	370.0	1,175.0	635.0	2,065.0	892.0	3,145.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,534.4	2,191.7	4,556.8	7,633.2	8,895.8	15,120.9	14,225.0	24,717.0	15,807.0	27,990.0
Total Capacity (Terabytes)	876.0	1,270.2	2,700.9	4,503.0	5,228.2	8,849.7	9,108.7	15,816.5	11,266.3	20,017.5
Cumulative Shipments (Units in millions)										
IBM	.4	.7	1.4	2.2	3.5	5.4	6.6	10.2	10.4	16.0
Non-IBM	3.4	5.3	6.9	11.4	13.6	23.3	24.8	43.2	36.8	65.4
WORLDWIDE TOTAL	3.8	6.0	8.3	13.6	17.2	28.7	31.4	53.4	47.3	81.4

TABLE 51

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues			Forecast											
				1994				1995			1996		1997		
	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS															
IBM Captive	25.1	50.0	51.2	8.6	--	658.0	595.0	--	1,082.0	913.6	1,378.1	1,309.1	1,288.0	1,650.0	20.4
Other U.S. Captive	--	12.9	75.7	--	--	13.5	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	37.7	172.6	--	1.7	459.1	9.2	.4	945.0	23.6	1,465.1	37.8	1,383.8	55.9	21.9
OEM/Integrator	2.6	49.8	785.3	--	12.6	1,246.6	89.6	8.5	2,010.4	91.2	2,662.1	267.3	2,347.9	515.0	25.3
TOTAL U.S. REVENUES	27.7	150.4	1,084.8	8.6	14.3	2,377.2	693.8	8.9	4,037.4	1,028.4	5,505.3	1,614.2	5,019.7	2,220.9	67.6
NON-U.S. MANUFACTURERS															
Captive	79.3	23.6	7.4	61.3	13.4	9.2	121.8	9.0	15.0	121.8	27.6	206.3	53.6	335.4	--
PCM/Reseller	--	--	--	--	--	--	24.6	--	17.6	22.1	37.7	30.5	50.6	48.7	3.2
OEM/Integrator	27.5	11.0	89.1	12.8	4.6	106.6	119.1	1.4	127.6	95.2	138.0	247.5	172.3	357.5	4.5
TOTAL NON-U.S. REVENUES	106.8	34.6	96.5	74.1	18.0	115.8	265.5	10.4	160.2	239.1	203.3	484.3	276.5	741.6	7.7
WORLDWIDE RECAP															
Captive	104.4	86.5	134.3	69.9	13.4	680.7	716.8	9.0	1,097.0	1,035.4	1,405.7	1,515.4	1,341.6	1,985.4	20.4
	-59.1%	-89.7%	+27.3%	-33.0%	-84.5%	+406.9%	--	-32.8%	+61.2%	+44.4%	+28.1%	+46.4%	-4.6%	+31.0%	--
PCM/Reseller	--	37.7	172.6	--	1.7	459.1	33.8	.4	962.6	45.7	1,502.8	68.3	1,434.4	104.6	25.1
	--	-71.5%	+69.4%	--	-95.5%	+166.0%	--	-76.5%	+109.7%	+35.2%	+56.1%	+49.5%	-4.6%	+53.1%	--
OEM/Integrator	30.1	60.8	874.4	12.8	17.2	1,353.2	208.7	9.9	2,138.0	186.4	2,800.1	514.8	2,520.2	872.5	29.8
	-75.3%	-70.6%	+208.4%	-57.5%	-71.7%	+54.8%	--	-42.4%	+58.0%	-10.7%	+31.0%	+176.2%	-10.0%	+69.5%	--
Total Revenues	134.5	185.0	1,181.3	82.7	32.3	2,493.0	959.3	19.3	4,197.6	1,267.5	5,708.6	2,098.5	5,296.2	2,962.5	75.3
	-64.3%	-84.3%	+140.6%	-38.5%	-82.5%	+111.0%	--	-40.2%	+68.4%	+32.1%	+36.0%	+65.6%	-7.2%	+41.2%	--
ANNUAL SHARE, BY DIAMETER	9.0%	12.3%	78.7%	2.3%	.9%	70.0%	26.8%	.4%	76.6%	23.0%	73.2%	26.8%	63.6%	35.5%	.9%

TABLE 52

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments			Forecast											
				1994				1995			1996		1997		
	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS															
IBM Captive	2.0	10.0	33.0	.7	--	814.0	700.0	--	1,757.0	1,450.0	2,600.0	2,200.0	2,800.0	3,000.0	30.0
Other U.S. Captive	--	3.9	28.8	--	--	8.7	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	36.4	309.5	--	1.6	1,267.0	23.0	.4	3,150.0	80.0	5,635.0	135.0	6,150.0	215.0	70.0
OEM/Integrator	.7	50.4	1,515.0	--	11.6	3,686.1	227.0	8.5	7,180.0	320.0	11,092.0	990.0	10,435.0	2,060.0	85.0
TOTAL U.S. SHIPMENTS	2.7	100.7	1,886.3	.7	13.2	5,775.8	950.0	8.9	12,087.0	1,850.0	19,327.0	3,325.0	19,385.0	5,275.0	185.0
NON-U.S. MANUFACTURERS															
Captive	4.6	6.2	3.5	3.8	4.2	5.4	97.0	3.0	20.0	145.0	40.0	250.0	85.0	430.0	--
PCM/Reseller	--	--	--	--	--	--	60.0	--	70.0	85.0	160.0	115.0	230.0	180.0	10.0
OEM/Integrator	2.7	14.6	170.4	1.6	6.0	400.5	315.0	2.0	510.0	340.0	600.0	900.0	820.0	1,375.0	15.0
TOTAL NON-U.S. SHIPMENTS	7.3	20.8	173.9	5.4	10.2	405.9	472.0	5.0	600.0	570.0	800.0	1,265.0	1,135.0	1,985.0	25.0
WORLDWIDE RECAP															
Captive	6.6	20.1	65.3	4.5	4.2	828.1	797.0	3.0	1,777.0	1,595.0	2,640.0	2,450.0	2,885.0	3,430.0	30.0
	-60.7%	-86.2%	+205.1%	-31.8%	-79.1%	--	--	-28.6%	+114.6%	+100.1%	+48.6%	+53.6%	+9.3%	+40.0%	--
PCM/Reseller	--	36.4	309.5	--	1.6	1,267.0	83.0	.4	3,220.0	165.0	5,795.0	250.0	6,380.0	395.0	80.0
	--	-70.0%	+133.1%	--	-95.6%	+309.4%	--	-75.0%	+154.1%	+98.8%	+80.0%	+51.5%	+10.1%	+58.0%	--
OEM/Integrator	3.4	65.0	1,685.4	1.6	17.6	4,086.6	542.0	10.5	7,690.0	660.0	11,692.0	1,890.0	11,255.0	3,435.0	100.0
	-77.3%	-67.2%	+343.8%	-52.9%	-72.9%	+142.5%	--	-40.3%	+88.2%	+21.8%	+52.0%	+186.4%	-3.7%	+81.7%	--
Total Shipments	10.0	121.5	2,060.2	6.1	23.4	6,181.7	1,422.0	13.9	12,687.0	2,420.0	20,127.0	4,590.0	20,520.0	7,260.0	210.0
	-68.6%	-73.9%	+285.8%	-39.0%	-80.7%	+200.1%	--	-40.6%	+105.2%	+70.2%	+58.6%	+89.7%	+2.0%	+58.2%	--
ANNUAL SHARE, BY DIAMETER	.5%	5.5%	94.0%	.1%	.3%	81.1%	18.5%	.1%	84.0%	15.9%	81.5%	18.5%	73.4%	25.9%	.7%
TOTAL CAPACITY (Terabytes)	6.9	103.4	1,159.9	4.3	15.8	3,650.8	832.1	9.4	7,393.5	1,446.9	12,952.5	2,864.0	14,970.0	4,932.0	115.5

TABLE 53

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	18.0	.8	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	399.3	18.2	839.7	3.0
PERSONAL COMPUTERS Business and professional, single user	1,386.5	63.2	24,351.2	87.0
WORKSTATIONS Engineering and office, single user	386.8	17.7	2,659.1	9.5
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	140.0	.5
OTHER APPLICATIONS	1.1	.1	--	--
Total	2,191.7	100.0	27,990.0	100.0

TABLE 54

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1993	Forecast 1994	1995	1996	1997
Captive					
8"	23.70	22.55	--	--	--
5.25"	5.65	4.80	4.41	--	--
3.5"	3.03	1.36	1.02	.88	.76
2.5"	--	1.41	1.01	.95	.88
1.8"	--	--	--	--	1.23
Captive Average	5.08	1.46	1.02	.92	.83
PCM/Reseller					
8"	--	--	--	--	--
5.25"	.84	1.54	1.47	--	--
3.5"	1.01	.61	.51	.39	.30
2.5"	--	.78	.53	.45	.37
1.8"	--	--	--	--	.57
PCM/Reseller Average	.97	.62	.51	.40	.30
OEM/Integrator					
8"	12.04	10.66	--	--	--
5.25"	1.39	1.44	1.39	--	--
3.5"	.92	.56	.47	.36	.29
2.5"	--	.73	.54	.45	.36
1.8"	--	--	--	--	.54
OEM/Integrator Average	.97	.58	.48	.38	.31

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 55

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 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	
Conner Peripherals	--	--	357.5	357.5	24.1	--	--	528.6	528.6	25.3
Seagate Technology	.3	23.0	386.0	409.3	27.5	.7	37.0	448.0	485.7	23.1
Maxtor	--	7.1	348.1	355.2	23.9	--	11.7	418.7	430.4	20.5
Quantum	--	--	186.0	186.0	12.5	--	--	290.0	290.0	13.8
Fujitsu	.7	--	75.9	76.6	5.2	2.5	6.9	158.8	168.2	8.0
Other U.S.	--	19.1	80.6	99.7	6.7	--	38.1	139.2	177.3	8.4
Other Non-U.S.	.2	1.9	--	2.1	.1	.2	7.7	11.6	19.5	.9
TOTAL	1.2	51.1	1434.1	1486.4	100.0	3.4	101.4	1994.9	2099.7	100.0

Note: 8 inch totals include 6.5 - 9.5 inch drives.

FIXED DISK DRIVES, 1 - 2 GIGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, 1 - 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

10.5" disk diameter

Fujitsu	F6425M4, F6425H

9.5" disk diameter

Hitachi	DKU-86I, H-6556-I

8" disk diameter

Fujitsu	M2392K

5.25" disk diameter

Fujitsu	M2266, M2652
Hitachi	DK516C-16
IBM	9333-3110, 9345-1/2
Seagate Technology	ST41600N, ST41800K

3.5" disk diameter

Conner Peripherals	CFA-1275A/S**, CFP-1080**
Fujitsu	M2694*, M2927**
Hewlett-Packard	C2247*, C3323A**
Hitachi	DK315C-11*, DK326C-10**
IBM	0662-S12**, 0664-P1S*, DPEA-31080**
Maxtor	MXT-1240S*,71260A/S**
Micropolis	2112A/S*, 4110A/S**
NEC	D3892*
Quantum	1225S ProDrive*, 1080S Empire**
Seagate Technology	ST11200N*, ST31200N**
Western Digital	WDAC31000**
Zentek	ZM 31160**

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.

There are still drives in this product group which are intended solely for mainframe computer applications, but they are now the minority. IBM's 3380 was the core of this product group during the first half of the 1980's. The original 3380 was first shipped in late 1981, after an extremely expensive (to IBM) delay of over a year from the announced delivery schedule. However, IBM increased the

capacity to 2.5 gigabytes with mid-life enhancements to the 3380 family in 1985, and most of the mainframe drive activity moved up to higher capacities, leaving the 3390-1, first shipped in 1989, and newer 5.25" drives as the remaining IBM mainframe drives in this product group.

As shipments of the older 10.5", 9.5", 9" and 8" drives for captive and non-captive markets faded, 5.25" drives, which are still currently available from four companies, became the major products in the 1-2 gigabyte range. Joining them since 1991 were 3.5" drives, now available from 12 firms, with the first shipments of 1" high 3.5" drives starting in 1993. The first 2.5" drives with capacity over 1 gigabyte are expected to be in production in 1995.

Market status

Worldwide shipments of disk drives in the 1-2 gigabyte range were up 92.4% in 1993, reaching 2.4 million units. 1994 shipments are projected at 4.2 million drives, up another 76.8%. However, total sales revenues have been declining during the same period due to product mix changes, as older high priced large drives are replaced by new drives with smaller disks and smaller prices. 1993's revenue total of $3.3 billion was down 15.6%, and the forecasted 1994 revenue of $3.2 billion will be down another 2.3%.

Disk drives in this product group are undergoing rapid changes in product mix. Previously the domain of drives designed for mainframes, the 1-2 gigabyte product group had, by 1991, become an area of rapid growth for 5.25" OEM drives, with declining captive shipments of high-end drives. By 1993, 14" and 8"/9" drives provided less than 1% of the shipment total, and 5.25" drives had declined to a 14.7% share. After achieving a 34.1% share of 1992 shipments, 3.5" drives rose rapidly to 84.6% of 1993 shipments, and they are expected to hold 97.8% of the 1994 overall total.

The movement initially to 5.25" and then to 3.5" drives occurred for the usual reasons. The smaller drives require less power, generate less heat and noise, and most significantly, have much lower prices. The average price for all OEM drives in the 1-2 gigabyte range was $3,654 in 1990, dropping to $2,035 in 1991, then to $1,516 in 1992, and reached $926 in 1993 -- with 1994's average OEM

price estimated at $582. The OEM/Integrator average price per megabyte for 3.5" drives was $1.20 in 1992, $.74 in 1993, and is estimated at $.49 in 1994. It has been a very rapid fall, caused by the large increase in shipments, the introduction of 1" high drives using fewer disks, and the extreme levels of competition -- which reached the industry's high capacity ranges during the 1993-94 period.

Historically, mainframe applications were the mainstay of drives in this capacity range, but those days are gone, and the 10.9% of unit shipments which went to mainframe applications in 1993 are disappearing completely. Even the 57.3% of 1993 shipments which were used in networks/minicomputer/multiuser applications will shrink to an estimated 2.8% in 1997, and 1993's 28.1% for workstation applications will drop to 9% in 1997. Personal computer applications consumed only 2.5% of the 1993 shipment total, but are destined to take an estimated 88% of 1997 shipments, as the high-end personal computer market continues to increase in size.

Seagate Technology again dominated noncaptive unit shipments for the product group in 1993 with 35.8% of the worldwide total, including 8", 5.25" and 3.5" drives. Hewlett-Packard held 11.9% and Micropolis 11.6%, with both firms shipping a combination of 5.25" and 3.5" disk drives.

Marketing trends

The rising high-end personal computer market, driven by the burgeoning data storage demands of expanding operating systems and application programs, growth of storage-hungry graphics and data base applications, and new storage requirements for CD-ROM and video products will drive overall shipments for this product group to a very high level in 1997. 1995 shipments are expected to be double those of 1994, and 1997 shipments are projected at 23.6 million drives. Although average noncaptive drive prices will obviously continue to decline, the rapid increase in unit shipments will push worldwide sales revenues for 1-2 gigabyte disk drives to over $10 billion in 1997, a higher revenue level than any other product group.

The last of the 8" and 5.25" drives are expected to be produced in 1995, leaving 3.5" drives in the dominant role. The full size 3.5" drives which led in shipments as recently as 1993 have already lost the lead to 1" high 3.5" drives in

1994 and are expected to be almost out of production by 1997. There is very little need today for 3.5" drives with more than 1" height, since the disk count has been rapidly reduced, and single disk 3.5" drives in this capacity range will appear well before the end of this forecast period.

The first 2.5" drives in the 1-2 gigabyte range are expected in 1995. Today's areal densities would make possible the production of such drives in 1994 if disk drive manufacturers were satisfied that adequate demand existed in the notebook computer market or with other applications. It is known that manufacturing plans for 2.5" 1 gigabyte drives are under way, and the demand for increased data storage with portable systems and miniaturized disk drive arrays will probably be adequate to start the market.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
10"-14"	.9	.4	--	--	--
	--	--	--	--	--
8"-9.5"	16.6	6.7	3.0	--	--
	.7%	.2%	--	--	--
5.25"	346.5	82.3	13.0	--	--
	14.7%	2.0%	.1%	--	--
3.5" 1.625" high	1,681.9	1,234.2	615.0	355.0	80.0
	71.2%	29.5%	7.0%	2.2%	.3%
3.5" 1" high or less	316.7	2,854.6	8,074.0	15,135.0	22,410.0
	13.4%	68.3%	91.4%	95.0%	95.1%
2.5"	--	--	125.0	445.0	1,080.0
	--	--	1.4%	2.8%	4.6%
Total	2,362.6	4,178.2	8,830.0	15,935.0	23,570.0

Technical trends

Drive designers have been faced with all of the usual head, disk, actuator and electronics issues as they plan and design drives for this product group. It has been mostly a question of availability. Will disks of proper coercivity and surface characteristics be available in the right quantities? Will 50% sliders be available or are 70% sliders the best choice? Are chips available for zoned recording, or digital signal processing, or for the higher transfer rates? In most cases, the answer has been yes.

Initially, the myriad of details associated with packaging as many as eight or more disks in a small drive was a formidable challenge, which became even more difficult when the number of disks had to be reduced to adhere to the quickly-popular 1" high 3.5" drive form factor. IBM helped by setting an industry standard for 31.5 mil disks with its Lightning series of 3.5" drives, and head suspensions have been modified for the narrow disk spacing required. For most drive designers the remaining problems involve chips with adequate data rates, the motors with higher rotation speeds, uncertainties about magnetoresistive head availability, more sophisticated error detection schemes, and maximizing the number of recording zones. The technical problems are difficult but they are being solved. The next major challenge for most of the drive manufacturers will be to design new 3.5" drive models optimized for the lowest possible manufacturing cost -- which will be needed to keep up with competition as the market concentrates on personal computer applications during the next few years.

Forecasting assumptions

1. IBM's shipments of Corsair full size 3.5" drives will end in 1994 and shipments of Spitfire 1" high 3.5" drives will end in 1995 as the result of a dual migration to separate families of newer 1" high 3.5" drives with lower parts count, intended for individual high performance applications, and low cost personal computer applications.
2. The final production of 10"-14" drives will be in 1994, and the last shipments of 5.25" and 8"-9.5" drives will be in 1995.
3. 3.5" drives will maintain shipment leadership of this product group with 1" high models throughout the forecast period, driven primarily by expanding disk storage requirements for high-end personal computers.
4. The first 2.5" drives with capacities over 1 gigabyte will be shipped in 1995.

TABLE 56

FIXED DISK DRIVES, 1 - 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	607.0	892.0	478.5	707.0	622.1	919.6	1,038.0	1,559.6	1,390.7	2,122.8
Other U.S. Captive	381.3	548.2	171.1	305.7	24.8	39.7	45.8	82.4	71.1	122.5
TOTAL U.S. CAPTIVE	988.3	1,440.2	649.6	1,012.7	646.9	959.3	1,083.8	1,642.0	1,461.8	2,245.3
PCM/Reseller	273.9	414.6	319.8	485.5	602.2	927.7	1,073.1	1,651.1	1,465.5	2,253.7
OEM/Integrator	781.0	1,029.7	918.4	1,234.7	1,538.1	2,198.3	2,328.5	3,430.3	2,683.4	4,125.9
TOTAL U.S. NONCAPTIVE	1,054.9	1,444.3	1,238.2	1,720.2	2,140.3	3,126.0	3,401.6	5,081.4	4,148.9	6,379.6
TOTAL U.S. REVENUES	2,043.2	2,884.5	1,887.8	2,732.9	2,787.2	4,085.3	4,485.4	6,723.4	5,610.7	8,624.9
Non-U.S. Manufacturers										
Captive	--	161.1	--	176.7	--	80.4	--	105.8	--	199.8
PCM/Reseller	32.3	32.3	--	--	9.3	39.5	24.3	100.0	32.7	161.7
OEM/Integrator	96.8	192.3	138.3	285.6	214.3	457.2	342.8	760.7	468.7	1,044.8
TOTAL NON-U.S. REVENUES	129.1	385.7	138.3	462.3	223.6	577.1	367.1	966.5	501.4	1,406.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,172.3	3,270.2	2,026.1	3,195.2	3,010.8	4,662.4	4,852.5	7,689.9	6,112.1	10,031.2
OEM Average Price ($000)		.926		.582		.455		.416		.362

TABLE 57

FIXED DISK DRIVES, 1 - 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	258.0	375.0	347.0	513.0	575.0	850.0	1,045.0	1,570.0	1,605.0	2,450.0
Other U.S. Captive	125.6	184.9	111.0	219.1	25.0	40.0	50.0	90.0	90.0	155.0
TOTAL U.S. CAPTIVE	383.6	559.9	458.0	732.1	600.0	890.0	1,095.0	1,660.0	1,695.0	2,605.0
PCM/Reseller	282.3	427.9	528.3	803.6	1,295.0	1,995.0	2,525.0	3,885.0	3,960.0	6,090.0
OEM/Integrator	836.2	1,083.9	1,560.8	2,100.5	3,402.0	4,862.0	5,600.0	8,250.0	7,450.0	11,455.0
TOTAL U.S. NONCAPTIVE	1,118.5	1,511.8	2,089.1	2,904.1	4,697.0	6,857.0	8,125.0	12,135.0	11,410.0	17,545.0
TOTAL U.S. SHIPMENTS	1,502.1	2,071.7	2,547.1	3,636.2	5,297.0	7,747.0	9,220.0	13,795.0	13,105.0	20,150.0
Non-U.S. Manufacturers										
Captive	--	17.4	--	32.2	--	24.0	--	85.0	--	180.0
PCM/Reseller	38.0	38.0	--	--	20.0	85.0	57.0	235.0	85.0	420.0
OEM/Integrator	121.7	235.5	250.2	509.8	456.0	974.0	820.0	1,820.0	1,265.0	2,820.0
TOTAL NON-U.S. SHIPMENTS	159.7	290.9	250.2	542.0	476.0	1,083.0	877.0	2,140.0	1,350.0	3,420.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,661.8	2,362.6	2,797.3	4,178.2	5,773.0	8,830.0	10,097.0	15,935.0	14,455.0	23,570.0
Total Capacity (Terabytes)	1,943.9	2,765.3	3,182.9	4,764.3	6,373.1	9,766.9	12,877.4	20,327.5	20,962.7	34,233.0
Cumulative Shipments (Units in millions)										
IBM	.6	1.0	.0	1.5	1.5	2.3	2.6	3.9	4.2	6.4
Non-IBM	2.6	4.0	5.0	7.6	10.2	15.6	19.3	30.0	32.1	51.1
WORLDWIDE TOTAL	3.2	5.0	6.0	9.1	11.8	18.0	21.9	33.9	36.4	57.5

TABLE 58

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues				Forecast											
					1994				1995				1996		1997	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	--	--	220.0	672.0	--	--	30.0	677.0	--	--	864.0	55.6	1,393.0	166.6	1,816.5	306.3
Other U.S. Captive	--	3.2	242.6	302.4	--	--	36.2	269.5	--	--	39.7	--	82.4	--	122.5	--
PCM/Reseller	--	--	97.7	316.9	--	--	6.6	478.9	--	--	927.7	--	1,644.8	6.3	2,238.5	15.2
OEM/Integrator	--	27.0	210.1	792.6	--	--	52.0	1,182.7	--	3.8	2,164.5	30.0	3,342.6	87.7	3,936.6	189.3
TOTAL U.S. REVENUES	--	30.2	770.4	2,083.9	--	--	124.8	2,608.1	--	3.8	3,995.9	85.6	6,462.8	260.6	8,114.1	510.8
NON-U.S. MANUFACTURERS																
Captive	34.3	93.5	19.6	13.7	13.7	60.8	73.8	28.4	27.0	29.4	24.0	--	105.8	--	199.8	--
PCM/Reseller	--	--	--	32.3	--	--	--	--	--	--	39.5	--	97.8	2.2	154.0	7.7
OEM/Integrator	--	3.0	29.9	159.4	--	.6	9.5	275.5	--	3.2	449.3	4.7	744.1	16.6	989.2	55.6
TOTAL NON-U.S. REVENUES	34.3	96.5	49.5	205.4	13.7	61.4	83.3	303.9	27.0	32.6	512.8	4.7	947.7	18.8	1,343.0	63.3
WORLDWIDE RECAP																
Captive	34.3	96.7	482.2	988.1	13.7	60.8	140.0	974.9	27.0	29.4	927.7	55.6	1,581.2	166.6	2,138.8	306.3
	-54.6%	-78.4%	-57.5%	+15.6%	-60.1%	-37.1%	-71.0%	-1.3%	-55.6%	-79.0%	-4.8%	--	+70.4%	+199.6%	+35.3%	+83.9%
PCM/Reseller	--	--	97.7	349.2	--	--	6.6	478.9	--	--	967.2	--	1,742.6	8.5	2,392.5	22.9
	--	--	-68.3%	+202.3%	--	--	-93.2%	+37.1%	--	--	+102.0%	--	+80.2%	--	+37.3%	+169.4%
OEM/Integrator	--	30.0	240.0	952.0	--	.6	61.5	1,458.2	--	7.0	2,613.8	34.7	4,086.7	104.3	4,925.8	244.9
	--	-59.8%	-63.8%	+408.8%	--	-98.0%	-74.4%	+53.2%	--	-88.6%	+79.2%	--	+56.4%	+200.6%	+20.5%	+134.8%
Total Revenues	34.3	126.7	819.9	2,289.3	13.7	61.4	208.1	2,912.0	27.0	36.4	4,508.7	90.3	7,410.5	279.4	9,457.1	574.1
	-55.2%	-76.2%	-61.1%	+97.8%	-60.1%	-51.5%	-74.6%	+27.2%	-56.0%	-82.5%	+54.8%	--	+64.4%	+209.4%	+27.6%	+105.5%
ANNUAL SHARE, BY DIAMETER	1.0%	3.9%	25.2%	69.9%	.4%	1.9%	6.5%	91.2%	.6%	.8%	96.8%	1.8%	96.5%	3.5%	94.4%	5.6%

TABLE 59

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments				Forecast 1994				1995				1996		1997	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	--	--	20.0	355.0	--	--	3.0	510.0	--	--	800.0	50.0	1,400.0	170.0	2,100.0	350.0
Other U.S. Captive	--	.4	67.0	117.5	--	--	11.5	207.6	--	--	40.0	--	90.0	--	155.0	--
PCM/Reseller	--	--	75.6	352.3	--	--	5.6	798.0	--	--	1,995.0	--	3,870.0	15.0	6,050.0	40.0
OEM/Integrator	--	6.0	158.7	919.2	--	--	38.5	2,062.0	--	3.0	4,794.0	65.0	8,035.0	215.0	10,935.0	520.0
TOTAL U.S. SHIPMENTS	--	6.4	321.3	1,744.0	--	--	58.6	3,577.6	--	3.0	7,629.0	115.0	13,395.0	400.0	19,240.0	910.0
NON-U.S. MANUFACTURERS																
Captive	.9	8.9	3.5	4.1	.4	6.4	14.2	11.2	3.0	6.0	15.0	--	85.0	--	180.0	--
PCM/Reseller	--	--	--	38.0	--	--	--	--	--	--	85.0	--	230.0	5.0	400.0	20.0
OEM/Integrator	--	1.3	21.7	212.5	--	.3	9.5	500.0	--	4.0	960.0	10.0	1,780.0	40.0	2,670.0	150.0
TOTAL NON-U.S. SHIPMENTS	.9	10.2	25.2	254.6	.4	6.7	23.7	511.2	3.0	10.0	1,060.0	10.0	2,095.0	45.0	3,250.0	170.0
WORLDWIDE RECAP																
Captive	.9	9.3	90.5	476.6	.4	6.4	28.7	728.8	3.0	6.0	855.0	50.0	1,575.0	170.0	2,435.0	350.0
	-65.4%	-65.8%	-31.6%	+157.3%	-55.6%	-31.2%	-68.3%	+52.9%	-53.1%	-79.1%	+17.3%	--	+84.2%	+240.0%	+54.6%	+105.9%
PCM/Reseller	--	--	75.6	390.3	--	--	5.6	798.0	--	--	2,080.0	--	4,100.0	20.0	6,450.0	60.0
	--	--	-58.0%	+343.0%	--	--	-92.6%	+104.5%	--	--	+160.7%	--	+97.1%	--	+57.3%	+200.0%
OEM/Integrator	--	7.3	180.4	1,131.7	--	.3	48.0	2,562.0	--	7.0	5,754.0	75.0	9,815.0	255.0	13,605.0	670.0
	--	-64.9%	-59.2%	+670.9%	--	-95.9%	-73.4%	+126.4%	--	-85.4%	+124.6%	--	+70.6%	+240.0%	+38.6%	+162.7%
Total Shipments	.9	16.6	346.5	1,998.6	.4	6.7	82.3	4,088.8	3.0	13.0	8,689.0	125.0	15,490.0	445.0	22,490.0	1,080.0
	-66.7%	-66.8%	-54.1%	+375.7%	-55.6%	-59.6%	-76.2%	+104.6%	-55.2%	-84.2%	+112.5%	--	+78.3%	+256.0%	+45.2%	+142.7%
ANNUAL SHARE, BY DIAMETER	--	.7%	14.7%	84.6%	--	.2%	2.0%	97.8%	--	.1%	98.5%	1.4%	97.3%	2.7%	95.5%	4.5%
TOTAL CAPACITY (Terabytes)	1.1	29.0	481.2	2,254.0	.5	12.7	115.5	4,635.6	5.7	17.4	9,606.4	137.5	19,793.5	534.0	32,829.0	1,404.0

TABLE 60

FIXED DISK DRIVES, 1 - 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	28.4	1.2	47.1	.2
MAINFRAME SYSTEMS General purpose	258.5	10.9	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	1,354.7	57.3	660.0	2.8
PERSONAL COMPUTERS Business and professional, single user	58.1	2.5	20,741.6	88.0
WORKSTATIONS Engineering and office, single user	662.9	28.1	2,121.3	9.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	2,362.6	100.0	23,570.0	100.0

TABLE 61

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1993	Forecast 1994	1995	1996	1997
Captive					
14"	31.17	27.44	--	--	--
8"	5.71	5.02	4.76	--	--
5.25"	4.02	3.63	3.76	--	--
3.5"	1.91	1.23	1.00	.90	.77
2.5"	--	--	1.00	.81	.67
Captive Average	2.45	1.41	1.04	.89	.75
PCM/Reseller					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	.92	.80	--	--	--
3.5"	.77	.52	.42	.32	.24
2.5"	--	--	--	.35	.29
PCM/Reseller Average	.80	.53	.42	.32	.24
OEM/Integrator					
14"	--	--	--	--	--
8"	2.47	1.10	--	--	--
5.25"	.93	.89	.72	--	--
3.5"	.74	.49	.40	.32	.24
2.5"	--	--	.42	.34	.28
OEM/Integrator Average	.78	.50	.40	.32	.24

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 62

FIXED DISK DRIVES, 1 - 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 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	
Seagate Technology	5.0	107.0	432.0	544.0	42.6	6.0	135.0	498.0	639.0	35.8
Hewlett-Packard	--	10.1	140.6	150.7	11.8	--	14.4	198.3	212.7	11.9
Micropolis	--	43.6	103.8	147.4	11.5	--	61.4	144.9	206.3	11.6
Fujitsu	1.2	2.0	105.0	108.2	8.5	1.3	9.2	180.9	191.4	10.7
IBM	--	--	113.0	113.0	8.8	--	5.0	155.0	160.0	9.0
Digital Equipment	--	--	72.8	72.8	5.7	--	--	119.8	119.8	6.7
Other U.S.	--	11.5	79.1	90.6	7.1	--	18.5	155.5	174.0	9.7
Other Non-U.S.	--	9.0	42.5	51.5	4.0	--	12.5	69.6	82.1	4.6
TOTAL	6.2	183.2	1088.8	1278.2	100.0	7.3	256.0	1522.0	1785.3	100.0

Note: 8 inch totals include 6.5 - 9.5 inch drives.

FIXED DISK DRIVES, 2 - 3 GIGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, 2 - 3 GIGABYTES

Coverage

Examples of disk drives in this group include:

9.5" disk diameter

Hitachi	H-6587

8" disk diameter

Fujitsu	M2671P, F6427K

6.5" disk diameter

Hitachi	H-6588-314, DKU-88I

5.25" disk diameter

Fujitsu	M2654SI
Hitachi	DK517C-37
Micropolis	1926S
Seagate Technology	ST42400N

3.5" disk diameter

Conner Peripherals	CFP-2105E/W**, CFP-2107E/W**
Fujitsu	M2903*
Hewlett-Packard	C2490A*
IBM	0664-N1H*, 9333-011*, DFHS-32160**
Micropolis	4221**
Quantum	2160S Empire*
Seagate Technology	ST12400N*, ST-32430N**

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.

The disk drive industry has a relatively short history in this capacity range. There was a brief period of activity in the mid-1980's, with a few drives designed for the mainframe market, but these were soon supplanted by drives with capacities above this range. Extensive participation by several disk drive manufacturers did not occur until the 1990's, driven by the blossoming demand for higher capacity disk drives in the network server and workstation markets.

Disk drives with individual spindles containing capacities above 2 gigabytes first appeared in 1985 with IBM's 3380-E, the double capacity model in the 3380

series. It was replaced by the triple capacity 3380-K in 1987, which raised the typical capacities for mainframe disk drives to a level above this product group. Most of the remaining 6.5", 8", 9.5" and 10.5" drives which followed have been intended for mainframe and supermini applications similar to IBM's, and most use standard industry technology, but generally more conservatively, to facilitate reliable production. Other 8" and 9" drives, now mostly out of production, were used typically in small mainframe, supermini and imaging applications.

5.25" drives above 2 gigabytes were shipped for the first time in 1991, and were once available from seven manufacturers, now down to four. 3.5" drives first became available in late 1992, with the introduction of IBM's 2 gigabyte 1.625" high Allicat series, now used in several IBM system applications and sold in the OEM market. The Allicat is currently used in IBM's RAMAC array subsystems for mainframe applications with first shipments at the end of September, 1994 -- but is destined to be replaced by the 4 gigabyte 3.5" Starfire drive when that drive is ready for high volume production. Half a dozen other manufacturers have also entered the market with 3.5" drives, some with 1" high models, and the file server and workstation markets have responded with growing usage of the new drives.

Market status

712,000 2-3 gigabyte disk drives were shipped in 1993, an increase of 263.1% over the previous year, the first year that this capacity range has been broken out as a separate product group. Rapidly growing usage in network file servers and workstation applications are expected to boost 1994 worldwide unit shipments to 1.9 million drives, up 171.1%. The rate of sales revenue increase will not be as great, due to shrinking shipments of older high cost drive models and intense competitive pressures. 1993's total revenues were $2.3 billion, a 38.9% increase, and 1994 revenues are forecasted at $3.5 billion, up 55.8%.

The transitional nature of the current applications for drives in this product group is reflected in the changing product mix. Shipments of 6.5", 8", and 9.5" drives for mainframe systems are fading, with final production expected next year, as the older drives are replaced by smaller drives with higher capacities. 5.25" drives, used for mainframe disk subsystems, network file servers and

minicomputers, increased shipments in 1993 to 337,400 units, up 164.8%. However, 5.25" drive shipments are declining in 1994 as many applications transition to 3.5" drives, with the 5.25" total for the year projected at 118,200 drives, down 65%.

3.5" drives have quickly become the major products in this capacity range. The first significant 3.5" drive shipments started in 1993, totaling 346,600 units, the majority of which were Allicat drives shipped by IBM for both captive requirements with the firm's own systems and to the OEM market. 1994 shipments of 3.5" drives are expected to provide 93% of the total shipments for the 2-3 gigabyte capacity range, 1.8 million drives, an increase of 418%. The first 1" high 3.5" drives, which are expected to soon dominate the 3.5" drive market, were shipped by at least four manufacturers in 1994.

2-3 megabyte disk drive shipments for personal computer applications in 1993 were negligible, but PC's are expected to constitute 41% of the market in 1997, as the high-end of that market continues to expand. Networks/minicomputer/multiuser applications were 57.6% of 1993 shipments and are forecasted to decline to 48% of 1997 shipments, although the unit shipment total will jump to 3.3 million drives. The 22.5% of 1993 shipments used for mainframe applications will shrink to 2.6% in 1997, as disk capacities used for that application grow beyond this product group.

Seagate Technology dominated noncaptive 1993 shipments with 59.2% of the worldwide total, a combination of 259,000 8", 5.25" and 3.5" drives. Hewlett-Packard held second place with 14.1%, and IBM was third with 9.6%.

Marketing trends

Noncaptive sales of 1" high 3.5" drives will lead the rapid growth in shipments expected for this product group through 1997. Overall unit shipments of 2-3 gigabyte drives in 1997 are forecasted at 6.8 million units. Despite increasing unit shipments, total sales revenues for the product group are expected to decline 11.3% in 1995, to $3.1 billion, as shipments of older drives diminish and noncaptive sales outpace the previously dominant captive sales channel. However, revenues are projected to start a growth trend again in 1996, the result of strong growth and stability in product mix and sales channels.

The final sales for drives in the 6.5"-9.5" group are expected in 1995, and the last 5.25" drives will probably be shipped in 1996. Full size 3.5" drive models in this capacity range will be almost gone by 1997, and 1" high 3.5" drives are projected to provide 97.8% of all shipments for the product group. It is expected that the first 2.5" drives with over 2 gigabytes capacity will be shipped by 1997, but the quantities shipped through the time period covered by this report will probably be modest.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
6.5"-9.5"	28.0 3.9%	16.8 .9%	6.0 .2%	-- --	-- --
5.25"	337.4 47.4%	118.2 6.1%	17.0 .5%	2.0 --	-- --
3.5" 1.625" high	346.6 48.7%	1,575.0 81.6%	610.0 18.2%	250.0 5.0%	75.0 1.1%
3.5" 1" high or less	-- --	220.5 11.4%	2,715.0 81.1%	4,795.0 95.0%	6,670.0 97.8%
2.5"	-- --	-- --	-- --	-- --	75.0 1.1%
Total	712.0	1,930.5	3,348.0	5,047.0	6,820.0

Technical trends

As the older disk drives pass from the scene in the 2-3 gigabyte capacity range, the major product development emphasis will be placed on development of 3.5" and smaller drives which can be manufactured efficiently at high production rates, utilizing designs with a low parts count. As the markets addressed with these products become more competitive, and with more than 40% of the 1997 shipments expected to be in the intensely competitive personal computer market, low manufacturing cost will rival performance and reliability as a design objective.

As always, continuing areal density improvements will be the largest influence on drive designers' ability to reduce drive costs. The well publicized 60% annual rate of improvement in areal density seems likely to be achieved for the balance of the current decade. By 1997, the industry probably will be able to

manufacture leading edge 2 gigabyte 3.5" drives with a single platter, and 2.5" drives with two platters. It should be noted, however, that the drives manufactured at very high production volumes typically have a much lower areal density than the leading edge drives of the same era, in order to obtain high manufacturing yields and low costs.

Most of the technology development needed for the future drives in this 2-3 gigabyte capacity range will not be specifically targeted to this product group. Development of semiconductors with the very high data rates required will be undertaken for all high-end disk drives. Miniaturization of heads and head assemblies will be applicable to most disk drives in the second half of the 1990's. The movement to advanced magnetoresistive head designs and improvement in disk substrates and disk surfaces will also find general application. Perhaps most important in providing the ability to continually evolve to improved drive designs will be the general adoption by most manufacturers of the "product family" concept. The disk drive industry's version of family planning will make possible rapid introduction of new components and recording technology, without wasting the time necessary to completely redesign products for each new version.

Forecasting assumptions

1. IBM will phase out the full size Allicat 3.5" drive in 1995, in favor of 1" high versions of the 3.5" Starfire, and lower cost follow-on designs, and will introduce a 2.5" drive in this capacity range by 1997.
2. 1995 will be the last production year for 6.5"-9.5" drives, and 5.25" drives will be produced for the last time in 1996.
3. Starting in 1995, shipments in this product group will be dominated by sales of 1" high 3.5" drives for network file server applications and single user personal computers.
4. First shipments of 2.5" drives in the 2-3 gigabyte capacity range will start in 1997.

TABLE 63

FIXED DISK DRIVES, 2 - 3 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	640.0	915.0	891.6	1,333.0	469.0	706.3	451.5	682.5	505.6	769.0
Other U.S. Captive	213.9	329.6	495.8	730.6	238.0	295.0	236.0	300.0	222.0	300.0
TOTAL U.S. CAPTIVE	853.9	1,244.6	1,387.4	2,063.6	707.0	1,001.3	687.5	982.5	727.6	1,069.0
PCM/Reseller	206.3	254.1	330.3	449.1	387.9	581.9	410.0	632.2	415.2	648.0
OEM/Integrator	343.3	416.1	623.7	732.3	1,021.1	1,282.9	1,218.9	1,627.0	1,294.0	1,849.1
TOTAL U.S. NONCAPTIVE	549.6	670.2	954.0	1,181.4	1,409.0	1,864.8	1,628.9	2,259.2	1,709.2	2,497.1
TOTAL U.S. REVENUES	1,403.5	1,914.8	2,341.4	3,245.0	2,116.0	2,866.1	2,316.4	3,241.7	2,436.8	3,566.1
Non-U.S. Manufacturers										
Captive	--	319.7	--	235.4	--	145.0	--	61.0	--	56.0
PCM/Reseller	--	--	--	--	10.8	21.6	8.6	31.3	13.0	38.7
OEM/Integrator	28.5	41.3	34.4	66.3	51.7	114.0	56.5	131.8	56.4	143.1
TOTAL NON-U.S. REVENUES	28.5	361.0	34.4	301.7	62.5	280.6	65.1	224.1	69.4	237.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,432.0	2,275.8	2,375.8	3,546.7	2,178.5	3,146.7	2,381.5	3,465.8	2,506.2	3,803.9
OEM Average Price ($000)		1.611		.899		.667		.530		.430

TABLE 64

FIXED DISK DRIVES, 2 - 3 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	128.0	183.0	184.0	275.0	157.0	235.0	215.0	325.0	312.0	475.0
Other U.S. Captive	47.5	72.9	173.0	281.0	125.0	155.0	165.0	210.0	185.0	250.0
TOTAL U.S. CAPTIVE	175.5	255.9	357.0	556.0	282.0	390.0	380.0	535.0	497.0	725.0
PCM/Reseller	124.7	153.8	347.0	468.5	540.0	810.0	720.0	1,110.0	865.0	1,350.0
OEM/Integrator	213.5	260.2	716.8	836.7	1,534.0	1,926.0	2,300.0	3,070.0	3,005.0	4,295.0
TOTAL U.S. NONCAPTIVE	338.2	414.0	1,063.8	1,305.2	2,074.0	2,736.0	3,020.0	4,180.0	3,870.0	5,645.0
TOTAL U.S. SHIPMENTS	513.7	669.9	1,420.8	1,861.2	2,356.0	3,126.0	3,400.0	4,715.0	4,367.0	6,370.0
Non-U.S. Manufacturers										
Captive	--	18.4	--	17.7	--	25.5	--	32.0	--	40.0
PCM/Reseller	--	--	--	--	15.0	30.0	15.0	55.0	27.0	80.0
OEM/Integrator	17.5	23.7	28.4	51.6	75.2	166.5	105.0	245.0	130.0	330.0
TOTAL NON-U.S. SHIPMENTS	17.5	42.1	28.4	69.3	90.2	222.0	120.0	332.0	157.0	450.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	531.2	712.0	1,449.2	1,930.5	2,446.2	3,348.0	3,520.0	5,047.0	4,524.0	6,820.0
Total Capacity (Terabytes)	1,184.7	1,581.0	3,017.4	4,021.3	5,227.2	7,152.9	7,709.4	11,047.2	10,711.0	16,140.3
Cumulative Shipments (Units in millions)										
IBM	.2	.3	.3	.5	.5	.8	.7	1.1	1.0	1.6
Non-IBM	.6	.0	1.9	2.6	4.2	5.7	7.5	10.4	11.7	16.8
WORLDWIDE TOTAL	.8	1.3	2.3	3.2	4.7	6.5	8.3	11.6	12.8	18.4

TABLE 65

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues			Forecast									
	1994			1995			1996		1997				
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	3.5"	2.5"
U.S. MANUFACTURERS													
IBM Captive	--	--	915.0	--	--	1,333.0	--	--	706.3	--	682.5	688.0	81.0
Other U.S. Captive	--	304.9	24.7	--	208.0	522.6	--	--	295.0	--	300.0	300.0	--
PCM/Reseller	--	175.2	78.9	--	28.5	420.6	--	--	581.9	--	632.2	648.0	--
OEM/Integrator	35.0	261.8	119.3	7.6	41.7	683.0	--	9.0	1,273.9	--	1,627.0	1,834.0	15.1
TOTAL U.S. REVENUES	35.0	741.9	1,137.9	7.6	278.2	2,959.2	--	9.0	2,857.1	--	3,241.7	3,470.0	96.1
NON-U.S. MANUFACTURERS													
Captive	315.5	4.2	--	208.9	26.5	--	87.5	20.0	37.5	7.0	54.0	56.0	--
PCM/Reseller	--	--	--	--	--	--	--	--	21.6	--	31.3	38.7	--
OEM/Integrator	13.1	28.2	--	9.4	14.9	42.0	1.8	4.8	107.4	--	131.8	143.1	--
TOTAL NON-U.S. REVENUES	328.6	32.4	--	218.3	41.4	42.0	89.3	24.8	166.5	7.0	217.1	237.8	--
WORLDWIDE RECAP													
Captive	315.5	309.1	939.7	208.9	234.5	1,855.6	87.5	20.0	1,038.8	7.0	1,036.5	1,044.0	81.0
	+16.9%	+80.1%	--	-33.8%	-24.1%	+97.5%	-58.1%	-91.5%	-44.0%	-65.0%	-.2%	+.7%	--
PCM/Reseller	--	175.2	78.9	--	28.5	420.6	--	--	603.5	--	663.5	686.7	--
	--	+197.5%	--	--	-83.7%	+433.1%	--	--	+43.5%	--	+9.9%	+3.5%	--
OEM/Integrator	48.1	290.0	119.3	17.0	56.6	725.0	1.8	13.8	1,381.3	--	1,758.8	1,977.1	15.1
	-54.7%	+56.5%	--	-64.7%	-80.5%	+507.7%	-89.4%	-75.6%	+90.5%	--	+27.3%	+12.4%	--
Total Revenues	363.6	774.3	1,137.9	225.9	319.6	3,001.2	89.3	33.8	3,023.6	7.0	3,458.8	3,707.8	96.1
	-69.6%	+86.2%	--	-37.9%	-58.7%	+163.7%	-60.5%	-89.4%	+.7%	-79.3%	+14.4%	+7.2%	--
ANNUAL SHARE, BY DIAMETER	16.0%	34.1%	49.9%	6.4%	9.0%	84.6%	2.8%	1.1%	96.1%	.2%	99.8%	97.6%	2.4%

Note: 14 inch totals include 10.5 - 14 inch drives.
8 inch totals include 6.5 - 9.5 inch drives.

TABLE 66

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments			Forecast									
				1994			1995			1996		1997	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	3.5"	2.5"
U.S. MANUFACTURERS													
IBM Captive	--	--	183.0	--	--	275.0	--	--	235.0	--	325.0	430.0	45.0
Other U.S. Captive	--	62.3	10.6	--	54.0	227.0	--	--	155.0	--	210.0	250.0	--
PCM/Reseller	--	95.6	58.2	--	17.5	451.0	--	--	810.0	--	1,110.0	1,350.0	--
OEM/Integrator	7.0	158.4	94.8	2.0	27.2	807.5	--	6.0	1,920.0	--	3,070.0	4,265.0	30.0
TOTAL U.S. SHIPMENTS	7.0	316.3	346.6	2.0	98.7	1,760.5	--	6.0	3,120.0	--	4,715.0	6,295.0	75.0
NON-U.S. MANUFACTURERS													
Captive	17.8	.6	--	12.4	5.3	--	5.5	5.0	15.0	2.0	30.0	40.0	--
PCM/Reseller	--	--	--	--	--	--	--	--	30.0	--	55.0	80.0	--
OEM/Integrator	3.2	20.5	--	2.4	14.2	35.0	.5	6.0	160.0	--	245.0	330.0	--
TOTAL NON-U.S. SHIPMENTS	21.0	21.1	--	14.8	19.5	35.0	6.0	11.0	205.0	2.0	330.0	450.0	--
WORLDWIDE RECAP													
Captive	17.8	62.9	193.6	12.4	59.3	502.0	5.5	5.0	405.0	2.0	565.0	720.0	45.0
	+64.8%	+265.7%	--	-30.3%	-5.7%	+159.3%	-55.6%	-91.6%	-19.3%	-60.0%	+39.5%	+27.4%	--
PCM/Reseller	--	95.6	58.2	--	17.5	451.0	--	--	840.0	--	1,165.0	1,430.0	--
	--	+295.0%	--	--	-81.7%	+674.9%	--	--	+86.3%	--	+38.7%	+22.7%	--
OEM/Integrator	10.2	178.9	94.8	4.4	41.4	842.5	.5	12.0	2,080.0	--	3,315.0	4,595.0	30.0
	-50.7%	+108.0%	--	-56.9%	-76.9%	+788.7%	-88.6%	-71.0%	+146.9%	--	+59.4%	+38.6%	--
Total Shipments	28.0	337.4	346.6	16.8	118.2	1,795.5	6.0	17.0	3,325.0	2.0	5,045.0	6,745.0	75.0
	-58.4%	+164.8%	--	-40.0%	-65.0%	+418.0%	-64.3%	-85.6%	+85.2%	-88.2%	+51.7%	+33.7%	--
ANNUAL SHARE, BY DIAMETER	3.9%	47.5%	48.6%	.9%	6.1%	93.0%	.2%	.5%	99.3%	--	100.0%	99.0%	1.0%
TOTAL CAPACITY (Terabytes)	76.4	796.1	708.5	46.8	261.0	3,713.5	17.0	39.3	7,096.6	4.2	11,043.0	15,987.3	153.0

Note: 14 inch totals include 10.5 - 14 inch drives.
8 inch totals include 6.5 - 9.5 inch drives.

TABLE 67

FIXED DISK DRIVES, 2 - 3 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	9.8	1.4	27.3	.4
MAINFRAME SYSTEMS General purpose	160.2	22.5	177.3	2.6
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	410.0	57.6	3,273.6	48.0
PERSONAL COMPUTERS Business and professional, single user	--	--	2,796.2	41.0
WORKSTATIONS Engineering and office, single user	132.0	18.5	545.6	8.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	712.0	100.0	6,820.0	100.0

TABLE 68

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1993	1994	1995	1996	1997
Captive					
14"	--	--	--	--	--
8"	6.33	5.98	5.61	--	--
5.25"	2.45	1.96	1.90	1.66	--
3.5"	2.40	1.85	1.23	.85	.67
2.5"	--	--	--	--	.90
Captive Average	2.76	1.99	1.31	.86	.69
PCM/Reseller					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	.73	.65	--	--	--
3.5"	.65	.44	.33	.25	.20
2.5"	--	--	--	--	--
PCM/Reseller Average	.70	.45	.33	.25	.20
OEM/Integrator					
14"	--	--	--	--	--
8"	1.80	1.43	1.28	--	--
5.25"	.67	.57	.47	--	--
3.5"	.60	.41	.31	.24	.17
2.5"	--	--	--	--	.24
OEM/Integrator Average	.70	.42	.31	.24	.18

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.

14 inch totals include 10.5 - 14 inch drives.

8 inch totals include 8 - 9.5 inch drives.

TABLE 69

FIXED DISK DRIVES, 2 - 3 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 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	
Seagate Technology	5.0	157.0	66.0	228.0	64.1	7.0	175.0	77.0	259.0	59.2
Hewlett-Packard	--	33.8	10.1	43.9	12.3	--	47.4	14.3	61.7	14.1
IBM	--	--	32.0	32.0	9.0	--	--	42.0	42.0	9.6
Digital Equipment	--	5.0	12.0	17.0	4.8	--	9.3	19.7	29.0	6.6
Micropolis	--	17.3	--	17.3	4.9	--	22.3	--	22.3	5.1
Other U.S.	--	--	--	--	--	--	--	--	--	--
Other Non-U.S.	1.8	15.7	--	17.5	4.9	3.2	20.5	--	23.7	5.4
TOTAL	6.8	228.8	120.1	355.7	100.0	10.2	274.5	153.0	437.7	100.0

Note: 8 inch totals include 6.5 - 9.5 inch drives.

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

1994 DISK/TREND REPORT

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

Coverage

Examples of disk drives in this group include:

10.8" disk diameter

IBM	3390-3, 3390-9

6.5" disk diameter

Hitachi	H-6588-9, DKU-88I-10

5.25" disk diameter

Fujitsu	Amdahl 6395 series
Micropolis	1936AV, 1991
Seagate Technology	ST410800N/W
Sequel	5350, 5400

3.5" disk diameter

Conner Peripherals	CFP-4207E/W*
IBM	DFHS-34320*, DFMS-35250*
Micropolis	3241*
Quantum	4280S*
Seagate Technology	ST15150N/W*, ST-15230N/W*

*Maximum 41.3 mm height, or less.

For many years the capacity range above 3 gigabytes was the exclusive territory of disk drives intended for mainframe computer applications. The first disk drive in the product group was IBM's 3,781 megabyte 3380K, with 14" disks, introduced in 1987, which in turn was made obsolete by IBM's 3390 series, using 10.8" disks. The 3390-2, with the same 3.7 gigabyte capacity as the 3380-K, but offering performance and price improvements, first shipped in 1989. The 3390-3, with 50% more capacity per spindle and further price reductions per megabyte, shipped in September, 1991. In June, 1993, the 3390-9 appeared, with 3 times more capacity, lower costs, but lower performance.

The various drives using 6.5"-10.5" disks in this capacity range since the late 1980's have been intended for mainframe and supermini applications similar to IBM's, and most use standard industry technology, but generally more conservatively, to facilitate reliable production. The 8" and 9" drives were the first to offer 3

gigabyte capacities for nonmainframe applications, and were used typically in small mainframe, supermini and imaging applications. In recent years, Fujitsu 8" and Hitachi 9.5" drives were included in plug compatible subsystems for mainframe applications equivalent to IBM 3380 and 3390 drives, although the newest PCM models use Fujitsu 5.25" and Hitachi 6.5" disks.

5.25" drives above 3 gigabytes appeared for the first time in late 1992, and are now available from four manufacturers. The 9 gigabyte 5.25" drives available from Seagate Technology and Micropolis starting in 1994 offer the lowest OEM price per megabyte of any drives currently available, and are already in demand for video-on-demand applications and large computer network file servers. IBM utilized magnetoresistive heads and PRML encoding with the firm's Starfire 4.3 and 5.2 gigabyte drives, the first 3.5" drives to pioneer the over 3 gigabyte range. Four additional companies have also announced 3.5" drives in this product group.

Market status

160,000 disk drives were shipped in 1993 in the DISK/TREND product group for drives with more than 3 gigabytes, the smallest total for any product group, but the group's sales revenues of $4.2 billion were the highest for any of the product groups. The high revenue total resulted from the fact that 85% of total unit shipments were used in mainframe applications and were sold at relatively high captive or PCM end user prices. The sales revenue total for drives in this group has been declining during the last few years, and a 17.2% reduction to $3.5 billion is forecasted for 1994, as several factors lower the industry's revenues for drives sold for mainframe usage.

Although the amount of new disk storage capacity sold for use in the IBM compatible mainframe market has continued to increase each year, the typical annual increase is now much smaller than in the last decade, as part of the enterprise system market moves out of the computer room to distributed "client/server" system architecture, taking data storage with it. The result is the sale each year of fewer of the very expensive mainframe drives, and the sale of more network file servers which use 5.25" or 3.5" high-end drives at more modest prices. Further reducing total revenues in this market has been the continuing

drop in price levels for the basic disk storage systems offered by the manufacturers, a trend which is not slowing down as the physical size of the drives continues to shrink.

Both 5.25" and 3.5" drives have enjoyed a surge of shipments in 1994. The new 9 gigabyte 5.25" drives from Seagate and Micropolis have found instant market acceptance in EMC's mainframe disk systems, network file servers and specialized video applications, by offering very high capacities in a limited space and by providing the best price per megabyte available for any disk drives currently available. The 4 gigabyte 3.5" drives are still in limited supply, but will be used in all of the same applications, and will be preferred in many applications with very high transaction rates.

In 1993, 78.2% of the unit shipments of disk drives with more than 3 gigabytes capacity were used with mainframe computers, but only 9% of the 1997 total is expected to be used with the same application. Networks/minicomputer/multiuser applications consumed only 14.6% of 1993 shipments, but are expected to take 70% of 1997 unit shipments. Workstations are expected to grow from 5.8% of 1993 shipments to 12.3% of 1997 shipments, and even personal computers will be a factor in 1997, consuming 8.5% of the total.

Hitachi accounted for 39.5% of the 1993 noncaptive worldwide unit shipment total, mostly with drives used in mainframe PCM/Reseller applications. Micropolis held second position, with 21.4%, all 5.25" drives.

Marketing trends

1997 unit shipments in this product group are projected to be almost 20 times greater than the 1993 total. By that time, all drives using larger diameter disks will be gone, 5.25" drives will start to decline in shipments, and 3.5" drives will dominate shipments, with close to 90% of the total. 1997 unit shipments are projected at 3,100 units, with sales revenues placed at $6.6 billion.

The last shipments of IBM's 3390 mainframe drive series are expected in 1995, replaced by the disk drive array series for which IBM has resurrected the "RAMAC" name it used on the first disk drive 38 years ago. Although offered initially with the 2 gigabyte Allicat 3.5" drive, the RAMAC arrays are expected to

be upgraded by usage of the 4 gigabyte Starfire 3.5" drives in the first half of 1995, with a procession of capacity upgrades using higher density drives to follow thereafter, providing a major boost to captive shipments of 3.5" drives in this product group.

Shipments of 3.5" drives through noncaptive marketing channels are expected to grow even faster, and 1995 shipments of over a million 3.5" drives are projected to provide 71.1% of the product group's overall total. The 1997 forecasted shipments of 2.7 million 3.5" drives will be 88.7% of the group's total for all disk drives.

Worldwide total unit shipments(000)	1993	1994	1995	1996	1997
10"-14"	77.2	44.0	5.6	--	--
	48.3%	8.7%	.4%	--	--
6.5"-9.5"	41.9	40.6	17.5	7.0	--
	26.2%	8.1%	1.2%	.3%	--
5.25"	40.9	276.0	384.5	492.0	350.0
	25.6%	54.9%	27.2%	21.0%	11.3%
3.5" 1.625" high	--	142.3	925.0	1,492.0	2,060.0
	--	28.3%	65.4%	63.6%	66.5%
3.5" 1" high	--	--	82.0	355.0	690.0
	--	--	5.8%	15.1%	22.3%
Total	160.0	502.9	1,414.6	2,346.0	3,100.0

Technical trends

This product group has enjoyed much of the disk drive industry's leading edge development efforts to improve areal density and performance. IBM's Starfire 3.5" drives have areal densities in the range of 560 megabits per square inch, up from 1993's leader, the IBM Spitfire, at 354, and the areal density of the Scorpion drive announced for delivery in the second half of 1995 will be 865 megabits per square inch. It seems clear that IBM will achieve its frequently stated objective of increasing the areal density of its high-end drives by an average of 60% per year, at least through the end of this decade. This rate of improvement will produce drives in 1997 with areal densities of more than 2 gigabits per square inch. At that recording density it will require only one 3.5" disk for each 2 giga-

bytes -- or much higher capacities depending on the encoding method and zoning technique, and whether compression is used. Advances in areal density by IBM and by independent drive and component manufacturers will also make it possible to extend the life of high-end 5.25" drives. The current 9 gigabyte 5.25" drives are expected to be followed by 18 gigabyte models, which will have a very positive effect on 1995/96 shipments by forcing down the price per megabyte to new lows.

The barriers to other companies achieving recording densities comparable to those in IBM's new drives will gradually fall during the next few years. Independent head manufacturers are expected to achieve quantity production capability for magnetoresistive heads, and some other disk drive manufacturers are already starting to use MR heads in production drives. Semiconductor manufacturers are also expected to provide several sources for PRML chips, with adequate data rates. Due to Seagate's pioneering 7,200 RPM Barracuda drive family, other firms will probably be able to find the appropriate drive motors and other scarce components needed for similar performance, and some manufacturers are already working on drives which will use drive motors in the 9,000 RPM range.

Forecasting assumptions

1. IBM will be successful in improving areal density utilized in high-end drives by an average of 60% per year, and other disk drive manufacturers will be able to match the same rate of increase, although 6 to 12 months behind IBM, during the forecast period covered by this report.
2. IBM will upgrade the RAMAC mainframe disk drive array to use 4 gigabyte 3.5" drives in the first half of 1995, and will further upgrade it with higher capacity 3.5" drives in 1996 and 1997.
3. PCM vendors will continue to match IBM's 3390 series with 8"-9.5", and with newly announced 5.25" and 6.5" drives, plus new 9 gigabyte 5.25" models, later adding 3.5" drives to compete with IBM's 1994 RAMAC array subsystem.
4. Shipments of 5.25" drives in OEM/Integrator markets will peak in 1996, with 3.5" drives taking a strong lead in total shipments for the product group starting in 1996.

TABLE 70

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1993 Revenues		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	2,190.0	3,200.0	1,290.0	1,902.4	1,768.2	2,736.5	2,485.2	3,838.0	2,737.5	4,350.0
Other U.S. Captive	9.6	23.0	8.2	17.8	25.2	33.6	76.5	114.8	104.0	160.0
TOTAL U.S. CAPTIVE	2,199.6	3,223.0	1,298.2	1,920.2	1,793.4	2,770.1	2,561.7	3,952.8	2,841.5	4,510.0
PCM/Reseller	27.7	34.9	106.9	139.2	181.9	247.6	228.5	328.2	223.0	335.9
OEM/Integrator	56.0	150.8	484.1	592.7	693.3	849.8	866.0	1,116.0	822.5	1,174.0
TOTAL U.S. NONCAPTIVE	83.7	185.7	591.0	731.9	875.2	1,097.4	1,094.5	1,444.2	1,045.5	1,509.9
TOTAL U.S. REVENUES	2,283.3	3,408.7	1,889.2	2,652.1	2,668.6	3,867.5	3,656.2	5,397.0	3,887.0	6,019.9
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	16.5	--	32.4	--	40.0
PCM/Reseller	348.9	839.7	372.1	859.4	297.0	693.0	151.5	456.8	88.2	352.8
OEM/Integrator	--	--	--	4.5	11.0	44.0	31.5	108.0	45.0	150.0
TOTAL NON-U.S. REVENUES	348.9	839.7	372.1	863.9	308.0	753.5	183.0	597.2	133.2	542.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,632.2	4,248.4	2,261.3	3,516.0	2,976.6	4,621.0	3,839.2	5,994.2	4,020.2	6,562.7
OEM Average Price ($000)		6.309		2.108		1.153		.900		.723

TABLE 71

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1993 Shipments		Forecast 1994		1995		1996		1997	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	50.5	74.0	62.5	91.2	226.6	350.6	327.0	505.0	365.0	580.0
Other U.S. Captive	2.0	4.8	3.0	6.5	9.0	12.0	30.0	45.0	52.0	80.0
TOTAL U.S. CAPTIVE	52.5	78.8	65.5	97.7	235.6	362.6	357.0	550.0	417.0	660.0
PCM/Reseller	13.4	17.2	60.0	79.3	165.0	225.0	255.0	370.0	350.0	530.0
OEM/Integrator	17.8	23.9	255.3	280.3	595.0	735.0	960.0	1,240.0	1,140.0	1,630.0
TOTAL U.S. NONCAPTIVE	31.2	41.1	315.3	359.6	760.0	960.0	1,215.0	1,610.0	1,490.0	2,160.0
TOTAL U.S. SHIPMENTS	83.7	119.9	380.8	457.3	995.6	1,322.6	1,572.0	2,160.0	1,907.0	2,820.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	5.0	--	12.0	--	20.0
PCM/Reseller	16.5	40.1	17.5	42.6	16.0	47.0	14.5	54.0	15.0	60.0
OEM/Integrator	--	--	--	3.0	10.0	40.0	35.0	120.0	60.0	200.0
TOTAL NON-U.S. SHIPMENTS	16.5	40.1	17.5	45.6	26.0	92.0	49.5	186.0	75.0	280.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	100.2	160.0	398.3	502.9	1,021.6	1,414.6	1,621.5	2,346.0	1,982.0	3,100.0
Total Capacity (Terabytes)	610.8	958.5	2,844.5	3,445.9	6,661.5	8,829.3	11,759.6	16,407.8	14,268.5	21,916.6
Cumulative Shipments (Units in thousands)										
IBM	354.0	532.2	416.5	623.4	643.1	974.0	970.1	1,479.0	1,335.1	2,059.0
Non-IBM	58.8	109.0	394.6	520.7	1,189.6	1,584.7	2,484.1	3,425.7	4,101.1	5,945.7
WORLDWIDE TOTAL	412.8	641.2	811.1	1,144.1	1,832.7	2,558.7	3,454.2	4,904.7	5,436.2	8,004.7

TABLE 72

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1993 Revenues			Forecast												
				1994				1995				1996			1997	
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																
IBM Captive	3,200.0	--	--	1,502.4	--	--	400.0	169.7	--	--	2,566.8	--	--	3,838.0	--	4,350.0
Other U.S. Captive	--	--	23.0	--	--	10.8	7.0	--	--	--	33.6	--	--	114.8	--	160.0
PCM/Reseller	--	--	34.9	--	--	114.6	24.6	--	--	97.5	150.1	--	100.0	228.2	63.0	272.9
OEM/Integrator	99.0	11.4	40.4	83.6	--	428.7	80.4	--	--	453.6	396.2	--	492.0	624.0	280.0	894.0
TOTAL U.S. REVENUES	3,299.0	11.4	98.3	1,586.0	--	554.1	512.0	169.7	--	551.1	3,146.7	--	592.0	4,805.0	343.0	5,676.9
NON-U.S. MANUFACTURERS																
Captive	--	--	--	--	--	--	--	--	--	--	16.5	--	--	32.4	--	40.0
PCM/Reseller	3.6	836.1	--	--	789.4	70.0	--	--	420.0	108.0	165.0	140.0	40.0	276.8	--	352.8
OEM/Integrator	--	--	--	--	--	--	4.5	--	--	--	44.0	--	--	108.0	--	150.0
TOTAL NON-U.S. REVENUES	3.6	836.1	--	--	789.4	70.0	4.5	--	420.0	108.0	225.5	140.0	40.0	417.2	--	542.8
WORLDWIDE RECAP																
Captive	3,200.0	--	23.0	1,502.4	--	10.8	407.0	169.7	--	--	2,616.9	--	--	3,985.2	--	4,550.0
	-22.5%	--	--	-53.0%	--	-53.0%	--	-88.7%	--	--	+543.0%	--	--	+52.3%	--	+14.2%
PCM/Reseller	3.6	836.1	34.9	--	789.4	184.6	24.6	--	420.0	205.5	315.1	140.0	140.0	505.0	63.0	625.7
	--	--	--	--	-5.6%	+428.9%	--	--	-46.8%	+11.3%	--	-66.7%	-31.9%	+60.3%	-55.0%	+23.9%
OEM/Integrator	99.0	11.4	40.4	83.6	--	428.7	84.9	--	--	453.6	440.2	--	492.0	732.0	280.0	1,044.0
	-46.3%	--	--	-15.6%	--	+961.1%	--	--	--	+5.8%	+418.5%	--	+8.5%	+66.3%	-43.1%	+42.6%
Total Revenues	3,302.6	847.5	98.3	1,586.0	789.4	624.1	516.5	169.7	420.0	659.1	3,372.2	140.0	632.0	5,222.2	343.0	6,219.7
	-23.4%	--	--	-52.0%	-6.9%	+534.9%	--	-89.3%	-46.8%	+5.6%	+552.9%	-66.7%	-4.1%	+54.9%	-45.7%	+19.1%
ANNUAL SHARE, BY DIAMETER	77.8%	19.9%	2.3%	45.2%	22.5%	17.8%	14.5%	3.7%	9.1%	14.3%	72.9%	2.3%	10.5%	87.2%	5.2%	94.8%

Note: 14 inch totals include 10 inch - 14 inch drives.
8 inch totals include 6.5 - 9.5 inch drives.

TABLE 73

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1993 Shipments			Forecast												
				1994				1995				1996			1997	
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																
IBM Captive	74.0	--	--	41.2	--	--	50.0	5.6	--	--	345.0	--	--	505.0	--	580.0
Other U.S. Captive	--	--	4.8	--	--	4.0	2.5	--	--	--	12.0	--	--	45.0	--	80.0
PCM/Reseller	--	--	17.2	--	--	59.0	20.3	--	--	65.0	160.0	--	80.0	290.0	70.0	460.0
OEM/Integrator	3.0	2.0	18.9	2.8	--	211.0	66.5	--	--	315.0	420.0	--	410.0	830.0	280.0	1,350.0
TOTAL U.S. SHIPMENTS	77.0	2.0	40.9	44.0	--	274.0	139.3	5.6	--	380.0	937.0	--	490.0	1,670.0	350.0	2,470.0
NON-U.S. MANUFACTURERS																
Captive	--	--	--	--	--	--	--	--	--	--	5.0	--	--	12.0	--	20.0
PCM/Reseller	.2	39.9	--	--	40.6	2.0	--	--	17.5	4.5	25.0	7.0	2.0	45.0	--	60.0
OEM/Integrator	--	--	--	--	--	--	3.0	--	--	--	40.0	--	--	120.0	--	200.0
TOTAL NON-U.S. SHIPMENTS	.2	39.9	--	--	40.6	2.0	3.0	--	17.5	4.5	70.0	7.0	2.0	177.0	--	280.0
WORLDWIDE RECAP																
Captive	74.0	--	4.8	41.2	--	4.0	52.5	5.6	--	--	362.0	--	--	562.0	--	680.0
	-14.0%	--	--	-44.3%	--	-16.7%	--	-86.4%	--	--	+589.5%	--	--	+55.2%	--	+21.0%
PCM/Reseller	.2	39.9	17.2	--	40.6	61.0	20.3	--	17.5	69.5	185.0	7.0	82.0	335.0	70.0	520.0
	--	--	--	--	+1.8%	+254.7%	--	--	-56.9%	+13.9%	+811.3%	-60.0%	+18.0%	+81.1%	-14.6%	+55.2%
OEM/Integrator	3.0	2.0	18.9	2.8	--	211.0	69.5	--	--	315.0	460.0	--	410.0	950.0	280.0	1,550.0
	-33.3%	--	--	-6.7%	--	--	--	--	--	+49.3%	+561.9%	--	+30.2%	+106.5%	-31.7%	+63.2%
Total Shipments	77.2	41.9	40.9	44.0	40.6	276.0	142.3	5.6	17.5	384.5	1,007.0	7.0	492.0	1,847.0	350.0	2,750.0
	-14.7%	--	--	-43.0%	-3.1%	+574.8%	--	-87.3%	-56.9%	+39.3%	+607.7%	-60.0%	+28.0%	+83.4%	-28.9%	+48.9%
ANNUAL SHARE, BY DIAMETER	48.4%	26.2%	25.4%	8.7%	8.1%	55.0%	28.2%	.4%	1.2%	27.3%	71.1%	.3%	21.1%	78.6%	11.3%	88.7%
TOTAL CAPACITY (Terabytes)	574.0	218.7	165.8	363.2	248.2	2,242.3	592.2	49.9	210.0	4,627.5	3,941.9	105.0	7,384.0	8,918.9	5,950.0	15,966.6

Note: 14 inch totals include 10 inch - 14 inch drives.
8 inch totals include 6.5 - 9.5 inch drives.

TABLE 74

WORLDWIDE SHIPMENTS OF IBM CAPTIVE AND PLUG COMPATIBLE FIXED DISK DRIVES

USED WITH MAINFRAME COMPUTER APPLICATIONS

	DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)									
	1993 Shipments		FORECAST							
			1994		1995		1996		1997	
	US	WW	US	WW	US	WW	US	WW	US	WW
3380K Type (3780 MB)										
PCM	.7	1.4	--	--	--	--	--	--	--	--
3390-2 type (3784 MB)										
PCM	1.7	6.3	.5	2.6	--	--	--	--	--	--
3390-3 type (5676 MB)										
IBM	42.0	62.0	21.0	32.0	2.5	4.0	--	--	--	--
PCM	14.1	32.5	14.3	36.0	6.0	15.0	2.5	6.0	--	--
3390-9 type (17028 MB)										
IBM	8.5	12.0	6.5	9.2	1.1	1.6	--	--	--	--
PCM	--	--	2.7	4.0	5.0	7.0	2.0	3.0	--	--
9345 type (1500 MB)										
IBM	13.0	20.0	2.0	3.0	--	--	--	--	--	--
Subsystems with array capability										
PCM (5.25/3.5", 2300 MB)	27.8	42.7	46.0	65.0	46.0	70.0	26.0	40.0	6.0	10.0
PCM (5.25", 9000 MB)	--	--	7.3	9.7	9.0	13.0	6.0	10.0	3.0	4.0
IBM (3.5", 1419 MB)	--	--	40.0	60.0	16.0	25.0	--	--	--	--
IBM (3.5", 2838 MB)	--	--	--	--	98.0	150.0	20.0	30.0	--	--
PCM (3.5", 2838 MB)	--	--	--	--	22.0	35.0	9.0	15.0	3.0	5.0
IBM (3.5", 5676 MB)	--	--	--	--	--	--	82.0	125.0	105.0	165.0
PCM (3.5", 5676 MB)	--	--	--	--	--	--	16.0	25.0	45.0	70.0
TOTAL SPINDLES	107.8	176.9	140.3	221.5	205.6	320.6	163.5	254.0	162.0	254.0
TOTAL FORMATTED CAPACITY (Terabytes)		898.1		947.0		1,092.8		1,246.3		1,407.1
		+18.5%		+5.4%		+15.4%		+14.1%		+12.9%

NOTES: When PCM drives are designed to emulate specific IBM drive models, quantities of such drives are counted in units equivalent in capacity to IBM individual spindles, even though different disk diameters and physical file organizations may be used. In some cases, an "equivalent" PCM spindle may be composed of two or more physical spindles in order to equal the capacity of a specific IBM spindle. In the case of PCM drives which do not match the capacities of specific IBM models, average capacities per spindle are used. For disk drive arrays such as IBM's RAMAC, capacities shown are net available capacities per spindle for all of the drives used in the array.

TABLE 75

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1993 Estimate Units (000)	1993 Estimate %	1997 Projection Units (000)	1997 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	2.2	1.4	6.2	.2
MAINFRAME SYSTEMS				
General purpose	125.1	78.2	279.0	9.0
NETWORKS/MINI/MULTIUSER				
Midrange systems and network servers	23.4	14.6	2,170.0	70.0
PERSONAL COMPUTERS				
Business and professional, single user	--	--	263.5	8.5
WORKSTATIONS				
Engineering and office, single user	9.3	5.8	381.3	12.3
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	160.0	100.0	3,100.0	100.0

TABLE 76

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1993	1994	1995	1996	1997
Captive					
14"	5.75	4.44	3.39	--	--
8"	--	--	--	--	--
5.25"	1.30	.67	--	--	--
3.5"	--	1.79	1.97	1.42	1.09
2.5"	--	--	--	--	--
Captive Average	5.61	3.30	2.02	1.42	1.09
PCM/Reseller					
14"	4.50	--	--	--	--
8"	3.93	3.18	2.00	1.33	--
5.25"	.64	.43	.24	.11	.05
3.5"	--	.30	.42	.31	.20
2.5"	--	--	--	--	--
PCM/Reseller Average	3.26	1.32	.52	.26	.16
OEM/Integrator					
14"	5.82	3.35	--	--	--
8"	1.83	--	--	--	--
5.25"	.43	.23	.12	.08	.05
3.5"	--	.29	.23	.16	.11
2.5"	--	--	--	--	--
OEM/Integrator Average	1.28	.28	.15	.11	.09

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.

14 inch totals include 10 inch - 14 inch drives.

8 inch totals include 6.5 - 9.5 inch drives.

TABLE 77

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1993 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
Hitachi	--	11.5	--	11.5	24.1	--	32.1	--	32.1	39.5
Micropolis	--	--	15.2	15.2	31.9	--	--	17.4	17.4	21.4
Other U.S.	.3	2.0	13.7	16.0	33.5	3.0	2.0	18.7	23.7	29.2
Other Non-U.S.	.1	4.9	--	5.0	10.5	.2	7.8	--	8.0	9.9
TOTAL	.4	18.4	28.9	47.7	100.0	3.2	41.9	36.1	81.2	100.0

Note: 14 inch totals include 10.5 - 14 inch drives.
8 inch totals include 6.5 - 9.5 inch drives.

RIGID DISK DRIVE SPECIFICATIONS

1994 DISK/TREND REPORT

RIGID MAGNETIC DISK DRIVE SPECIFICATIONS

Coverage

This section includes most rigid disk drives intended for computer data storage which are now in new production or announced, arranged alphabetically by manufacturer.

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 IBM's disk drives and those produced by some other system manufacturers, captive drives which are similar to OEM/Integrator models made by the same manufacturer are not listed.

Capacities

Formatted capacity is used to determine the appropriate DISK/TREND product group for each drive. Prior to 1992, drives were grouped according to unformatted capacity, but the industry movement to embedded controllers eventually made that practice obsolete, since the majority of drives now are specified in formatted capacities.

In the specifications, capacities are listed as "U" for unformatted or "F" for formatted. In general, unformatted capacities are shown only for OEM/Integrator and PCM/Reseller drives without embedded controllers, and formatted capacities are given for captive drives and noncaptive drives with embedded controllers, such as SCSI or PC/AT. Capacities per track are listed, except for drives with zoned recording, in which each band of tracks has a different capacity.

Average access time

All DISK/TREND specifications use the term "average access time" to describe the combination of average positioning time and average 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 highest 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, or the data rate between the drive and its controller, if the controller is not embedded. If the manufacturer has specified more than one communication mode (such as synchronous and asynchronous for SCSI drives, or PIO and DMA for IDE drives), 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, 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.

1994 DISK/TREND product groups for rigid magnetic disk drives

Removable magnetic media:
1. Disk cartridge drives

Fixed magnetic media:
2. Fixed disk drives, less than 100 megabytes
3. Fixed disk drives, 100-200 megabytes
4. Fixed disk drives, 200-300 megabytes
5. Fixed disk drives, 300-500 megabytes
6. Fixed disk drives, 500 MB - 1 gigabyte
7. Fixed disk drives, 1 - 2 gigabytes
8. Fixed disk drives, 2 - 3 gigabytes
9. Fixed disk drives, more than 3 gigabytes

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	AMDAHL
DRIVE	DR312C	DR312D	DR322C	DR322D	6390-A/B24 6390-A/B28 6390-A/B2C 6390-A/B2F
DISK/TREND GROUP	4	4	6	6	7
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Thin Film
Interface	PC AT	SCSI-2	PC AT	SCSI-2	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245.6	F: 245.6	F: 545.3	F: 545.3	F: 1,892
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,160	F: 28,160	Varies by zone	Varies by zone	F: 56,664
Data surfaces per spindle	4	4	4	4	15
Tracks per surface	2180	2180	3623	3623	2226
Track density (TPI)	2540	2540	4097	4097	2050
Maximum linear density (BPI) (FCI)	49393 37044	49393 37044	56370 42278	56370 42278	32733 24550
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3448	3448	4510	4510	4348
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	13	13	12	12	10.7
Average rotational delay (msec)	8.7	8.7	6.7	6.7	6.9
Average access time (msec)	21.7	21.7	18.7	18.7	17.6
Data transfer rate (KBytes/sec)	8000	8000 synch. 4000 asynch.	8000	10000 synch. 4000 asynch.	4500
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	--
FIRST CUSTOMER SHIPMENT	4/93	4/93	9/93	9/93	4Q91
COMMENTS					PCM 3390 Drive has 4, 8, 12, or 16 spindles Mfr. by Fujitsu

MANUFACTURER	AMDAHL	AMDAHL	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY
DRIVE	6390-A/B34 6390-A/B38 6390-A/B3C 6390-A/B3F	6395-A 6395-A9C 6395-A9X	A130	A135	A175
DISK/TREND GROUP	9	9	3	3	3
MARKET	PCM	PCM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	210 mm OD 100 mm ID	130 mm OD 40 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	Thin Film	MR Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,838/3,390	F: 4,255	F: 131.48	F: 131.48	F: 175.10
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	20	2	2	2
Tracks per surface	3339/3987	3339	1438	1438	2120
Track density (TPI)			2763	2763	3920
Maximum linear density (BPI) (FCI)			80000 60000	80000 60000	74240 55667
Recording code	1,7 RLL		1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4348	4340	2981	2981	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	11.5/13	14.5	15	15	13
Average rotational delay (msec)	6.9	6.9	10.1	10.1	8.3
Average access time (msec)	18.4/19.9	21.4	25.1	25.1	21.3
Data transfer rate (KBytes/sec)	4500	4500	2280	2280	2485
SIZE: (mm) H x W x D	--	--	12.5 x 69.9 x 87.6	10 x 69.9 x 87.6	12.3 x 69.9 x 87.6
FIRST CUSTOMER SHIPMENT	9/92	3Q94	6/93	8/93	8/94
COMMENTS	PCM 3390-3 Drive has 4, 8, 12, or 16 spindles Mfr. by Fujitsu	PCM 3390-9 Drive has 4, 8, 12, 16, 20, 24, 28 or 32 spindles. Mfr. by Fujitsu	*Glass disk	*Glass disk	*Glass disk

MANUFACTURER	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY
DRIVE	A260	A265	A340	A345	A520
DISK/TREND GROUP	4	4	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 262.96	F: 262.96	F: 350.20	F: 350.20	F: 526.42
REMOVABLE	--	--	--	--	--
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	6
Tracks per surface	1438	1502	2120	2106	2120
Track density (TPI)	2763	2884	3920	4029	3920
Maximum linear density (BPI) (FCI)	80000 60000	77500 58120	74240 55667	74240 55667	74240 55667
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	2981	3600	3600	3600	3600
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	13	13	13	13
Average rotational delay (msec)	10.1	8.3	8.3	8.3	8.3
Average access time (msec)	25.1	21.3	21.3	21.3	21.3
Data transfer rate (KBytes/sec)	2280	2550	2485	2485	2485
SIZE: (mm) H x W x D	15.2 x 69.9 x 87.6	12.7 x 69.9 x 87.6	15 x 69.9 x 88.9	12.7 x 69.9 x 88.9	15 x 69.9 x 88.9
FIRST CUSTOMER SHIPMENT	9/93	8/94	8/94	9/94	10/94
COMMENTS	*Glass disk	*Glass disk	*Glass disk	*Glass disk	*Glass disk

MANUFACTURER	AREAL TECHNOLOGY	AURA ASSOCIATES	AURA ASSOCIATES	AURA ASSOCIATES	AURA ASSOCIATES
DRIVE	A700	AU1085I	AU1085P-III	AU63-III	AU1126I
DISK/TREND GROUP	6	2	2	2	3
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
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	PC AT	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 702.64	F: 85.3	--	--	F: 125.9
REMOVABLE	--	--	F: 85	F: 62.9	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	4	2	2	4
Tracks per surface	2120	1125	1498	1500	1410
Track density (TPI)	3920	2550	3336	3200	3200
Maximum linear density (BPI) (FCI)	74240 55667	49300 36990	72000 54000	57000 43000	59140 44355
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	5400	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	15	16	16	16
Average rotational delay (msec)	8.3	5.6	5.6	5.5	5.6
Average access time (msec)	21.3	20.6	21.6	21.5	21.6
Data transfer rate (KBytes/sec)	2485	4500	5000	5000	4500
SIZE: (mm) H x W x D	19 x 69.9 x 88.9	15 x 50.8 x 76.8	10.5 x 54 x 85.6	10.5 x 54 x 85.6	15 x 50.8 x 76.8
FIRST CUSTOMER SHIPMENT	1Q95	2Q93	1Q95	4Q93	4Q93
COMMENTS	*Glass disk		PCMCIA Type III	PCMCIA Type III	

MANUFACTURER	AURA ASSOCIATES	AVATAR SYSTEMS	AVATAR SYSTEMS	AVATAR SYSTEMS	AVATAR SYSTEMS
DRIVE	AU1170P-III	ASR-2085NI ASR-2085NS Remington	ASR-2128HI Maxim	ASR-3085FI ASR-3085FS Magnum	ASR-3085NI ASR-3085NS Colt
DISK/TREND GROUP	3	1	1	1	1
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	SCSI-2, PC AT	PC AT	SCSI-2, PC AT	SCSI-2, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 170	F: 85.9	F: 85.9	F: 85.9	F: 85.9
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	2	2	2
Tracks per surface	1498	1730	1730	1730	1730
Track density (TPI)	3336	3100	3100	3100	3100
Maximum linear density (BPI) (FCI)	72000 54000	52100 39075	52100 39075	52100 39075	52100 39075
Recording code	1,7 RLL	1, 7 RLL	1, 7 RLL	1, 7 RLL	1, 7 RLL
Rotational speed (RPM)	5400	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)	16	12	12	12	12
Average rotational delay (msec)	5.6	6.7	6.7	6.7	6.7
Average access time (msec)	21.6	18.7	18.7	18.7	18.7
Data transfer rate (KBytes/sec)	5000	1200	1200	1200	1200
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	19 x 72.4 x 101.6	22 x 72.4 x 101.6	25.4 x 101.6 x 146.1	12.7 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q95	2/94	4Q94	2/94	1Q95
COMMENTS	PCMCIA Type III	Removable data cartridge *Glass disk	Removable data cartridge *Glass disk. Includes H-P 1.3" Kittyhawk 42.8 MB drive	Removable data cartridge *Glass disk. Includes 3.5" 1.44 MB floppy drive	Removable data cartridge *Glass disk

MANUFACTURER	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY
DRIVE	CT-80	CT-80MC	CT-105MC	CT-130MC	CT-170
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
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	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 85.33	--	--	--	--
REMOVABLE	--	F: 85.33	F: 105	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	1084	1084	832	1010	1467
Track density (TPI)	2490	2490	2490	2840	3300
Maximum linear density (BPI) (FCI)	50411 37808	50411 37808	62244 46683	67580 50685	98000 73500
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)	18	18	18	18	16
Average rotational delay (msec)	6.25	6.25	6.25	6.25	6.25
Average access time (msec)	24.25	24.25	24.25	24.25	22.25
Data transfer rate (KBytes/sec)	4000	4000	4000	4000	11000
SIZE: (mm) H x W x D	10 x 50.8 x 78	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	4/93	4/93	12/93	5/94	9/94
COMMENTS		PCMCIA Type III	PCMCIA Type III	PCMCIA Type III	PCMCIA Type III

MANUFACTURER	CALLUNA TECHNOLOGY	COMPAREX	COMPAREX	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CT-210	6490-A24 6490-A28 6490-B24 6490-B28 6490-B2C	6490-A34 6490-A38 6490-B34 6490-B38 6490-B3C	CFN-250A FilePro Notebook Trigger	CFN-250S FilePro Notebook Trigger
DISK/TREND GROUP	4	7	8	4	4
MARKET	OEM	PCM	PCM	OEM	OEM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	9.5"	9.5"	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film, MIG	Thin Film, MIG
Interface	PCMCIA-ATA	IBM	IBM	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 1,892	F: 2,838	F: 252.7	F: 252.7
REMOVABLE	F: 210	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 56,664	F: 56,664	Varies by zone	Varies by zone
Data surfaces per spindle	4	15	15	6	6
Tracks per surface	1602	2226	3339	1339	1339
Track density (TPI)	3600	*	*	2611	2611
Maximum linear density (BPI) (FCI)	111333 83500	*	*	58230 43684	58230 43684
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4800	4260	4260	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	16	10	12.5	12	12
Average rotational delay (msec)	6.25	7.1	7.1	6.7	6.7
Average access time (msec)	22.25	17.1	19.6	18.7	18.7
Data transfer rate (KBytes/sec)	11000	4200	4200	8000	6000 synch. 3000 asynch.
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	--	--	19.5 x 69.8 x 101.6	19.5 x 69.8 x 101.6
FIRST CUSTOMER SHIPMENT	4Q94	4Q90	2Q92	4Q93	4Q93
COMMENTS	PCMCIA Type III	PCM 3390-2. Drive has 4,8, or 12 spindles. *Not announced. 2 heads/surface Mfr. by Hitachi	PCM 3390-3. Drive has 4,8, or 12 spindles. *Not announced. 2 heads/surface Mfr. by Hitachi		

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFS-210A FilePro Bobcat	CFS-270A FilePro Cabo	CFA-340 FilePro II Advantage	CFA-425A FilePro Advantage Steamboat	CFA-425S FilePro Advantage Steamboat
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film, MIG	Thin Film, MIG	MIG	Thin Film	Thin Film
Interface	PC AT	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 213.4	F: 270	F: 343	F: 426	F: 426
REMOVABLE	--	--	--	--	--
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	4	2	2
Tracks per surface	2388	2595	2111	3613	3613
Track density (TPI)	2774	2988	2553	3833	3833
Maximum linear density (BPI) (FCI)	58566 43924	68000 51000	56833 42622	77350 58012	77350 58012
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3400	4011	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)	14	15	13	12	12
Average rotational delay (msec)	8.3	8.8	7.5	6.7	6.7
Average access time (msec)	22.3	23.8	20.5	18.7	18.7
Data transfer rate (KBytes/sec)	11100	11100 PIO* 13300 DMA**	10000 synch.	16700 PIO* 16700 DMA**	5000 synch. 2500 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	11/94		8/94	8/94
COMMENTS		*PIO Mode 3 **DMA Mode 1		*PIO Mode 4 M3=11.1 MB/sec **DMA Mode 2 M2=13.3 MB/sec.	

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFL-350A FilePro Notebook Trigger	CFL-420A FilePro Notebook Kiwi	CFN-340A FilePro Notebook Trigger	CFS-420A FilePro Bobcat	CFS-425A FilePro Cabo
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film, MIG	Thin Film, MIG	Thin Film, MIG	Thin Film, MIG
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 350	F: 422	F: 344.5	F: 426.8	F: 425
REMOVABLE	--	--	--	--	--
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	6	4	2
Tracks per surface	2225	2393	1598	2388	3687
Track density (TPI)	4110	4200	3004	2774	3840
Maximum linear density (BPI) (FCI)	70600 52950	80000 60000	65564 49173	58566 43924	75000 57000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3750	3600	4000	3600	3600
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	14	15
Average rotational delay (msec)	8	8.3	6.7	8.3	8.3
Average access time (msec)	20	20.3	19.7	22.3	23.3
Data transfer rate (KBytes/sec)	11100 PIO*	11100 PIO*	8000	7500	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	12.7 x 69.8 x 101.6	12.7 x 69.8 x 101.6	19.5 x 69.8 x 101.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q94	1Q95	4Q93	4Q93	11/94
COMMENTS	*PIO Mode 3	*PIO Mode 3			*PIO Mode 3 **DMA Mode 1

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFA-540A FilePro III Advantage	CFA-540S FilePro III Advantage	CFA-850A FilePro Advantage Steamboat	CFA-850S FilePro Advantage Steamboat	CFS-540A FilePro Cabo
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film, MIG	Thin Film, MIG	Thin Film	Thin Film	Thin Film, MIG
Interface	PC AT	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 541	F: 541	F: 852	F: 852	F: 541
REMOVABLE	--	--	--	--	--
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	2805	2805	3613	3613	2574
Track density (TPI)	3253	3253	3833	3833	2990
Maximum linear density (BPI) (FCI)	62500 46850	62500 46850	77350 58012	77350 58012	70000 52000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4500	3600
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	15
Average rotational delay (msec)	6.7	6.7	6.7	6.7	8.3
Average access time (msec)	18.7	18.7	18.7	18.7	23.3
Data transfer rate (KBytes/sec)	10000	10000 synch. 5000 asynch.	16700 PIO* 16700 DMA**	10000 synch. 5000 asynch.	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	4Q93	8/94	8/94	11/94
COMMENTS			*PIO Mode 4 M3=11.1 MB/sec **DMA Mode 2 M1=13.3 MB/ sec.		*PIO Mode 3 **DMA Mode 1

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFS-850A FilePro Cabo	CFA-1080A FilePro IV Advantage	CFA-1275A FilePro Advantage Steamboat	CFA-1275S FilePro Advantage Steamboat	CFP-1080E FilePro Performance Antiqua
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film, MIG	Thin Film, MIG	Thin Film	Thin Film	Thin Film, MIG
Interface	PC AT	PC AT	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 850	F: 1,080	F: 1,278	F: 1,278	F: 1,080
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	8	6	6	6
Tracks per surface	3687	2842	3613	3613	3658
Track density (TPI)	3833	3245	3833	3833	3833
Maximum linear density (BPI) (FCI)	75000 57000	65000 48740	77350 58012	77350 58012	64000 48000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	4500	4500	4500	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)	15	10.5	12	12	11
Average rotational delay (msec)	8.3	6.7	6.7	6.7	5.6
Average access time (msec)	23.3	17.2	18.7	18.7	16.6
Data transfer rate (KBytes/sec)	11100 PIO* 13300 DMA**	10000	16700 PIO* 16700 DMA**	10000 synch. 5000 asynch.	20000 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	11/94	4Q93	8/94	8/94	11/94
COMMENTS	*PIO Mode 3 **DMA Mode 1		*PIO Mode 4 M3=11.1 MB/sec **DMA Mode 2 M1=13.3 MB/ sec.		

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFP-1080S FilePro Performance Antiqua	CFS-1275A FilePro Cabo	CFP-2105E CFP-2105S FilePro Performance Cayman	CFP-2105W FilePro Performance Cayman	CFP-2107E CFP-2107S FilePro Performance Cayman
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film, MIG	Thin Film, MIG	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	PC AT	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,278	F: 2,147	F: 2,147	F: 2,147
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	6	10	10	10
Tracks per surface	3658	3687	3892	3892	3924
Track density (TPI)	3833	3833	4030	4030	4010
Maximum linear density (BPI) (FCI)	64000 48000	75000 57000	78000 58500	78000 58500	78000 58500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	3600	5400	5400	7200
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)	11	15	8.5 RD/9.0 WR	8.5 RD/9.0 WR	8.5 RD/9.0 WR
Average rotational delay (msec)	5.6	8.3	5.6	5.6	4.17
Average access time (msec)	16.6	23.3	14.1 RD/14.6 WR	14.1 RD/14.6 WR	12.67/13.17
Data transfer rate (KBytes/sec)	10000 synch.	11100 PIO* 13300 DMA**	20000 synch.	10000 synch.	20000 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	11/94	11/94	10/94	10/94	10/94
COMMENTS		*PIO Mode 3 **DMA Mode 1			

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	DIGITAL EQUIPMENT	DIGITAL EQUIPMENT
DRIVE	CFP-2107W FilePro Performance Cayman	CFP-4207E CFP-4207S FilePro Performance Cayman	CFP-4207W FilePro Performance Cayman	RF36	RZ26L
DISK/TREND GROUP	8	9	9	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive	Captive
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI-2	SCSI-2	SCSI-2	DSSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,147	F: 4,220	F: 4,220	F: 1,600	F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	10	20	20	16	8
Tracks per surface	3924	3924	3924	2651	3117
Track density (TPI)	4010	4055	4055	2756	3256
Maximum linear density (BPI) (FCI)	78000 58500	78000 58500	78000 58500	54100 40575	61509 46131
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	7200	5400	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)	8.5 RD/9.0 WR	9.0 RD/9.5 WR	9.0 RD/9.5 WR	9.5	9.5
Average rotational delay (msec)	4.17	4.17	4.17	5.6	5.6
Average access time (msec)	12.67/13.17	13.17/13.67	13.17/13.67	15.1	15.1
Data transfer rate (KBytes/sec)	10000 synch.	21000 synch.	10000 synch.	4000	10000-20000 syn 5000-10000 asyn
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/94	10/94	10/94	5/93	10/93
COMMENTS					

MANUFACTURER	DIGITAL EQUIPMENT	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR
DRIVE	RZ28	3055 Capella	DSP3053L	3110 Capella	DSP3105
DISK/TREND GROUP	8	6	6	7	7
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,103	U: 689 F: 551	F: 535	U: 1,379 F: 1,103	U: 1,342 F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 29,184
Data surfaces per spindle	16	4	4	8	14
Tracks per surface	3042	3115	3100	3115	2570
Track density (TPI)	3318	3256	3218	3256	2756
Maximum linear density (BPI) (FCI)	60431 45323	57996 43497	60431 45323	57996 43497	56000 42000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	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)	9.5	8.5 RD/9.5 WR	9.5	8.5 RD/9.5 WR	9.5
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	15.1	14.1/15.1	15.1	14.1/15.1	15.1
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	20000 synch.* 10000 asynch.*	20000 synch. 10000 asynch.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	7/93	3Q94	3Q93	3Q94	3/92
COMMENTS			*16 bit		

MANUFACTURER	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR
DRIVE	DSP3107L	DSP3133L	DSP3160	VP3107	3221 Capella
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,070	F: 1,337.5	U: 2,045 F: 1,600	U: 1,225 F: 1,075	U: 2,812 F: 2,206
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	10	16	5	8
Tracks per surface	3100	3100	2599	3832	4125
Track density (TPI)	3218	3218	2756	3858	4350
Maximum linear density (BPI) (FCI)	60431 45323	60431 45323	54000 40500	72490 54368	92000 69000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	7200	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)	9.5	9.5	10	9	8 RD/9 WR
Average rotational delay (msec)	5.6	5.6	5.6	4.17	5.6
Average access time (msec)	15.1	15.1	15.6	13.17	13.6/14.6
Data transfer rate (KBytes/sec)	20000 synch.* 10000 asynch.*	20000 synch.* 10000 asynch.*	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q93	3Q93	3/93	2Q94	4Q94
COMMENTS	*16 bit	*16 bit			

MANUFACTURER	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR	DIGITAL EQUIPMENT-AVASTOR
DRIVE	DSP3210	VP3215	DSP5300	DSP5350	DSP5400
DISK/TREND GROUP	8	8	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,103	U: 2,450 F: 2,150	F: 3,000	U: 4,300 F: 3,500	F: 4,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	16	10	20	25	26
Tracks per surface	3042	3832	3035	3035	3035
Track density (TPI)	3218	3858	2756	2756	2756
Maximum linear density (BPI) (FCI)	60431 45323	72490 54368		44000 33000	50500 37875
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	7200	5400	5400	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)	10	9	11.5	11.5	11.5
Average rotational delay (msec)	5.6	4.17	5.6	5.6	5.6
Average access time (msec)	15.6	13.17	17.1	17.1	17.1
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	2Q93	2Q94	8/93	1Q93	8/93
COMMENTS					

MANUFACTURER	DIGITAL EQUIPMENT-AVASTOR	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	SP3430	FK202A-80R	FK202S-80R	FK303-52	FK309-26
DISK/TREND GROUP	9	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	MIG	Ferrite	Ferrite
Interface	SCSI-2	PC AT	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 4,901 F: 4,300	F: 84.9	F: 84.9	U: 51.2	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F:	F:	U: 10,416	U: 10,416
Data surfaces per spindle	20	4	4	8	4
Tracks per surface	3832	1012	1012	615	615
Track density (TPI)	3858	1881	1881	753	753
Maximum linear density (BPI) (FCI)	72284 54213	48500 36375	48500 36375	15600	15600
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	MFM	MFM
Rotational speed (RPM)	7200	3450	3450	3350	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9	19	19	40 (including settling)	65 (including settling)
Average rotational delay (msec)	4.17	8.7	8.7	8.96	8.96
Average access time (msec)	13.17	27.7	27.7	48.96	73.96
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.			625	625
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	19.05 x 70 x 101.6	19.05 x 70 x 101.6	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q94	1991	1991	8/87	4/87
COMMENTS					

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK309S-26R	FK309S-50R	FK314S-45R	FK314S-90R	FK204S-160Z
DISK/TREND GROUP	2	2	2	2	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	SCSI	SCSI	SCSI	SCSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 22.5	F: 42.5	F: 45.12	F: 91.0	F: 170
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 9,216	F: 16,896	F:	F: 20,400	Varies by zone
Data surfaces per spindle	4	4	2	4	4
Tracks per surface	615	615	1106	1113	1420
Track density (TPI)	880	880	1440	1440	2540
Maximum linear density (BPI) (FCI)	14200 9466	25600 17066	33500 25125	33500 25125	49000 36800
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3350	3150	3540	3540	4300
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	47 (including settling)	47 (including settling)	25	25	15
Average rotational delay (msec)	8.95	9.52	8.47	8.5	7
Average access time (msec)	55.95	56.52	33.47	33.5	22
Data transfer rate (KBytes/sec)	645	1093		1500	2790
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	19.05 x 70 x 101.6
FIRST CUSTOMER SHIPMENT	1Q88	1Q88	1991	4Q90	1993
COMMENTS					

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK317S-210R	FK317S-240R	FK319A-240R	FK319S-240R	FK319A-360Z
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 210.1	F: 249.5	F: 240	F: 240	F: 360
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F:	F: 29,696	F: 29,696	Varies by zone
Data surfaces per spindle	6	6	4	4	4
Tracks per surface	1319	1510	2114	2114	2420
Track density (TPI)	1880	1880	2540	2540	2820
Maximum linear density (BPI) (FCI)	44400 33300	49500 37125	52500 39400	52500 39400	54100 40600
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4020	4020	4395	4395	4600
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	12	12	12
Average rotational delay (msec)	7.46	7.46	6.8	6.8	6.5
Average access time (msec)	23.46	23.46	18.8	18.8	18.5
Data transfer rate (KBytes/sec)			2750	2750	4638
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1991	1991	1992	1992	1993
COMMENTS					

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJITSU	FUJITSU
DRIVE	FK319S-360Z	FK320A-540Z	FK320S-540Z	M2611S/SA/SB	M2611T
DISK/TREND GROUP	5	6	6	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Ferrite	Ferrite
Interface	SCSI-2	PC AT	SCSI-2	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 360	F: 540	F: 540	F: 45.07	F: 45.07
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 17,408	F: 16,896
Data surfaces per spindle	4	6	6	2	2
Tracks per surface	2420	2420	2420	1334	1334
Track density (TPI)	2820	2820	2820	1681	1681
Maximum linear density (BPI) (FCI)	54100 40600	54100 40600	54100 40600	29571 22178	29571 22178
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4600	5400	5400	3490	3490
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	10	10	25	25
Average rotational delay (msec)	6.5	5.6	5.6	8.6	8.6
Average access time (msec)	18.5	15.6	15.6	33.6	33.6
Data transfer rate (KBytes/sec)	4638	4700	4700	2500 synch. 1500 asynch.	7400 max.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1993	1993	1993	4Q88	3Q89
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2612ES/ESA/ESB M2612S/SA/SB	M2612ET/T	M2631S	M2631T	M2633S
DISK/TREND GROUP	2	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	SCSI	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 90.84	F: 90.15	U: 58 F: 45	U: 58 F: 45	U: 116 F: 90
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 16,896	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	2	2	4
Tracks per surface	1334	1334	916	916	916
Track density (TPI)	1681	1681	2000	2000	2000
Maximum linear density (BPI) (FCI)	29571 22178	29571 22178	42500 31875	42500 31875	42500 31875
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	3490	3609	3609	3609
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)	20/25*	20/25	18	18	18
Average rotational delay (msec)	8.6	8.6	8.3	8.3	8.3
Average access time (msec)	28.6/33.6*	28.6/33.6	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	2500 synch. 1500 asynch.	7400 max.	5000 synch. 3000 asynch.	6300 max.	5000 synch. 3000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	4Q88	3Q89	2Q92	2Q92	2Q92
COMMENTS	*ESA/S/SA/SB				

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2633T	M2613ES/ESA/ESB M2613S/SA/SB	M2613ET/T	M2614ES/ESA/ESB M2614S/SA/SB	M2614ET/T
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 116 F: 90	F: 136.6	F: 135.23	F: 182.36	F: 180.31
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 17,408	F: 16,896	F: 17,408	F: 16,896
Data surfaces per spindle	4	6	6	8	8
Tracks per surface	916	1334	1334	1334	1334
Track density (TPI)	2000	1681	1681	1681	1681
Maximum linear density (BPI) (FCI)	42500 31875	29571 22178	29571 22178	29571 22178	29571 22178
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3609	3490	3490	3490	3490
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)	18	20/25*	20/25	20/25*	20/25
Average rotational delay (msec)	8.3	8.6	8.6	8.6	8.6
Average access time (msec)	26.3	28.6/33.6*	28.6/33.6	28.6/33.6*	28.6/33.6
Data transfer rate (KBytes/sec)	6300 max.	2500 synch. 1500 asynch.	7400 max.	2500 synch. 1500 asynch.	7400 max.
SIZE: (mm) H x W x D	17 x 69.9 x 100	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q92	4Q88	3Q89	4Q88	3Q89
COMMENTS		*ESA/S/SA/SB		*ESA/S/SA/SB	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2616ES/ESA/ESB M2616SA	M2616ET/T	M2617T	M2635S	M2635T
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM		
MEDIA: Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	65 mm OD	65 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID Thin Film	20 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	Thin Film	Thin Film
Interface	SCSI	PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	F: 105	F: 105	F: 160	F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 16,896	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	2	4	4
Tracks per surface	1542	1542	2010	1574	1574
Track density (TPI)	1681	1681	2267	2600	2600
Maximum linear density (BPI)	32069	32069	39297	57000	57000
(FCI)	24052	24052	29457	42750	42750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	3490	3490	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)	20	20	16	14.5	14.5
Average rotational delay (msec)	8.6	8.6	8.6	6.7	6.7
Average access time (msec)	28.6	28.6	24.6	21.2	21.2
Data transfer rate (KBytes/sec)	2500 synch. 1500 asynch.	7400 max.	6300	10000 synch. 5000 asynch.	8000
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	17 x 69.9 x 100	17 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	7/92	2Q93	2Q93
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2618T	M2636S	M2636T	M2637S Hornet	M2637T Hornet
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 210	F: 200	F: 200	F: 240	F: 240
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	5	5	6	6
Tracks per surface	2010	1574	1574	1574	1574
Track density (TPI)	2267	2600	2600	2600	2600
Maximum linear density (BPI) (FCI)	39297 29457	57000 42750	57000 42750	57000 42750	57000 42750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	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)	16	14.5	14.5	14.5	14.5
Average rotational delay (msec)	8.6	6.7	6.7	6.7	6.7
Average access time (msec)	24.6	21.2	21.2	21.2	21.2
Data transfer rate (KBytes/sec)	6300	10000 synch. 4000 asynch.	8000	10000 synch. 4000 asynch.	8000
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	7/92	1Q93	1Q93	2Q93	1Q93
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2681S Picobird-6'	M2681T Picobird-6'	M2704S Hornet-5	M2704T Hornet-5	M2249S/SA/SB
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	MIG	MR Thin Film	MR Thin Film	Ferrite
Interface	SCSI-2	PC AT	SCSI-2	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 264	F: 264	F: 260	F: 260	F: 333.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 16,640
Data surfaces per spindle	3	3	3	3	15
Tracks per surface	2379	2379			1243
Track density (TPI)	2713	2713	4300	4300	1267
Maximum linear density (BPI) (FCI)	58000 43500	58000 43500	78000	78000	19295 14471
Recording code	1,7 RLL	1,7 RLL	PRML	PRML	1,7 RLL
Rotational speed (RPM)	4500	4500	5400	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	13.8	13.8	12	12	18
Average rotational delay (msec)	6.7	6.7	5.6	5.6	8.3
Average access time (msec)	20.5	20.5	17.6	17.6	26.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	11100 PIO*	10000 synch. 5000 asynch.	8000	2500 synch. 1500 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	17 x 69.9 x 100	17 x 69.9 x 100	82.6 x 146.1 x 218
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	1Q94	1Q94	1Q88
COMMENTS		*PIO Mode 3			

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2261H/HA/HB M2261S/SA/SB	M2262H/HA/HB M2262S/SA/SB	M2622F/FA/FB M2622H/HA/HB	M2622S/SA/SB	M2622T
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI	SCSI	SCSI-1/2	SCSI-1/2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 357.1	F: 492	F: 330.17	F: 330.17	F: 326.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	F: 27,136	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	11	7	7	7
Tracks per surface	1658	1658	1435	1435	1435
Track density (TPI)	1712	1712	1751	1751	1751
Maximum linear density (BPI) (FCI)	28816 21612	28816 21612	46383 34787	46383 34787	46383 34787
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	4400	4400	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	12	12	12
Average rotational delay (msec)	8.3	8.3	6.8	6.8	6.8
Average access time (msec)	24.3	24.3	18.8	18.8	18.8
Data transfer rate (KBytes/sec)	4000 synch. 1750 asynch.	4000 synch. 1750 asynch.	10000 synch. 4000 asynch.	5000 synch. 3000 asynch.	7400 max.
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	4Q91	1Q91	3Q91
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2623F/FA/FB M2623H/HA/HB	M2623S/SA/SB	M2623T	M2682S Picobird-6'	M2682T Picobird-6'
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI-1/2	SCSI-1/2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 425.1	F: 425.1	F: 420.1	F: 353	F: 352
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	9	9	4	4
Tracks per surface	1435	1435	1435	2379	2379
Track density (TPI)	1751	1751	1751	2713	2713
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	46383 34787	58000 43500	58000 43500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	4400	4400	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	12	12	12	13.8	13.8
Average rotational delay (msec)	6.8	6.8	6.8	6.7	6.7
Average access time (msec)	18.8	18.8	18.8	20.5	20.5
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	5000 synch. 3000 asynch.	7400 max.	10000 synch. 5000 asynch.	11100 PIO*
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q91	1Q91	3Q91	1Q94	1Q94
COMMENTS					*PIO Mode 3

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2705S Hornet-5	M2705T Hornet-5	F6423B	F6425G	F6425K4/L4
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MR Thin Film	MR Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	PC AT	Fujitsu	Fujitsu	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 350	F: 350	F: 630.0	F: 630.0	F: 630.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	4	4	14	8	8
Tracks per surface			988	1770	1770
Track density (TPI)	4300	4300	1193	1370	910
Maximum linear density (BPI) (FCI)	78000	78000	25300 18975	21300 15975	24420 16280
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	3620	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	13	12	15
Average rotational delay (msec)	5.6	5.6	8.3	8.3	8.3
Average access time (msec)	17.6	17.6	21.3	20.3	23.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	8000	3000	3000	3000
SIZE: (mm) H x W x D	17 x 69.9 x 100	17 x 69.9 x 100	--	--	--
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	8/88	12/88	3Q86
COMMENTS			Drive has 4 spindles 2 heads/surface	Drive has 4 spindles 2 heads/surface	Drive has 4 spindles 2 heads/surface

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2263H/HA/HB M2263S/SA/SB	M2344K/KS	M2360A	M2361A	M2372K/KS
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	Mod. SMD, SCSI	Modified SMD	Modified SMD	Mod. SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 671.9	U: 690.1	U: 689.8	U: 689.8	U: 823.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	U: 40,960	U: 40,960	U: 40,960	U: 40,960
Data surfaces per spindle	15	13.5	10	10	13.5
Tracks per surface	1658	1248	1684	1682	1490
Track density (TPI)	1712	846	880	880	1193
Maximum linear density (BPI) (FCI)	28816 21612	20767 13844	18620 12413	18620 12413	20766 13844
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3673	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	18	18	16
Average rotational delay (msec)	8.3	8.3	8.17	8.3	8.3
Average access time (msec)	24.3	24.3	26.17	26.3	24.3
Data transfer rate (KBytes/sec)	4000 synch. 1750 asynch.	2458	2507-12537	2458	2458
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	--	--	--	--
FIRST CUSTOMER SHIPMENT	4Q88	2Q87	3Q86	2Q85	9/87
COMMENTS		2 heads/surface except servo surface	Parallel data transfer, 4 or 5 channels 2 heads/surface	2 heads/surface	2 heads/surface except servo surface

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2380A	M2382K/P	M2391D	M2391K	M2624F/FA/FB M2624H/HA/HB
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	Modified SMD	Mod. SMD, IPI-2	Modified SMD	Modified SMD	SCSI-1/2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,000.2	U: 1,000.2	U: 965	U: 1,062	F: 520.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 49,728	U: 49,728	U: 45,792	U: 50,400	Varies by zone
Data surfaces per spindle	13.5	13.5	11	11	11
Tracks per surface	1490	1490	1916	1916	1435
Track density (TPI)	1193	1193	1456	1456	1751
Maximum linear density (BPI) (FCI)	25211 18908	25211 18908	22764 17073	25055 18791	46383 34787
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3709	3620	3600	3600	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	12	12	12
Average rotational delay (msec)	8.1	8.3	8.3	8.3	6.8
Average access time (msec)	24.1	24.3	20.3	20.3	18.8
Data transfer rate (KBytes/sec)	3074-18444	3000	2750	3000	10000 synch. 4000 asynch.
SIZE: (mm) H x W x D	--	--	--	--	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q89	1Q88	1Q90	1Q90	4Q91
COMMENTS	Par. data trans 4,5,6 channels. Total capacity varies in each version. 2 heads/surface except servo s.	2 heads/surface except servo surface			

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2624S/SA/SB	M2624T	M2684S Picobird-6'	M2684T Picobird-6'	M2690ESA
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	MIG	MIG	Thin Film
Interface	SCSI-1/2	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 520.1	F: 513.5	F: 532	F: 528	F: 560
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	11	11	6	6	8
Tracks per surface	1435	1435	2379	2379	1819
Track density (TPI)	1751	1751	2700	2700	2208
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	58000 43500	58000 43500	48724 36543
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	4400	4500	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	12	12	13.8	13.8	8
Average rotational delay (msec)	6.8	6.8	6.7	6.7	5.6
Average access time (msec)	18.8	18.8	20.5	20.5	13.6
Data transfer rate (KBytes/sec)	5000 synch. 3000 asynch.	7400 max.	10000 synch. 5000 asynch.	11100 PIO*	10000 synch. 4000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q91	3Q91	1Q94	1Q94	1/93
COMMENTS				*PIO Mode 3	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2691EH/EHA/EHB M2691ES/ESA/ESB	M2691H/HA/HB M2691S/SA/SB	M2692EH/EHA/EHB M2692ES/ESA/ESB	M2692H/HA/HB M2692S/SA/SB	M2693EH/EHA/EHB M2693ES/ESA/ESB
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 648.4	F: 648.4	F: 793.6	F: 793.6	F: 938.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	9	11	11	13
Tracks per surface	1819	1819	1819	1819	1819
Track density (TPI)	2208	2208	2208	2208	2208
Maximum linear density (BPI) (FCI)	48724 36543	48724 36543	48724 36543	48724 36543	48724 36543
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4400	5400	4400	4400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	10	10	10
Average rotational delay (msec)	5.6	6.8	5.6	6.8	5.6
Average access time (msec)	15.6	16.8	15.6	16.8	15.6
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	11/92	5/92	11/92	5/92	11/92
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2693H/HA/HB M2693S/SA/SB	M2706S Hornet-5	M2706T Hornet-5	F6425H	F6425M4/N4
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Sputtered	Oxide Sputtered
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	Ferrite	Ferrite
Interface	SCSI-2	SCSI-2	PC AT	Fujitsu	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 938.7	F: 530	F: 530	F: 1,890	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 47,476	F: 47,476
Data surfaces per spindle	13	6	6	16	12
Tracks per surface	1819			2654	2360
Track density (TPI)	2208	4300	4300	1370	1160
Maximum linear density (BPI) (FCI)	48724 36543	78000	78000	24440 18330	24425 16283
Recording code	1,7 RLL	PRML	PRML	1,7 RLL	2,7 RLL
Rotational speed (RPM)	4400	5400	5400	3620	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	12	12	16	17
Average rotational delay (msec)	6.8	5.6	5.6	8.3	8.3
Average access time (msec)	16.8	17.6	17.6	24.3	25.3
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	10000 synch. 5000 asynch.	8000	3000	3000
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	17 x 69.9 x 100	17 x 69.9 x 100	--	--
FIRST CUSTOMER SHIPMENT	5/92	1Q94	1Q94	12/88	3Q86
COMMENTS				Drive has 4 spindles 2 heads/surface	Drive has 4 spindles 2 heads/surface

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6427H	M2266H/HA/HB M2266S/SA/SB	M2392D	M2392K	M2651H/HA/HB M2651S/SA/SB
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	210 mm OD 100 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Fujitsu	SCSI	Modified SMD	Modified SMD	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,890	F: 1,079.1	U: 1,842	U: 2,027	F: 1,313
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 43,520	U: 45,792	U: 50,400	F: 45,056
Data surfaces per spindle	15	15	21	21	15
Tracks per surface	2655	1658	1916	1916	1944
Track density (TPI)	2080	1634	1456	1456	1840
Maximum linear density (BPI) (FCI)	33310 24980	46635 34976	22764 17073	25055 18791	50257 37692
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4340	3600	3600	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	14.5	12	12	11
Average rotational delay (msec)	6.9	8.3	8.3	8.3	5.6
Average access time (msec)	18.9	22.8	20.3	20.3	16.6
Data transfer rate (KBytes/sec)	4500	4800 synch. 2000 asynch.	2750	3000	10000 synch. 3000 asynch.
SIZE: (mm) H x W x D	--	82.6 x 146.1 x 203.2	--	--	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	12/90	2Q90	1Q90	1Q90	2Q91
COMMENTS	Drive has maximum 16 spindles				

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2652H/HA/HB M2652HD/HDA/HDB M2652S/SA/SB	M2694EH/EHA/EHB M2694ES/ESA/ESB	M2694H/HA/HB M2694S/SA/SB	M2927 Allegro-1'E	F6427K
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MR Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,752	F: 1,083.9	F: 1,083.9	F: 1,080	F: 2,835
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 45,056	Varies by zone	Varies by zone	Varies by zone	F: 47,476
Data surfaces per spindle	20	15	15	6	15
Tracks per surface	1944	1819	1819		4007
Track density (TPI)	1840	2208	2208	3550	2820
Maximum linear density (BPI) (FCI)	50257 37692	48724 36543	48724 36543	75500	33310 24982
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	1,7 RLL
Rotational speed (RPM)	5400	5400	4400	5400	4340
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	10	10	10	13
Average rotational delay (msec)	5.6	5.6	6.8	5.6	6.9
Average access time (msec)	16.6	15.6	16.8	15.6	19.9
Data transfer rate (KBytes/sec)	10000 synch. 3000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.	20000 synch. 10000 asynch.	4758
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	--
FIRST CUSTOMER SHIPMENT	2Q91	11/92	5/92	1Q94	7/92
COMMENTS					Drive has maximum of 16 spindles

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	HEWLETT-PACKARD
DRIVE	M2654H/HA/HB M2654S/SA/SB Hummingbird	M2654SI DynaCACHE Hummingbird	M2671P	M2903	C2244
DISK/TREND GROUP	8	8	8	8	6
MARKET	OEM	OEM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MR Thin Film	MIG
Interface	SCSI-2	SCSI-2	IPI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,055	F: 2,055	U: 2,648	F: 2,118	F: 566
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 45,056	F: 45,056	U: 66,096	Varies by zone	Varies by zone
Data surfaces per spindle	21	21	15	13	7
Tracks per surface	2179	2179	2671		1918
Track density (TPI)	1953	1953	2080	3553	2304
Maximum linear density (BPI) (FCI)	50871 38153	50871 38153	33310 24983	75534	49987 33325
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	2,7 RLL
Rotational speed (RPM)	5400	5400	4340	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	11.5	12	11.2	10.5
Average rotational delay (msec)	5.6	5.6	6.91	5.6	5.6
Average access time (msec)	17.6	17.1	18.91	16.8	16.1
Data transfer rate (KBytes/sec)	10000 synch. 4000 asynch.	10000 synch. 3000 asynch.	4781	20000 synch. 10000 asynch.	20000 synch. 2500-5000 asyn.
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	--	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	7/92	1Q94	2Q90	2Q94	1Q92
COMMENTS					

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
DRIVE	C2247	C3323A	C2490A	DK110A-8	DK522-10
DISK/TREND GROUP	7	7	8	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	48 mm OD 12 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	Thin Film	Thin Film	MIG	Ferrite
Interface	SCSI-2	SCSI-2	SCSI-2	PC AT	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,052	F: 1,050	F: 2,100	F: 85	U: 103.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	U: 20,944
Data surfaces per spindle	13	7	18	4	6
Tracks per surface	1918	2898	2465	1076	823
Track density (TPI)	2304	3223	2735	2750	960
Maximum linear density (BPI) (FCI)	49987 33325	69200 51900	59000 44250	55300 41500	18500 12333
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	6400	4464	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	10.5	9.5 RD/10.5 WR	8.9	16	25
Average rotational delay (msec)	5.6	5.6	4.9	6.7	8.3
Average access time (msec)	16.1	15.1/16.1	13.8	22.7	33.3
Data transfer rate (KBytes/sec)	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.	5000	1250
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	12.5 x 50.8 x 79	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q92	4Q93	2Q93	4/93	12/86
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK522C-10	DK110A-13	DK120P-13	DK524-20	DK524C-20
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	MIG	MIG	Ferrite	Ferrite
Interface	SCSI	PC AT	PCMCIA-ATA	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 87.5	F: 128	--	U: 200.5	F: 168.9
REMOVABLE	--	--	F: 130	--	--
Capacity per track (Bytes)	F: 17,920	Varies by zone	Varies by zone	U:	F:
Data surfaces per spindle	6	4	4		
Tracks per surface	819	1304	1260	1105	1105
Track density (TPI)	960	3300	3200	1100	1100
Maximum linear density (BPI) (FCI)	18500 12333	75000 50000	75000 50000	29800 19866	29800 19866
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	4464	4464	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	16	16	25	25
Average rotational delay (msec)	8.3	6.7	6.7	8.3	8.3
Average access time (msec)	33.3	22.7	22.7	33.3	33.3
Data transfer rate (KBytes/sec)	1500 max.	5000	5000	1814	4000
SIZE: (mm) H x W x D	41.3 x 146.1 x 218	12.5 x 50.8 x 79	10.5 x 54 x 85.6	41.3 x	41.3 x
FIRST CUSTOMER SHIPMENT	1/87	4/93	4Q94	3Q88	4Q88
COMMENTS			PCMCIA Type III		

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK312C-20	DK312C-25	DK324C-21A	DK221A-34	DK314C-41
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Thin Film
Interface	SCSI	SCSI	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 209	F: 251	F: 215.0	F: 340	F: 418.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,456	F: 19,456	F: 26,624	Varies by zone	F: 25,600
Data surfaces per spindle	10	12	6	4	14
Tracks per surface	1076	1076	1346	1967	1169
Track density (TPI)	1660	1660	2117	3500	1803
Maximum linear density (BPI) (FCI)	38800 25866	38800 25866	43000 32250	83000 62250	44222 29466
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	4464	3600
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)	16.8*	16.8*	17	12 RD/15 WR	16.8
Average rotational delay (msec)	8.3	8.3	8.3	6.7	8.3
Average access time (msec)	25.1	25.1	25.3	18.7/21.7	25.1
Data transfer rate (KBytes/sec)	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.	4000 synch. 1500 asynch.	8000	4000 synch. 1500 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	12.5 x 69.9 x 101.6	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q89	3Q89	8/91	8/94	2Q91
COMMENTS	*Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.	*Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.			

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK514-38	DK514C-38	DK514S-38	DK815-5	DK211A-51
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	224 mm OD 100 mm ID	65 mm OD 20 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ESDI	SCSI	Modified SMD	Modified SMD	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 382.3	F: 321.8	U: 382.3	U: 525.38	F: 510
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	F: 25,600	U: 30,240	U: 30,240	Varies by zone
Data surfaces per spindle	14	14	14	14	6
Tracks per surface	903	898	903	1241	1967
Track density (TPI)	1033	1033	1033	860	3500
Maximum linear density (BPI)	26000	26000	26000	14585	83000
(FCI)	17333	17333	17333	9723	62250
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	4464
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	16	16	16	18	12 RD/15 WR
Average rotational delay (msec)	8.3	8.3	8.3	8.3	6.7
Average access time (msec)	24.3	24.3	24.3	26.3	18.7/21.7
Data transfer rate (KBytes/sec)	1815	4000 synch. 1500 asynch.	1815	1815	8000
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	82.6 x 146.1 x 248.5	--	19 x 69.9 x 101.6
FIRST CUSTOMER SHIPMENT	3Q87	1Q88	3Q87	11/84	5/94
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK211C-51	DK325C-57	DK326C-6	DK326C-6WD	DK515-78
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	MIG
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 510	F: 573	F: 601	F: 601	U: 780
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	U: 40,960
Data surfaces per spindle	6	6	4	4	14
Tracks per surface	1967	2458	3202	3202	1361
Track density (TPI)	3500	2800	3600	3600	1296
Maximum linear density (BPI) (FCI)	83000 62250	52200 39150	63500 47625	63500 47625	40210 26806
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	4464	4500	6300	6300	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12 RD/15 WR	12.4	9.8	9.8	16
Average rotational delay (msec)	6.7	6.7	4.76	4.76	8.3
Average access time (msec)	18.7/21.7	19.1	14.56	14.56	24.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	5000 synch. 2500 asynch.	10000 synch. 2500 asynch.	20000 synch. 5000 asynch.	2458
SIZE: (mm) H x W x D	19 x 69.9 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	8/94	3Q92	1/94	3/94	4Q88
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK515C-78 DK515C-78D	DK515S-78D DK515S-78S	DK711S-60D DK711S-60S	DKU-861-J14 DKU-861-J24 H-6586-J14 H-6586-J24	DKU-871-114 DKU-871-124 H-6587-114 H-6587-124
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	Captive, OEM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	9.5"	9.5"
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	MIG	Ferrite	Ferrite	Thin Film
Interface	SCSI	Modified SMD	Modified SMD	IBM, Hitachi	IBM, Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 660.9	U: 780	U: 600	F: 630	F: 946
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 34,816	U: 40,960	U: 30,240	F: 47,476	F: 56,664
Data surfaces per spindle	14	14	22	15	15
Tracks per surface	1356	1391	903	885	1113
Track density (TPI)	1296	1296	1033		
Maximum linear density (BPI) (FCI)	40210 26806	40210 26806	26000 17333		
Recording code	2,7 RLL	2,7 RLL	2,7 RLL		1,7 RLL
Rotational speed (RPM)	3600	3600	4876	3600	4260
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	12	11	8.5
Average rotational delay (msec)	8.3	8.3	6.15	8.3	7.1
Average access time (msec)	24.3	24.3	18.15	19.3	15.6
Data transfer rate (KBytes/sec)	4000 synch. 1500 asynch.	2458	2458	3000	4200
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 248.5	127 x 216 x 380	--	--
FIRST CUSTOMER SHIPMENT	4Q88	2Q89	4Q87	3Q88	9/90
COMMENTS			Oversized packaging	Drive has 8 spindles	-114: max. 8 HDAs -124: max. 12 HDAs. Also compatible mode to H-6586J 2 heads/surface

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK315C-10	DK315C-11	DK315C-14	DK326C-10	DK326C-10WD
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,054	F: 1,100	F: 1,400	F: 1,052	F: 1,052
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 30,200	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	11	15	15	7	7
Tracks per surface	2469	2488	2464	3202	3202
Track density (TPI)	2800	2800	2800	3600	3600
Maximum linear density (BPI) (FCI)	52300 39225	54000 40500	52300 39225	63500 47625	63500 47625
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	6300	6300
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.8	10.4	11.8	9.8	9.8
Average rotational delay (msec)	6.7	6.7	6.7	4.76	4.76
Average access time (msec)	18.5	17.1	18.5	14.56	14.56
Data transfer rate (KBytes/sec)	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	20000 synch. 5000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q92	2Q92	3Q92	1/94	3/94
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK516-12	DK516-15	DK516C-16	DKU-861-G14 DKU-861-G24 H-6586-G14 H-6586-G24	DKU-861-K14 DKU-861-K24 H-6586-K14 H-6586-K24
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	9.5"	9.5"
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Thin Film
Interface	ESDI	ESDI	SCSI	IBM, Hitachi	IBM, Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,229	U: 1,538	F: 1,342	F: 1,260	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 45,880	U: 45,880	F: 41,472	F: 47,476	F: 47,476
Data surfaces per spindle	15	15	15	15	15
Tracks per surface	1787	2235	2172	1770 (Physical)	2655
Track density (TPI)	1512	2000	1954		
Maximum linear density (BPI) (FCI)	46375 34780	44060 33045	48525 36393		
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14	13.5	13	12.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	22.3	21.8	21.3	20.8
Data transfer rate (KBytes/sec)	2750	2753	5000 synch. 2000 asynch.	3000	3000
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	--	--
FIRST CUSTOMER SHIPMENT	3Q90	1Q91	3Q90	3Q88	3Q88
COMMENTS				Drive has 8 spindles	Drive has 8 spindles 2 heads/surface

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-871-214 DKU-871-224	H-6556-1	DK517C-26	DK517C-37	DKU-881-310 DKU-F881-304
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM, PCM	Captive	OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	9.5"	9.5"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	6.5"
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Thin Film	Thin Film	Thin Film
Interface	IBM, Hitachi	Hitachi	SCSI-2	SCSI-2	Hitachi, IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,892	F: 1,260	U: 2,600 F: 2,050	U: 3,700 F: 2,870	F: 2,838
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 47,476	F: 41,984	F: 41,984	F: 56,664
Data surfaces per spindle	15	15	15	21	15
Tracks per surface	2226	1770 (Physical)	3307	3307	3339
Track density (TPI)			2800	2800	2520
Maximum linear density (BPI) (FCI)			54000 40500	54000 40500	47300 35475
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	3600	5400	5400	4260
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10.5	15	12	12	13.5
Average rotational delay (msec)	7.1	8.3	5.6	5.6	7.1
Average access time (msec)	17.6	23.3	17.6	17.6	20.6
Data transfer rate (KBytes/sec)	4200	3000	10000 synch. 2500 asynch.	10000 synch. 2500 asynch.	4200
SIZE: (mm) H x W x D	--	--	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	--
FIRST CUSTOMER SHIPMENT	9/90	3/88	2Q92	2Q92	5/93
COMMENTS	-214: max. 8 HDAs -224: max. 12 HDAs 2 heads/surface	Drive has 4 spindles			Available with 4 to 32 HDAs

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS
DRIVE	H-6587-314 H-6587-324	H-6588-314	DKU-881-10 DKU-F881-904 H-6588-9	7693	7699
DISK/TREND GROUP	8	8	9	8	9
MARKET	Captive	Captive	Captive,OEM,PCM	PCM	PCM
MEDIA: Nominal disk diameter	9.5"	6.5"	6.5"	6.5"	6.5"
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	Thin Film	MR Thin Film
Interface	Hitachi, IBM	Hitachi, IBM	Hitachi, IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,920	F: 2,920	F: 8,514	F: 2,838	F: 8,514
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	F: 113,328	F: 56,664	F: 113,328
Data surfaces per spindle	15	15	19	15	19
Tracks per surface	3436	3436	3955	3339	3955
Track density (TPI)	1930	2520	3500	2520	3500
Maximum linear density (BPI) (FCI)	29100 21825	47300 35475	81964 61473	47300 35475	81964 61473
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	4260	1980	4260	1980
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	13.5	16.5	13.5	16.5
Average rotational delay (msec)	7.1	7.1	15.2	7.1	15.2
Average access time (msec)	19.1	20.6	31.7	20.6	31.7
Data transfer rate (KBytes/sec)	4200	4200	3900	4200	3900
SIZE: (mm) H x W x D	--	--	--	--	--
FIRST CUSTOMER SHIPMENT	9/90	6/93	6/94	6/93	3Q94
COMMENTS	-314: max. 8 HDAs -324: max. 12 HDAs. Also compatible mode to H-6586K 2 heads/surface	Available with 4 to 32 HDAs	Available with 4 to 32 HDAs	PCM 3390-3	PCM 3390-9

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	H2172 (Wakasa)	H3171-A2 (Tosa)	DHAA-2270 Travelstar (Shima-2)	DHAS-2270 Travelstar (Shima-2)	DSAA-3270 (Satsuma-1.5)
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MIG	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI, PC AT	PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 172	F: 171	F: 270	F: 270	F: 270
REMOVABLE	--	--	--	--	--
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	2264	2420	2788	2788	
Track density (TPI)	4300	2800	5300	5300	4300
Maximum linear density (BPI) (FCI)	74800 56100	55000 41250	93100 69825	93100 69825	83200 62400
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3800	3600	3800	3800	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)	14	14	14	14	12
Average rotational delay (msec)	7.9	8.3	7.9	7.9	6.7
Average access time (msec)	21.9	22.3	21.9	21.9	18.7
Data transfer rate (KBytes/sec)	4500 synch. 6000 asynch.	8300	8300	10000 synch.	8300
SIZE: (mm) H x W x D	17 x 70 x 100	25.4 x 101.6 x 146.1	17 x 70 x 100	17 x 70 x 100	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q93	2Q93	1Q94	2Q94	1Q94
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DSAS-3270 (Satsuma-1.5)	H2258 (Wakasa)	H3256-A3 (Tosa)	9336-10 (Redwing)	DB0A-2360 Travelstar LP (Bolero)
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	Captive	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film*
DRIVE: Heads	MR Thin Film	MR Thin Film	MIG	MIG	MR Thin Film
Interface	SCSI-2	SCSI, PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 270	F: 258	F: 256	F: 471	F: 360
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 29,696	Varies by zone
Data surfaces per spindle	2	3	3	11	2
Tracks per surface		2264	2420	1458	3476
Track density (TPI)	4300	4300	2800	1677	6350
Maximum linear density (BPI) (FCI)	83200 62400	74800 56100	55000 41250	30320 26951	101400 76050
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	1,7 RLL
Rotational speed (RPM)	4500	3800	3600	4986	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Embedded
Average positioning time (msec)	12	14	14	11.2	13
Average rotational delay (msec)	6.7	7.9	8.3	6.02	7.5
Average access time (msec)	18.7	21.9	22.3	17.22	20.5
Data transfer rate (KBytes/sec)	10000 synch.	4500 synch. 6000 asynch.	8300	4000	11100 PIO**
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	17 x 70 x 100	25.4 x 101.6 x 146.1	82.6 x 146.1 x 203.2	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	2Q94	3Q93	2Q93	9/90	10/94
COMMENTS				AS/400 9406 Disk unit, contains 2-4 disk drives	*Glass disk **PIO Mode 3

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DHAA-2344 Travelstar (Shima-3)	DHAA-2405 Travelstar (Shima-3)	DHAS-2344 Travelstar (Shima-3)	DHAS-2405 Travelstar (Shima-3)	DSAA-3360 (Satsuma-2)
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	PC AT	PC AT	SCSI-2	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 344	F: 405	F: 344	F: 405	F: 365
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	3	3	3	2
Tracks per surface	2788	2788	2788	2788	3875
Track density (TPI)	5300	5300	5300	5300	4300
Maximum linear density (BPI) (FCI)	93100 69825	93100 69825	93100 69825	93100 69825	83200 62400
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3800	3800	3800	3800	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)	14	14	14	14	12
Average rotational delay (msec)	7.9	7.9	7.9	7.9	6.7
Average access time (msec)	21.9	21.9	21.9	21.9	18.7
Data transfer rate (KBytes/sec)	8300	8300	10000 synch.	10000 synch.	8300
SIZE: (mm) H x W x D	17 x 70 x 100	17 x 70 x 100	17 x 70 x 100	17 x 70 x 100	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	2Q94	2Q94	1Q94
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DSAS-3360 (Satsuma-2)	H2344 (Wakasa)	H3342-A4 (Tosa)	0662-508 (Spitfire)	9333-3100 (Redwing)
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MIG	MR Thin Film	MIG
Interface	SCSI-2	SCSI, PC AT	PC AT	SCSI-2	IBM Serial
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 365	F: 344	F: 342	F: 625	F: 857
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 29,696
Data surfaces per spindle	2	4	4	3	20
Tracks per surface	3875	2264	2420	4116	1458
Track density (TPI)	4300	4300	2800	4077	1677
Maximum linear density (BPI) (FCI)	83200 62400	74800 56100	55000 41250	86900 77245	30320 26951
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4500	3800	3600	5400	4986
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	14	14	8.5 RD/10.0 WR	11.2
Average rotational delay (msec)	6.7	7.9	8.3	5.6	6.02
Average access time (msec)	18.7	21.9	22.3	14.1/15.6	17.22
Data transfer rate (KBytes/sec)	10000 synch.	4500 synch. 6000 asynch.	8300	20000 synch. 10000 asynch.	4000
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	17 x 70 x 100	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2Q94	3Q93	2Q93	3Q93	9/92
COMMENTS					RS/6000 Up to 4 HDAs

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9336-020 (Redwing)	9336-025 (Spitfire)	9337-015 9337-115 9337-215 (Spitfire)	DB0A-2540 Travelstar LP (Bolero)	DB0A-2720 Travelstar LP (Bolero)
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film*
DRIVE: Heads	MIG	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 857	F: 857	F: 542	F: 540	F: 720
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,696	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	20		5	3	4
Tracks per surface	1458		2234	3476	3476
Track density (TPI)	1677		4077	6350	6350
Maximum linear density (BPI) (FCI)	30320 26951		78202	101400 76050	101400 76050
Recording code	PRML	PRML	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4986	5400	5400	4000	4000
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	11.2	8.8	6.5	13	13
Average rotational delay (msec)	6.02	5.6	5.6	7.5	7.5
Average access time (msec)	17.22	14.4	12.1	20.5	20.5
Data transfer rate (KBytes/sec)	4000	10000 synch. 5000 asynch.	20000 synch. 6000 asynch.	11100 PIO**	11100 PIO**
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	12.5 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	9/90	2/94	9/93	10/94	10/94
COMMENTS	AS/400 Disk unit contains 2-4 disk drives	AS/400 Disk unit contains 4 disk drives		*Glass disk **PIO Mode 3	*Glass disk **PIO Mode 3

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DHAA-2540 Travelstar (Shima-4)	DHAS-2540 Travelstar (Shima-4)	DPEA-30540 Deskstar XP (Pegasus)	DPES-30540 Deskstar XP (Pegasus)	DSAA-3540 (Satsuma-3)
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	PC AT	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 548	F: 548	F: 540	F: 540	F: 548
REMOVABLE	--	--	--	--	--
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	2	2	3
Tracks per surface	2788	2788	4896	4896	3875
Track density (TPI)	5300	5300	5340	5340	4300
Maximum linear density (BPI) (FCI)	93100 69825	93100 69825	85600 64200	85600 64200	83200 62400
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3800	3800	5400	5400	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)	14	14	10.5 RD/12.5 WR	10.5 RD/12.5 WR	12
Average rotational delay (msec)	7.9	7.9	5.6	5.6	6.7
Average access time (msec)	21.9	21.9	16.1/18.1	16.1/18.1	18.7
Data transfer rate (KBytes/sec)	8300	10000 synch.	11100 PIO*	10000 synch.	8300
SIZE: (mm) H x W x D	17 x 70 x 100	17 x 70 x 100	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q94	2Q94	8/94	8/94	1Q94
COMMENTS			*PIO Mode 3		

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DSAA-3720 (Satsuma-4)	DSAS-3540 (Satsuma-3)	DSAS-3720 (Satsuma-4)	DVAA-2810 Travelstar (Shima-V)	DVAS-2810 Travelstar (Shima-V)
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	PC AT	SCSI-2	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 730	F: 548	F: 730	F: 810	F: 810
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	3	4	6	6
Tracks per surface	3875	3875	3875	2788	2788
Track density (TPI)	4300	4300	4300	5300	5300
Maximum linear density (BPI) (FCI)	83200 62400	83200 62400	83200 62400	93100 69825	93100 69825
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	3800	3800
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	14	14
Average rotational delay (msec)	6.7	6.7	6.7	7.9	7.9
Average access time (msec)	18.7	18.7	18.7	21.9	21.9
Data transfer rate (KBytes/sec)	8300	10000 synch.	10000 synch.	8300	10000 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	17 x 70 x 100	17 x 70 x 100
FIRST CUSTOMER SHIPMENT	1Q94	2Q94	2Q94	5/94	5/94
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0615	0662-A10 (Spitfire)	0662-S12 0662-S1D (Spitfire)	0662-SW1 0662-SWD (Spitfire)	0664-P1S (Allicat P10)
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IPI-2	PC AT	SCSI-2	SCSI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,639	F: 1,052	F: 1,052	F: 1,052	U: 2,005 F: 1,741
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,668	Varies by zone	Varies by zone	Varies by zone	U: 58,024
Data surfaces per spindle	15	5	5	5	15
Tracks per surface	2157	4136	4136	4136	2304
Track density (TPI)	2403	4077	4077	4077	3168
Maximum linear density (BPI) (FCI)	44663 33497	86900 78200	86900 78200	86900 78200	68700
Recording code	1,7 RLL	PRML	PRML	PRML	PRDF
Rotational speed (RPM)	5380	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	8.5 RD/10.1 WR	8.6 RD/10.1 WR	8.6 RD/10.1 WR	9.4 RD/11 WR
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	17.6	14.1 RD/15.7 WR	14.2 RD/15.7 WR	14.2 RD/15.7 WR	15 RD/16.6 WR
Data transfer rate (KBytes/sec)	4550	11100 PIO* 13300 DMA**	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	5220
SIZE: (mm) H x W x D	82.6 x 211 x 768	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 159.3
FIRST CUSTOMER SHIPMENT	5/91	1Q94	2Q93	2Q93	12/92
COMMENTS	2 HDAs per drawer	*PIO Mode 3 M2=8.3 MB/sec. M4=16.7 MB/sec **DMA Mode 1			

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9333-3110 (Redwing)	9345-B12	9345-B22	DFHC-31080 Ultrastar XP (Starfire HP)	DFHS-31080 Ultrastar XP (Starfire HP)
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IBM Serial-Link	IBM	IBM	SSA	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,007	F: 1,001	F: 1,502	F: 1,080	F: 1,080
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,696	F: 46,456	F: 46,456	Varies by zone	Varies by zone
Data surfaces per spindle	20	15	15	4	4
Tracks per surface	1695	1438	2156	4416	4416
Track density (TPI)	2098	2403	2403	4351	4351
Maximum linear density (BPI) (FCI)	30320 26951	44663 33497	44663 33497	121000	121000
Recording code	PRML	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4986	5380	5380	720	7200
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	11.2	10	12	6.9 RD/9.5 WR	6.9 RD/9.5 WR
Average rotational delay (msec)	6.02	5.6	5.6	4.17	4.17
Average access time (msec)	17.22	15.6	17.6	11.07/13.67	11.07/13.67
Data transfer rate (KBytes/sec)	4000	4400	4400	20000	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 211 x 768	82.6 x 211 x 768	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	5/92	1Q92	1Q92	2Q94	2Q94
COMMENTS		2 HDAs per drawer	2 HDAs per drawer		

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DFMS-31080 Ultrastar (Starfire HC)	DPEA-31080 Deskstar XP (Pegasus)	DPES-31080 Deskstar XP (Pegasus)	0664-M1H (Allicat S10)	0664-N1H (Allicat S10)
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	PC AT	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,080	F: 1,080	U: 2,490 F: 2,013.7	U: 2,490 F: 2,013.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 48,128	F: 48,128
Data surfaces per spindle	4	4	4	15	15
Tracks per surface	4416	4896	4896	2870	2870
Track density (TPI)	4351	5340	5340	3168	3168
Maximum linear density (BPI) (FCI)	128900	85600 64200	85600 64200	81913	81913
Recording code	PRML	1,7 RLL	1,7 RLL	PRDF	PRDF
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	6.9 RD/9.5 WR	10.5 RD/12.5 WR	10.5 RD/12.5 WR	9.2 RD/10.7 WR	9.2 RD/10.7 WR
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	12.5/15.1	16.1/18.1	16.1/18.1	14.8 RD/16.3 WR	14.8 RD/16.3 WR
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	11100 PIO*	10000 synch.	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	25.4 x 101.6 x 146	41.3 x 101.6 x 153.2	41.3 x 101.6 x 153.2
FIRST CUSTOMER SHIPMENT	2Q94	8/94	8/94	11/92	11/92
COMMENTS		*PIO Mode 3			

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9333-011 9333-501 (Allicat)	DFHC-32160 Ultrastar XP (Starfire HP)	DFHS-32160 Ultrastar XP (Starfire HP)	DFMS-32160 Ultrastar (Starfire HC)	DFMS-32600 Ultrastar (Starfire HC)
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IBM Serial-Link	SSA	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,013.7	F: 2,160	F: 2,160	F: 2,160	F: 2,600
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 48,128	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	8	8	7	8
Tracks per surface	2870	4416	4416	4416	4416
Track density (TPI)	3168	4351	4351	4351	4351
Maximum linear density (BPI) (FCI)	81913	121000	121000	128900	128900
Recording code	PRDF	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5400	7200	7200	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.2 RD/10.7 WR	7.5 RD/9.5 WR	7.5 RD/9.5 WR	7.5 RD/9.5 WR	8 RD/9.5 WR
Average rotational delay (msec)	5.6	4.17	4.17	5.6	5.6
Average access time (msec)	14.8/16.3	11.67/13.67	11.67/13.67	13.1/15.1	13.6 RD/15.1
Data transfer rate (KBytes/sec)	8000	20000	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	8/93	2Q94	2Q94	2Q94	2Q94
COMMENTS	RS/6000 Up to 4 HDAs				

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0664-CSH 0664-DSH (Allicat S20)	0664-ESH 0664-FSH (Allicat S20)	3390-A24 3390-A28 3390-B24 3390-B28 3390-B2C	3390-A34 3390-A38 3390-B34 3390-B38 3390-B3C	3390-A94 3390-A98 3390-B94 3390-B98 3390-B9C
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.8"	10.8"	10.8"
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,027	F: 4,027	F: 3,784	F: 5,676	F: 17,028
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 48,128	F: 48,128	F: 56,664	F: 56,664	F: 169,992
Data surfaces per spindle	15	15	15	15	15
Tracks per surface	2870	2870	4452	6678	6678
Track density (TPI)	3168	3168	2242	2984	2984
Maximum linear density (BPI) (FCI)	81913	81913	27940 20955	30008 22506	
Recording code	PRDF	PRML	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	5400	5400	4260	4260	1320
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9.4 RD/11.4 WR	9.4 RD/11.4 WR	12.5	15	22.5
Average rotational delay (msec)	5.6	5.6	7.1	7.1	22.8
Average access time (msec)	15 RD/17 WR	15 RD/17 WR	19.6	22.18	45.3
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	4200	4200	3900
SIZE: (mm) H x W x D	82.6 x 146.1 x 209.5	82.6 x 146.1 x 209.5	--	--	--
FIRST CUSTOMER SHIPMENT	2Q93	2Q93	12/89	9/91	6/93
COMMENTS	Two 3.5" drives in HH 5.25" package, addressed as single drive	Two 3.5" drives in HH 5.25" package, addressed as single drive	A24=2 HDAs A28=4 HDAs B24=2 HDAs B28=4 HDAs B2C=6 HDAs 2 heads/surface	A34= 2 HDAs A38= 4 HDAs B34= 2 HDAs B38= 4 HDAs B3C= 6 HDAs 2 heads/surface	A94= 2 HDAs A98= 4 HDAs B94= 2 HDAs B98= 4 HDAs B9C= 6 HDAs 2 heads/surface

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DCHC-38700 Ultrastar2 XP (Scorpion HP)	DCHS-38700 Ultrastar2 XP (Scorpion HP)	DCMS-310800 Ultrastar2 (Scorpion HC)	DFHS-34320 Ultrastar XP (Starfire HP)	DFHC-34320 Ultrastar XP (Starfire HP)
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SSA	SCSI-2	SCSI-2	SCSI-2	SSA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 8,700	F: 8,700	F: 10,800	F: 4,320	F: 4,320
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	18	18	20	16	16
Tracks per surface	*	*	*	4416	4416
Track density (TPI)	*	*	*	4351	4351
Maximum linear density (BPI) (FCI)	*	*	*	121000	121000
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	7200	7200	5400	7200	7200
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)	8.5 RD	8.5 RD	8.9 RD	8.0 RD/10.1 WR	8.0 RD/10.1 WR
Average rotational delay (msec)	4.17	4.17	5.6	4.17	4.17
Average access time (msec)	12.67	12.67	14.5	12.17/14.27	12.17/14.27
Data transfer rate (KBytes/sec)	20000	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000
SIZE: (mm) H x W x D	41.3 x 101.6 x 146	41.3 x 101.6 x 146	41.3 x 101.6 x 146	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q95	4Q95	4Q95	2Q94	2Q94
COMMENTS	*Not announced 790 megabits per square inch areal density	*Not announced 790 megabits per square inch areal density	*Not announced 865 megabits per square inch areal density		

MANUFACTURER	IBM	IBM	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	DFMS-34320 Ultrastar (Starfire HC)	DFMS-35250 Ultrastar (Starfire HC)	1841PA Ranger	1882PA Cobra	1885 McKinley
DISK/TREND GROUP	9	9	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MIG	MIG	MIG
Interface	SCSI-2	SCSI-2	PCMCIA-ATA	PCMCIA-ATA	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,320	F: 5,250	--	--	F: 85
REMOVABLE	--	--	F: 42.5	F: 85	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	13	16	2	3	3
Tracks per surface	4416	4416	1015	1203	1203
Track density (TPI)	4351	4351	2409	2750	2750
Maximum linear density (BPI) (FCI)	128900	128900	58500 43875	71100 53325	71100 53325
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	3571	3571	3571
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)	8.0 RD/10.1 WR	8.6 RD/10.1 WR	18	18	18
Average rotational delay (msec)	5.6	5.6	8.4	8.4	8.4
Average access time (msec)	13.6/15.7	14.2/15.7	26.4	26.4	26.4
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	5000	5000	5000
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	10.5 x 54 x 85.6	12.5 x 54 x 85.6	15 x 51 x 77
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	4Q92	3Q92	3Q92
COMMENTS			PCMCIA Type III Ramp loaded heads	Ramp loaded heads	Ramp loaded heads

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	8105PA Viper	8170PA Viper	PocketFile 105	PocketFile 170	8260PA Viper
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	PCM	PCM	OEM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
Recording medium	Thin Film	Thin Film*	Thin Film	Thin Film*	Thin Film*
DRIVE: Heads	MIG	Thin Film	MIG	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: 105.4	F: 170.8	F: 260.4
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	1107	1370	1650
Track density (TPI)	2840	3800	2840	3800	4200
Maximum linear density (BPI) (FCI)	70000 52000	84000 63000	70000 52000	84000 63000	105000 78750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 PRML
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	15	12	12
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	21.7	18.7	21.7	18.7	18.7
Data transfer rate (KBytes/sec)	10700	12000	10700	12000	12000
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	1/94	3/94	3Q94
COMMENTS	PCMCIA Type III Ramp loaded heads	PCMCIA Type III Ramp loaded heads *Untextured disks	PCMCIA Type III Ramp loaded heads	PCMCIA Type III Ramp loaded heads *Untextured disks	PCMCIA Type III Ramp loaded heads *Untextured disks

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	JTS	JTS
DRIVE	PocketFile 260	8340PA Viper	8420PA Cobalt	P3270	P3420
DISK/TREND GROUP	4	5	5	4	5
MARKET	PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 260.4	F: 340.6	F: 421.1	F: 270	F: 420
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	6	2	3
Tracks per surface	1650	2000	2000	1024	1024
Track density (TPI)	4200	5100	4200	3300	3300
Maximum linear density (BPI)	105000	113000	105000	56830	56830
(FCI)	78750	84750	78750	42662	42662
Recording code	1,7 PRML	1,7 PRML	1,7 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	5200	4200	4200
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	11/16.5	11/16.5
Average rotational delay (msec)	6.7	6.6	5.77	7.14	7.14
Average access time (msec)	18.7	18.6	17.77	18.14/23.64	18.14/23.64
Data transfer rate (KBytes/sec)	12000	18000	18000	10000	10000
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	12.7 x 101.6 x 146.1	12.7 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q94	4Q94	1Q95	4Q94	4Q94
COMMENTS	PCMCIA Type III Ramp loaded heads *Untextured disks	PCMCIA Type III Ramp loaded heads *Untextured disks	PCMCIA Type III Ramp loaded heads *Untextured disks		

MANUFACTURER	JTS	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	P3540	MobileMax 85 Lite	7131A	7135AV	7171
DISK/TREND GROUP	6	2	3	3	3
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film*	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	
Interface	PC AT	PCMCIA-ATA	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 131.1	F: 135	F: 172.9
REMOVABLE	F: 540	F: 85	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	2	1	2
Tracks per surface	1024	1565	2096	2666	2233
Track density (TPI)	3300	3600	2500	3100	2762
Maximum linear density (BPI) (FCI)	56830 42662	69600 52200	42600 31950	64100 48075	50600 37950
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4200	4464	3551	3551	3551
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)	11/16.5	16	14	14	14
Average rotational delay (msec)	7.14	6.7	8.45	8.45	8.45
Average access time (msec)	18.14/23.64	22.7	22.45	22.45	22.45
Data transfer rate (KBytes/sec)	10000	4000	9000	11100 PIO* 13300 DMA**	8000
SIZE: (mm) H x W x D	12.7 x 101.6 x 146.1	5 x 54 x 85.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	2H95	2Q93	8/94	
COMMENTS		PCMCIA Type II *Glass disk 3.3 or 5 volts		*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1	

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	MobileMax 105	MobileMax 121 Lite	MobileMax 131	MobileMax 171	7213A
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID
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	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	F: 212.78
REMOVABLE	F: 105	F: 121	F: 131	F: 171.2	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	4	4	4
Tracks per surface	1254	1793	1534	1675	1698
Track density (TPI)	2727	4120	3332	3555	1973
Maximum linear density (BPI) (FCI)	58000 43500	86500 64875	58000 43500	67500 50625	42700 32000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4464	4464	4464	4464	3551
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)	19	16	19	16	15
Average rotational delay (msec)	6.72	6.7	6.72	6.72	8.45
Average access time (msec)	25.72	22.7	25.72	22.72	23.45
Data transfer rate (KBytes/sec)	4000	4000	4000	7500	9000
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/94	2H95	4/94	8/94	1Q92
COMMENTS	PCMCIA Type III *Glass disk	PCMCIA Type II *Glass disk 3.3 or 5 volts	PCMCIA Type III *Glass disk	PCMCIA Type III *Glass disk	

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7213S	7245A	7245S	7270AV	7273A
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	
Interface	SCSI	PC AT	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 211.57	F: 245.6	F: 245.6	F: 270	F: 273
REMOVABLE	--	--	--	--	--
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	2	2
Tracks per surface	1698	1952	1952	2666	2771
Track density (TPI)	1973	2340	2340	3100	3050
Maximum linear density (BPI) (FCI)	42700 32000	42600 31950	42600 31950	64100 48075	68500 51375
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3551	3551	3551	3551	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	15	15	14	12
Average rotational delay (msec)	8.45	8.45	8.45	8.45	6.7
Average access time (msec)	23.45	23.45	23.45	22.45	18.7
Data transfer rate (KBytes/sec)	10000 synch.	9000	10000 synch.	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q92	4Q92	1Q93	8/94	4Q93
COMMENTS				*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1	*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7273S	7345A	7345S	7420AV	7540AV
DISK/TREND GROUP	4	5	5	5	6
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	PC AT	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 273	F: 345.1	F: 345.1	F: 422	F: 540
REMOVABLE	--	--	--	--	--
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	2771	2233	2233	2666	2666
Track density (TPI)	3050	2762	2762	3100	3100
Maximum linear density (BPI) (FCI)	68500 51375	50600 37950	50600 37950	64100 48075	64100 48075
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3551	3551	3551	3551
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	14	14	14	14
Average rotational delay (msec)	6.7	8.45	8.45	8.45	8.45
Average access time (msec)	18.7	22.45	22.45	22.45	22.45
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	9000	10000 synch.	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q94	1Q93	2Q93	8/94	8/94
COMMENTS				*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1	*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7546A	71050A Excalibur	71050S Excalibur	71260A Excalibur	71260S Excalibur
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 546	F: 1,050	F: 1,050	F: 1,260	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	5	5	6	6
Tracks per surface	2771	3854	3854	3854	3854
Track density (TPI)	3050	4030	4030	4030	4030
Maximum linear density (BPI) (FCI)	68500 51375	78400 58800	78400 58800	78400 58800	78400 58800
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	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)	12	12	12	12	12
Average rotational delay (msec)	6.7	6.67	6.67	6.67	6.67
Average access time (msec)	18.7	18.67	18.67	18.67	18.67
Data transfer rate (KBytes/sec)	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	10000 synch. 5000 asynch.	11100 PIO* 13300 DMA**	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	11/94	2/95	11/94	2/95
COMMENTS	*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1	*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1		*PIO Mode 3 M2=8.3 MB/sec. **DMA Mode 1	

MANUFACTURER	MAXTOR	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY
DRIVE	MXT-1240S	11/11 Micro-Magnum	11/R Micro-Magnum	5/5 Micro-Magnum	5/R Micro-Magnum
DISK/TREND GROUP	7	1	1	1	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	ST506	ST506	ST506	ST506
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,240	U: 13.6	--	U: 6.4	--
REMOVABLE	--	U: 13.6	U: 13.6	U: 6.4	U: 6.75
Capacity per track (Bytes)	Varies by zone	U: 10,640	U: 10,640	U: 10,032	U: 10,890
Data surfaces per spindle	15	4	2	4	2
Tracks per surface	2234	640	640	320	311
Track density (TPI)	2364	908	908	454	454
Maximum linear density (BPI) (FCI)	44000 33000	10890	10890	8725	8617
Recording code	1,7 RLL	MFM	MFM	MFM	MFM
Rotational speed (RPM)	6300	3254	3254	3443	3443
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8.5 RD/9.5 WR	40	40	40	40
Average rotational delay (msec)	4.76	9.2	9.2	8.7	8.7
Average access time (msec)	13.26/14.26	49.2	49.2	48.7	48.7
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	625	625	625	625
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 146.1 x 266.1	41.3 x 146.1 x 266.7	41.3 x 146.1 x 266.7	41.3 x 146.1 x 266.7
FIRST CUSTOMER SHIPMENT	2Q92	1986	1986	1986	1986
COMMENTS		Removable data cartridge	Removable data cartridge	Removable data cartridge	Removable data cartridge

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2105A	2105S	2108S	2205A	2205S
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	SCSI-2	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 560	F: 557	F: 698	F: 542	F: 585
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	8	10	5	5
Tracks per surface	1760	1760	1760	2372	2372
Track density (TPI)	1980	1980	1980	2764	2764
Maximum linear density (BPI) (FCI)	48750 36563	48750 36563	48750 36563	63331 47498	63331 47498
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	10	10	10
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	15.6	15.6	15.6	15.6	15.6
Data transfer rate (KBytes/sec)	5000	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	5000 max.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q92	3Q92	3Q92	3Q93	2Q93
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2210A	2112A	2112S	2210AV	2210S
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	PC AT, IDE	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 976	F: 1,050	F: 1,050	F: 1,056	F: 1,056
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	15	15	9	9
Tracks per surface	2372	1760	1760	2360	2372
Track density (TPI)	2764	1980	1980	2764	2764
Maximum linear density (BPI) (FCI)	63331 47498	48750 36563	48750 36563	63331 47498	63331 47498
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	10	10	10
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	15.6	15.6	15.6	15.6	15.6
Data transfer rate (KBytes/sec)	5000 max.	5000	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 146.1 x 203.2	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q93	3Q91	3Q91	10/93	2Q93
COMMENTS				Optimized for video applications	

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	2217A	2217AV	2217S	4110A Taurus I	4110AV Taurus I
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	SCSI-2	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,626	F: 1,765	F: 1,765	F: 1,052	F: 1,010
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	15	15	9	9
Tracks per surface	2372	2360	2372	2415	2415
Track density (TPI)	2764	2764	2764	2750	2750
Maximum linear density (BPI)	63331	63331	63331	60000	60000
(FCI)	47498	47498	47498	45000	45000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	10	8.5	8.5
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	15.6	15.6	15.6	14.1	14.1
Data transfer rate (KBytes/sec)	5000 max.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q93	10/93	2Q93	4Q93	
COMMENTS		Optimized for video applications			Optimized for video applications

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	4110S Taurus 1	1926S	4221 Taurus 2	1936AV	1936S
DISK/TREND GROUP	7	8	8	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
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	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,052	F: 2,158	F: 2,140	F: 3,022	F: 3,022
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	15	9	21	21
Tracks per surface	2415	2772		2759	2772
Track density (TPI)	2750	2280		2280	2280
Maximum linear density (BPI)	60000	53860		53860	53860
(FCI)	45000	40400		40400	40400
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	7200	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.5	13	8.9	13	13
Average rotational delay (msec)	5.6	5.6	4.17	5.6	5.6
Average access time (msec)	14.1	18.6	13.07	18.6	18.6
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	10000 synch. 4000 asynch.	20000 synch. 5000 asynch.	10000 synch. 4000 asynch.	10000 synch. 4000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	82.6 x 146.1 x 203.2	25.4 x 101.6 x 146.1	82.6 x 101.6 x 146.1	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2Q93	3Q93	2Q94		3Q92
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS
DRIVE	1991 Scorpio 1	3243 Capricorn 2	MiniPORT 42P	MiniPORT 85A	MiniPORT 85P
DISK/TREND GROUP	9	9	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
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	SCSI-2	SCSI-2	PCMCIA-ATA	PC AT	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 9,100	F: 4,295	--	F: 84.8	--
REMOVABLE	--	--	F: 42.4	--	F: 84.8
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	27	19	2	4	4
Tracks per surface	4356	3840	1076	1076	1076
Track density (TPI)		4200	2750	2750	2750
Maximum linear density (BPI) (FCI)		75000 56250	55300 41500	55300 41500	55300 41500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	7200	4464	4464	4464
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	12	8.9	16	16	16
Average rotational delay (msec)	5.6	4.17	6.7	6.7	6.7
Average access time (msec)	17.6	13.07	22.7	22.7	22.7
Data transfer rate (KBytes/sec)	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.	5000	5000	5000
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	41.3 x 101.6 x 146.1	10.5 x 54 x 85.6	12.5 x 50.8 x 79	13.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q93	1Q93	1Q93
COMMENTS			PCMCIA Type III		

MANUFACTURER	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS
DRIVE	MP87P	MiniPORT 128P	MiniPORT 128A	MP130P3	MP170A
DISK/TREND GROUP	2	3	3	3	3
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID
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	PC AT	PCMCIA-ATA	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 128	--	F: 171
REMOVABLE	F: 88	F: 128	--	F: 131	--
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	4	4
Tracks per surface	1445	1260	1260	1305	1445
Track density (TPI)	3400	3200	3200	3200	3400
Maximum linear density (BPI) (FCI)	94500 70875	75000 50000	75000 50000	76500 57375	94500 70875
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4464	4464	4464	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)	15	16	16	15	15
Average rotational delay (msec)	6.72	6.7	6.7	6.72	6.72
Average access time (msec)	21.72	22.7	22.7	21.72	21.72
Data transfer rate (KBytes/sec)	8000	5000	5000	8000	8000
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	13.5 x 54 x 85.6	12.5 x 50.8 x 79	10.5 x 54 x 85.6	12.5 x 50.8 x 79
FIRST CUSTOMER SHIPMENT	3Q94	3Q93	3Q93	4/94	3Q94
COMMENTS	PCMCIA Type III			PCMCIA Type III	

MANUFACTURER	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS	MINISTOR PERIPHERALS
DRIVE	MP170P3	MP260P3	MP340P3	MP340A	MP510A
DISK/TREND GROUP	3	3	3	5	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	48 mm OD 12 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	F: 340	F: 510
REMOVABLE	F: 178	F: 260	F: 340	--	--
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	6
Tracks per surface	1445	1305	1445	2094	2094
Track density (TPI)	3400	3200	3400	3620	3620
Maximum linear density (BPI) (FCI)	94500 70875	76500 57375	94500 70875	80200 53400	80200 53400
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4464	4464	4464	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)	15	15	15	12	12
Average rotational delay (msec)	6.72	6.72	6.72	6.7	6.7
Average access time (msec)	21.72	21.72	21.72	18.7	18.7
Data transfer rate (KBytes/sec)	8000	8000	8000	8000	8000
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	12.5 x 70.1 x 101.85	19 x 70.1 x 101.85
FIRST CUSTOMER SHIPMENT	3Q94	4/94	3Q94	9/94	9/94
COMMENTS	PCMCIA Type III	PCMCIA Type III 2X version of MP130P3 using Stac data compression	PCMCIA Type III 2X version of MP170P3 using Stac data compression		

MANUFACTURER	MINISTOR PERIPHERALS	NEC	NEC	NEC	NEC
DRIVE	MP680A	D1632	D1731	D3142	D3735
DISK/TREND GROUP	6	2	2	2	2
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	48 mm OD 12 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	MIG
Interface	PC AT	PCMCIA-ATA	PC AT	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 680	--	F: 85.3	U: 53.4	F: 45
REMOVABLE	--	F: 80	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F:	U: 10,416	F: 20,992
Data surfaces per spindle	8	2	4	8	2
Tracks per surface	2094		1125	642	1074
Track density (TPI)	3620		2564	850	1800
Maximum linear density (BPI) (FCI)	80200 53400		49320 36990	14000	30000 22500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	MFM	1,7 RLL
Rotational speed (RPM)	4464	5400	5400	3600	3456
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	16	17	28	25
Average rotational delay (msec)	6.7	5.6	5.6	8.3	8.7
Average access time (msec)	18.7	21.6	22.6	36.3	33.7
Data transfer rate (KBytes/sec)	8000	4500	4500	625	1500
SIZE: (mm) H x W x D	19 x 70.1 x 101.85	10.5 x 54 x 85.6	15 x 50.8 x 76.9	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q94	1994	1993	1Q88	6/90
COMMENTS		PCMCIA Type III			

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3835	D1741	D3746	D3765	D3855 D3856
DISK/TREND GROUP	2	3	3	3	3
MARKET	Captive, OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	MIG
Interface	SCSI	PC AT	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 45	--	F: 128	F: 176.5	F: 105
REMOVABLE	--	F: 125.9	--	--	--
Capacity per track (Bytes)	F: 20,992	Varies by zone	Varies by zone	F: 29,690	F: 20,992
Data surfaces per spindle	2	4	2	4	4
Tracks per surface	1075	1411	1673	1486	1251
Track density (TPI)	1800	3200	2200	2036	1800
Maximum linear density (BPI) (FCI)	30000 22500	59140 44355	51000 38250	49403 37052	32000 24000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3456	5400	4500	3600	3456
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)	25	17	14	16.5	25
Average rotational delay (msec)	8.7	5.6	6.67	8.3	8.7
Average access time (msec)	33.7	22.6	20.67	24.8	33.7
Data transfer rate (KBytes/sec)	1500 asynch.	4500	5000	2365	1500 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	15 x 50.8 x 76.9	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2/90	3Q93	3Q93	2Q91	12/89
COMMENTS					D3856 has 19 msec. average positioning time

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3861	D3865	D3766	D3866	D2713
DISK/TREND GROUP	3	3	4	4	5
MARKET	Captive, OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 114.78	F: 176.5	F: 245.1	F: 245.1	F: 352
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 29,690	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	7	4	4	4	4
Tracks per surface	915	1486	1673	1673	
Track density (TPI)	1311	2036	2200	2200	3600
Maximum linear density (BPI) (FCI)	25484 16989	49403 37052	51000 38250	51000 38250	
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3573	3600	4500	4500	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	20	16.5	14	14	14 RD/15 WR
Average rotational delay (msec)	8.4	8.3	6.67	6.67	7.5
Average access time (msec)	28.4	24.8	20.67	20.67	21.5 RD/22.5 WR
Data transfer rate (KBytes/sec)	1250	2365	5000		
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	3/89	2Q91	3Q93		4Q94
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3713	D3772	D3781	D3813	D3872
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	Captive, OEM	Captive, OEM	OEM	Captive, OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	PC AT	PC AT	SCSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 345.6	F: 331.46	F: 426.16	F: 345.6	F: 331.46
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 32,200	F: 32,200	Varies by zone	F: 32,200
Data surfaces per spindle	4	7	9	4	7
Tracks per surface		1468	1468		1468
Track density (TPI)		2000	2000		2000
Maximum linear density (BPI) (FCI)		49000 36750	49000 36750		49000 36750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4090	3600	3600	4090	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	12	14	14	12	14
Average rotational delay (msec)	7.3	8.3	8.3	7.3	8.3
Average access time (msec)	19.3	22.3	22.3	19.3	22.3
Data transfer rate (KBytes/sec)	5000	5000 synch. 2365 asynch.	5000 synch. 2365 asynch.		5000 synch. 2365 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT		2Q91	2Q91		2Q91
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	QUANTUM	QUANTUM
DRIVE	D3881	D3392	D3892	127A Daytona	127S Daytona
DISK/TREND GROUP	5	7	7	3	3
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	SCSI-2	IPI-2	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 426.16	F: 1,434	F: 1,434	F: 127	F: 127
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,200	F: 30,208	F: 30,208	Varies by zone	Varies by zone
Data surfaces per spindle	9	19	19	2	2
Tracks per surface	1468	2495	2495	1704	1704
Track density (TPI)	2000	2840	2840	3100	3100
Maximum linear density (BPI) (FCI)	49000 36750	55900 41925	55900 41925	71600 53700	71600 53700
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	14	11.8	11.8	17	17
Average rotational delay (msec)	8.3	5.6	5.6	6.7	6.7
Average access time (msec)	22.3	17.4	17.4	23.7	23.7
Data transfer rate (KBytes/sec)	5000 synch. 2365 asynch.	5000 synch. 2500 asynch.	5000 synch. 2500 asynch.	11100 PIO* 13300 DMA**	10000 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	12.5 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	2Q91	2Q93	2Q93	1/94	1/94
COMMENTS				*PIO Mode 3 **DMA Mode 1	

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	170AT GLS Go.Drive	170AT LPS ProDrive	170S GLS Go.Drive	170S LPS ProDrive	210A LPS ProDrive
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MIG
Interface	PC AT	PC AT	SCSI-2	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 170	F: 170	F: 170	F: 170	F: 211.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	4	2	2
Tracks per surface	1395	2337	1395	2337	2515
Track density (TPI)	2529	2670	2529	2670	2670
Maximum linear density (BPI) (FCI)	57812 43359	48865 36648	57812 43359	48865 36648	55179 41384
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
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)	17	14	17	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	25.3	22.3	25.3	22.3	22.3
Data transfer rate (KBytes/sec)	4000	6000	4000 synch. 3000 asynch.	10000 synch. 5000 asynch.	6000
SIZE: (mm) H x W x D	17 x 70 x 101.6	25.4 x 101.6 x 146.1	17 x 70 x 101.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	6/93	4Q93	6/93	4Q93	1Q94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	256A Daytona	256S Daytona	270A Maverick	270AT LPS ProDrive	270S LPS ProDrive
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	SCSI-2	PC AT	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 256	F: 256	F: 270	F: 270.6	F: 270.6
REMOVABLE	--	--	--	--	--
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	2	2	2
Tracks per surface	1704	1704	2856	2740	2740
Track density (TPI)	3100	3100	2950	2875	2875
Maximum linear density (BPI) (FCI)	71600 53700	71600 53700	60204 45266	62600 45900	62600 45900
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3600	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)	17	17	14	12	12
Average rotational delay (msec)	6.7	6.7	8.3	6.7	6.7
Average access time (msec)	23.7	23.7	22.3	18.7	18.7
Data transfer rate (KBytes/sec)	11100 PIO* 13300 DMA**	10000 synch.	6000	6000	10000 synch. 6000 asynch.
SIZE: (mm) H x W x D	12.5 x 70 x 100	12.5 x 70 x 100	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1/94	1/94	6/94	4Q93	4Q93
COMMENTS	*PIO Mode 3 **DMA Mode 1				

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	270S Maverick	340A LPS ProDrive	340S LPS ProDrive	341A Daytona	341S Daytona
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	SCSI-2	PC AT	SCSI-2	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 270	F: 342	F: 342	F: 341	F: 341
REMOVABLE	--	--	--	--	--
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	6	6
Tracks per surface	2856	2337	2337	1704	1704
Track density (TPI)	2950	2670	2670	3100	3100
Maximum linear density (BPI) (FCI)	60204 45266	48650 36487	48650 36487	71600 53700	71600 53700
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	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)	14	12	12	17	17
Average rotational delay (msec)	8.3	8.3	8.3	6.7	6.7
Average access time (msec)	22.3	20.3	20.3	23.7	23.7
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	6000	10000 synch. 6000 asynch.	11100 PIO* 13300 DMA**	10000 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	19 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT	6/94	4Q93	4Q93	1/94	1/94
COMMENTS				*PIO Mode 3 **DMA Mode 1	

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	365A Lightning	365S Lightning	420A LPS ProDrive	514A Daytona	514S Daytona
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	PC AT	SCSI-2	PC AT	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 365.7	F: 365.7	F: 421	F: 514	F: 514
REMOVABLE	--	--	--	--	--
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	4	8	8
Tracks per surface	3673	3673	2519	1704	1704
Track density (TPI)	3794	3794	2670	3100	3100
Maximum linear density (BPI) (FCI)	63515 47636	63515 47636	55179 41595	71600 53700	71600 53700
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3600	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)	11	11	12	17	17
Average rotational delay (msec)	6.7	6.7	8.3	6.7	6.7
Average access time (msec)	17.7	17.7	20.3	23.7	23.7
Data transfer rate (KBytes/sec)	6000	10000 asynch. 6000 synch.	6000	11100 PIO* 13300 DMA**	10000 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.2	19 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT	4/94	4/94		1/94	1/94
COMMENTS				*PIO Mode 3 **DMA Mode 1	

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	540A Lightning	540A LPS ProDrive	540A Maverick	540S Empire	540S Lightning
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	PC AT	PC AT	SCSI-3	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 541.3	F: 541.3	F: 540	U: 616 F: 540	F: 541.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	4	4	4	3
Tracks per surface	3673	2740	2856	2874	3673
Track density (TPI)	3794	2875	2950	3014	3794
Maximum linear density (BPI) (FCI)	63515 47636	62600 45900	60204 45266	63600 47700	63515 47636
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3600	5400	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)	11	12	14	9.5 RD/11 WR	11
Average rotational delay (msec)	6.7	6.7	8.3	5.6	6.7
Average access time (msec)	17.7	18.7	22.3	15.1 RD/16.6 WR	17.7
Data transfer rate (KBytes/sec)	6000	6000	6000	20000 synch. 10000 asynch.	10000 synch. 6000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/94	4Q93	6/94	4Q93	4/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	540S LPS ProDrive	540S Maverick	730A Lightning	730S Lightning	DSP3053L
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 541.3	F: 540	F: 731.5	F: 731.5	U: 684 F: 535
REMOVABLE	--	--	--	--	--
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	2740	2856	3673	3673	3117
Track density (TPI)	2875	2950	3794	3794	3256
Maximum linear density (BPI) (FCI)	62600 45900	60204 45266	63515 47636	63515 47636	61509 46132
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3600	4500	4500	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	14	11	11	9.5
Average rotational delay (msec)	6.7	8.3	6.7	6.7	5.6
Average access time (msec)	18.7	22.3	17.7	17.7	15.1
Data transfer rate (KBytes/sec)	10000 synch. 6000 asynch.	10000 synch. 5000 asynch.	6000	10000 synch. 6000 asynch.	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	6/94	4/94	4/94	10/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	1050S ProDrive	1080S Empire	1225S ProDrive	1400S Empire	1800S ProDrive
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI-2	SCSI-3	SCSI-2	SCSI-3	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,050	U: 1,232 F: 1,080	F: 1,225	U: 1,604 F: 1,400	U: 2,133 F: 1,800
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	12	8	14	8	14
Tracks per surface	2448	2874	2959	3115	2959
Track density (TPI)	2670	3014	3260	3200	3260
Maximum linear density (BPI) (FCI)	50500 37900	63600 47700	50500 37900	80000 90000	63691 47768
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	1,7 RLL
Rotational speed (RPM)	4500	5400	4500	5400	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)	10 RD/12 WR	9.5 RD/11 WR	10 RD/12 WR	9.5 RD/11 WR	10 RD/12 WR
Average rotational delay (msec)	6.7	5.6	6.7	5.6	6.7
Average access time (msec)	16.7/18.7	15.1 RD/16.6 WR	16.7/18.7	15.1/16.6	16.7 RD/18.7 WR
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	20000 synch. 10000 asynch.	10000 synch. 5000 asynch.	20000 synch. 5000 asynch.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	9/92	4Q93	9/92	1Q94	8/93
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	DSP3107L	DSP3133L	XP31070 Atlas	2100S Empire	2160S Empire
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-3	SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,368 F: 1,070	U: 1,709 F: 1,337	U: 1,344 F: 1,075	U: 2,406 F: 2,100	U: 2,475 F: 2,160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	10	5	12	12
Tracks per surface	3117	3117	3832	3115	3100
Track density (TPI)	3256	3256	3858	3200	3150
Maximum linear density (BPI) (FCI)	61509 46132	61509 46132	81765 61324	80000 90000	80000 90000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	5400	5400	7200	5400	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)	9.5	9.5	8.5	9.5 RD/11 WR	9.5 RD/11 WR
Average rotational delay (msec)	5.6	5.6	4.17	5.6	5.6
Average access time (msec)	15.1	15.1	12.67	15.1/16.6	15.1/16.6
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 5000 asynch.	20000 synch. 5000 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/94	10/94	4Q94	1Q94	1Q94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	DSP3210	VP31110 Capella	VP32210 Capella	XP32150 Atlas	XP32151 (2140S) Grand Prix
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,688 F: 2,148	U: 1,412 F: 1,108	U: 2,824 F: 2,216	U: 2,689 F: 2,150	U: 2,619 F: 2,140
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	16	4	8	10	10
Tracks per surface	3045	4165	4165	3832	4066
Track density (TPI)	3256	4350	4350	3858	4000
Maximum linear density (BPI) (FCI)	64000 48000	98600 73950	98600 73950	81765 61324	89600 79600
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	5400	5400	5400	7200	7200
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)	9.5	8.5 RD/9.5 WR	8.5 RD/9.5 WR	8.5	8.6 RD/10.6 WR
Average rotational delay (msec)	5.6	5.6	5.6	4.17	4.17
Average access time (msec)	15.1	14.1/15.1	14.1/15.1	12.67	12.77/14.77
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.	20000 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/94	1Q95	1Q95	4Q94	4Q94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	RAYMOND ENGINEERING	RAYMOND ENGINEERING	SAGEM
DRIVE	XP34300 Atlas	XP34301 (4280S) Grand Prix	8440	84300	MSA 252-200
DISK/TREND GROUP	9	9	2	5	4
MARKET	OEM, PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Thin Film	Ferrite
Interface	SCSI-2	SCSI-3	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 5,378 F: 4,300	U: 5,238 F: 4,280	--	--	--
REMOVABLE	--	--	F: 40.55	F: 306	F: 200
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 11,264	F: 27,648	F: 23,040
Data surfaces per spindle	20	20	8	9	16
Tracks per surface	3832	4066	450	1231	720
Track density (TPI)	3858	4000	850	2075	950
Maximum linear density (BPI)	81765	89600	17000	46227	19680
(FCI)	61324	79600	17000	30818	14760
Recording code	1,7 RLL	PRML	MFM	2,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	3637	3688	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Embedded
Average positioning time (msec)	8.5	8.6 RD/10.6 WR	115	25	17
Average rotational delay (msec)	4.17	4.17	8.3	8.1	8.3
Average access time (msec)	12.67	12.77/14.77	123.3	33.1	25.3
Data transfer rate (KBytes/sec)	20000 synch. 10000 asynch.	20000 synch.	400	1200	1500
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	58.4 x 106.7 x 188	58.4 x 106.7 x 188	220 x 440 x 500
FIRST CUSTOMER SHIPMENT	4Q94	4Q94	1987	1991	10/90
COMMENTS			Mil-Spec ruggedized drive and electronics assembly. *Removable disk drive cartridge	Mil-Spec ruggedized drive and electronics assembly. *Removable disk drive cartridge	Militarized Subsystem Removable Head/Disk Module

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	SHD-3122A	SHD-3211A	SHD-3172A	SHD-3212A	PLS-30540A/S
DISK/TREND GROUP	4	4	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 251.9	F: 213.4	F: 356.8	F: 426.8	F: 540
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,239	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	4	4	4
Tracks per surface	1902	2570	2223	2570	2912
Track density (TPI)	2251	2899	2500	2899	3200
Maximum linear density (BPI) (FCI)	45269 33952	57112 42834	53555 40166	57112 42834	64400 48300
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	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)	16	13	13	13	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	6.67
Average access time (msec)	24.3	21.3	21.3	21.3	18.67
Data transfer rate (KBytes/sec)	8000	8000	8000	8000	11000
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT		1Q94	3Q93	1Q94	4Q94
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	SHD-30540A	ST7050P	ST9052A	ST9080A	ST9100A ST9100AG
DISK/TREND GROUP	6	2	2	2	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	48 mm OD 12 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PCMCIA-ATA	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 540	--	F: 42.6	F: 64.0	F: 85.3
REMOVABLE	--	F: 42.6	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	2	2	2	2
Tracks per surface	2768	1074	1065		
Track density (TPI)	3125	2748	2165	2650	2650
Maximum linear density (BPI) (FCI)	64120 48898	53200 39900	40500 27000	45600 30400	58200 43760
Recording code	1,7 RLL	1, 7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3545	3450	3450	3545
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	16	16	16	16
Average rotational delay (msec)	8.3	8.46	8.7	8.7	8.5
Average access time (msec)	21.3	24.46	24.7	24.7	24.5
Data transfer rate (KBytes/sec)	11000	4000	4000	4000	4000
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	10.5 x 54 x 85.6	12.5 x 70.1 x 101.9	12.5 x 70.1 x 101.9	12.5 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	3Q94	1993	4Q91	3Q92	1Q93
COMMENTS		PCMCIA Type III			

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3120A	ST3144A	ST3145A	ST9140AG	ST9144A
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	65 mm OD	65 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID Thin Film	20 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 106.9	F: 130	F: 130.7	F: 127	F: 127.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	3	2	4	6
Tracks per surface	1024	1001			1065
Track density (TPI)	1760	1760	2400	2760	2165
Maximum linear density (BPI)	34600	34600	42700	57120	40500
(FCI)	23000	23000	32025	42840	27000
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3528	3528	3811	3546	3450
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	8.5	8.5	7.87	8.46	8.7
Average access time (msec)	24.5	24.5	23.87	24.46	24.7
Data transfer rate (KBytes/sec)	4000	4000	5000	8000	4000
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	12.5 x 70.1 x 101.9	19.05 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	1/91	3Q91	3Q93	3Q93	4Q91
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9145AG	ST9150AG	ST9190AG	ST3243A	ST3250A Medalist 210xe
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 127	F: 131.2	F: 170	F: 214	F: 214
REMOVABLE	--	--	--	--	--
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	2
Tracks per surface				1996	
Track density (TPI)	2650		2760	2178	
Maximum linear density (BPI) (FCI)	45600 30400		57120 42840	42700 32000	
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3449	3980	3546	3811	3811
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	16	14
Average rotational delay (msec)	8.7	7.5	8.46	7.87	7.87
Average access time (msec)	24.7	23.5	24.46	23.87	21.87
Data transfer rate (KBytes/sec)	4000	11100 PIO* 13300 DMA**	8000	4000	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	19.05 x 70.1 x 101.9	12.5 x 70.1 x 101.9	12.5 x 70.1 x 101.9	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6
FIRST CUSTOMER SHIPMENT		1Q94	3Q93	2Q92	4Q93
COMMENTS		*PIO Mode 3 **DMA Mode 1			*PIO Mode 3 **DMA Mode 1

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3283N	ST3290A	ST3291A Medalist XE	ST3295A Medalist 275xe	ST9235AG
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
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	SCSI-2	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 248.62	F: 262	F: 273	F: 272	F: 209.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	4	2	2	6
Tracks per surface	1672				
Track density (TPI)	1960	2400			2750
Maximum linear density (BPI) (FCI)	35000 26250	42700 32025			45500 30300
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	4500	3811	3811	3811	3450
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	16	13	14	16
Average rotational delay (msec)	6.7	7.87	7.87	7.87	8.69
Average access time (msec)	18.7	23.87	20.87	21.87	24.69
Data transfer rate (KBytes/sec)	10000 synch. 3000 asynch.	5000	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	4000
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	19.05 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	1Q92	2Q93	4Q93	9/94	3Q92
COMMENTS			*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9235N	ST9240AG	ST9300AG ST9300AR	ST3390A	ST3390N
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI	PC AT	PC AT	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 209	F: 210.4	F: 262.4	F: 341.3	F: 341.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6			3	3
Tracks per surface				2676	2676
Track density (TPI)	2750			3000	3000
Maximum linear density (BPI) (FCI)	45500 30300			42700 32000	42700 32000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3450	3980	3980	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	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	16	12	12
Average rotational delay (msec)	8.69	7.5	7.5	6.7	6.7
Average access time (msec)	24.69	23.5	23.5	18.7	18.7
Data transfer rate (KBytes/sec)	5000 synch.	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	5500	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	19.05 x 70.1 x 101.9	12.5 x 70.1 x 101.9	12.5 x 70.1 x 101.9	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6
FIRST CUSTOMER SHIPMENT	3Q92	1Q94	1Q94	3/93	3/93
COMMENTS		*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1		

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3391A Medalist 340xe	ST3491A Medalist 425xe	ST3550A Medalist	ST3550N Medalist	ST9385AG
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
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	PC AT	PC AT	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 341	F: 428	F: 452.4	F: 456.5	F: 341
REMOVABLE	--	--	--	--	--
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	5	5	6
Tracks per surface			2126	2126	
Track density (TPI)			2400	2400	3282
Maximum linear density (BPI) (FCI)			52602 39451	52602 39451	59124 44343
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3811	3811	4500	4500	3980
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	13	14	12	12	16
Average rotational delay (msec)	7.87	7.87	6.7	6.7	7.54
Average access time (msec)	20.87	21.87	18.7	18.7	23.54
Data transfer rate (KBytes/sec)	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	10000 synch. 5000 asynch.	11100 PIO** 13300 DMA***
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	19.5 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	4Q93	4Q93	4Q92	4Q92	4Q93
COMMENTS	*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1		*Glass-ceramic disk **PIO Mode 3 ***DMA Mode 1

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9550AG	ST3600A	ST3600N ST3600ND	ST3610N ST3610NC ST3610ND	ST3620N ST3620NC ST3620ND
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	PC AT	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 455	U: 600 F: 525	U: 600 F: 525	U: 635 F: 535	U: 650 F: 560
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	7	7	7	5
Tracks per surface		1877	1877	1872	2700
Track density (TPI)	3282	2150	2150	2150	3000
Maximum linear density (BPI) (FCI)	59124 44343	47000 35250	47000 35250	42000 31500	49000 36750
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3980	4500	4500	5411	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	10.5 RD/12 WR	10.5 RD/12 WR	10.5 RD/12 WR	9 RD/10.5 WR
Average rotational delay (msec)	7.54	6.7	6.7	5.5	5.6
Average access time (msec)	23.54	17.2/18.7	17.2/18.7	16/17.5	14.6/16.1
Data transfer rate (KBytes/sec)	11100 PIO** 13300 DMA***	4000	10000 synch. 4000 asynch.	10000 synch. 5000 asynch.	10000 synch.
SIZE: (mm) H x W x D	19.05 x 70.1 x 101.9	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	1Q92	1Q92	12/92	3Q93
COMMENTS	*Glass-ceramic disk **PIO Mode 3 ***DMA Mode 1				

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3655A Medalist	ST3655N Medalist	ST3660A Medalist 545xe	ST3780A Medalist	ST5660A Decathlon
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	PC AT	SCSI-2	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 528.5	F: 545.3	F: 545	F: 722	F: 545
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	5	4	4	4
Tracks per surface				3876	3420
Track density (TPI)	3000	3000			
Maximum linear density (BPI) (FCI)	53192 39894	53192 39894			
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3811	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	14	12	12
Average rotational delay (msec)	6.7	6.7	7.87	6.67	6.67
Average access time (msec)	18.7	18.7	21.87	18.67	18.67
Data transfer rate (KBytes/sec)	11100 PIO* 13300 DMA**	10000 synch. 5000 asynch.	11100 PIO* 13300 DMA**	16700 PIO* 16700 DMA**	16700 PIO* 16700 DMA**
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	19 x 102.1 x 127
FIRST CUSTOMER SHIPMENT	2Q93	3Q93	9/94		1Q94
COMMENTS	*PIO Mode 3 **DMA Mode 1		*PIO Mode 3 **DMA Mode 1	*PIO Mode 4 **DMA Mode 2	*PIO Mode 4 **DMA Mode 2

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST5660N Decathlon	ST9655AG	ST11200N ST11200NC ST11200ND	ST11901N ST11901ND	ST11950N ST11950ND Barracuda 1
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI	PC AT	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 545.3	F: 524	U: 1,200 F: 1,050	U: 2,003 F: 1,700	U: 2,031 F: 1,689
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4		15	13	15
Tracks per surface	3420		1877	2626	2706
Track density (TPI)			2150	3000	3047
Maximum linear density (BPI) (FCI)			42000 31500	50000 37500	52187 39140
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3980	5400	5400	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	16	10.5 RD/12 WR	9 RD/10.5 WR	8 RD/9 WR
Average rotational delay (msec)	6.67	7.5	5.6	5.6	4.17
Average access time (msec)	18.67	23.5	16.1/17.6	14.6/16.1	12.17/13.17
Data transfer rate (KBytes/sec)	10000 synch. 5000 asynch.	11100 PIO* 13300 DMA**	10000 synch. 4000 asynch.	20000 synch. 10000 asynch.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	19 x 102.1 x 127	19.05 x 70.1 x 101.9	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	41.3 x 101.6 x 151.6
FIRST CUSTOMER SHIPMENT	1Q94	2Q94	2Q92	2Q93	4/93
COMMENTS		*PIO Mode 3 **DMA Mode 1			

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST12450W ST12450WD Barracuda 2,2HP	ST31200N ST31200NC ST31200ND	ST31220A Medalist	ST31230N ST31230NC ST31230ND Hawk 2LP	ST31230W ST31230WC ST31230WD Hawk 2LP
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
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	SCSI-2	SCSI-2	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,437 F: 1,781	U: 1,260 F: 1,050	F: 1,083	U: 1,200 F: 1,050	U: 1,200 F: 1,050
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	18	9	6	5	5
Tracks per surface	2707	2626	3876	3898	3898
Track density (TPI)		3000		4200	4200
Maximum linear density (BPI) (FCI)		55000 41250		78000 58500	78000 58500
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	5400	4500	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8 RD/9 WR	9 RD/10.5 WR	12	9 RD/10.5 WR	9 RD/10.5 WR
Average rotational delay (msec)	4.17	5.6	6.67	5.6	5.6
Average access time (msec)	12.17/13.17	14.6/16.1	18.67	14.6/16.1	14.6/16.1
Data transfer rate (KBytes/sec)	20000 synch.	10000 synch. 4000 asynch.	16700 PIO* 16700 DMA**	10000 synch.	20000 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 151.6	25.4 x 101.6 x 146.1	25.4 x 102.1 x 146.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q94	2Q93		2Q94	2Q94
COMMENTS	2 head parallel version of Barracuda 2		*PIO Mode 4 **DMA Mode 2		

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41200N ST41200ND ST41200NM ST41200NV Wren 7	ST41201J ST41201K Elite 1	ST41520N ST41520ND Elite 1	ST41600N ST41600ND ST41601N ST41601ND Elite 1	ST41650N ST41650ND Wren 8
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
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	SCSI-2	Mod. SMD, IPI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,200 F: 1,050	U: 1,200	U: 1,600 F: 1,370	U: 1,600 F: 1,370	U: 1,650 F: 1,420
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	U: 33,600	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	17	17	17	15
Tracks per surface	1931	2101	2101	2101	2110
Track density (TPI)	1600	1801	1801	1801	1760
Maximum linear density (BPI) (FCI)	32750 24562	33344 22229			40000 30000
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	5400	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	11.5	11.5	11.5	15
Average rotational delay (msec)	8.3	5.6	5.6	5.6	8.3
Average access time (msec)	23.3	17.1	17.1	17.1	23.3
Data transfer rate (KBytes/sec)	4800 synch.	3000	5000 synch.	5000 synch.	5000 synch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 252.5	82.6 x 146.1 x 252.2	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	5/89	1Q90	12/90	12/90	12/90
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41651N ST41651ND Wren 8	ST41800K Elite 2	ST42000N ST42000ND Elite 2	ST42100N Wren 9	ST12400N ST12400NC ST12400ND
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
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	SCSI-2	IPI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,650 F: 1,420	U: 1,986	U: 2,106 F: 1,792	U: 2,200 F: 1,900	U: 2,500 F: 2,100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	U: 84,000	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	18	19	15	19
Tracks per surface	2107	2627	2627	2574	2626
Track density (TPI)	1760			2150	3000
Maximum linear density (BPI) (FCI)	40000 30000			46000 34500	50000 37500
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	11	11	12.9	9 RD/10.5 WR
Average rotational delay (msec)	8.3	5.6	5.6	8.3	5.6
Average access time (msec)	23.3	16.6	16.6	21.2	14.6/16.1
Data transfer rate (KBytes/sec)	10000 synch.	7500	10000 synch.	10000 synch.	10000 synch. 5000 asynch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	82.6 x 146.1 x 216	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	9/91	3Q91	3Q92	3Q91	2Q93
COMMENTS		2 head parallel version of Elite 2			

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST12550N ST12550ND Barracuda 2	ST12550W ST12550WD Barracuda 2	ST32430N ST32430NC ST32430ND Hawk 2LP	ST32430W ST32430WC ST32430WD Hawk 2LP	ST32550N ST32550ND Barracuda 2LP
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	MR Thin Film	
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,572 F: 2,139	U: 2,572 F: 2,139	U: 2,600 F: 2,147	U: 2,600 F: 2,147	U: 2,541 F: 2,147
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	19	19	9	9	11
Tracks per surface	2707	2707	3898	3898	3680
Track density (TPI)			4200	4200	
Maximum linear density (BPI) (FCI)			78000 58500	78000 58500	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	5400	5400	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	9 RD/10.5 WR	9 RD/10.5 WR	8 RD/9 WR
Average rotational delay (msec)	4.17	4.17	5.6	5.6	4.17
Average access time (msec)	12.17/13.7	12.17/13.17	14.6/16.1	14.6/16.1	12.17/13.17
Data transfer rate (KBytes/sec)	10000 synch.	20000 synch.	10000 synch.	20000 synch.	10000 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 151.6	41.3 x 101.6 x 151.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2/93	7/93	2Q94	2Q94	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32550W ST32550WD ST32550WD Barracuda 2LP	ST42400N ST42400ND Elite 2	ST43200K Elite 3, 2HP	ST43400N ST43400ND Elite 3	ST43401N ST43401ND ST43402ND Elite 3
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IPI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,541 F: 2,147	U: 2,500 F: 2,129	U: 3,386	U: 3,555 F: 2,912	U: 3,555 F: 2,912
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	11	19	20	21	21
Tracks per surface	3680	2627	2627	2627	2627
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8 RD/9 WR	11	11	11	11
Average rotational delay (msec)	4.17	5.6	5.6	5.6	5.6
Average access time (msec)	12.17/13.17	16.6	16.6	16.6	16.6
Data transfer rate (KBytes/sec)	20000 synch.	5000 synch.	25000	10000 synch. 6000 asynch.	20000 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	82.6 x 146.1 x 203.2	82.6 x 146.1 x 221	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2Q94	3Q91	3/92	2/92	4/92
COMMENTS			2 head parallel version of Elite 3		Dual port optional

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST15150N ST15150ND Barracuda 4	ST15150W ST15150WD Barracuda 4	ST15230N ST15230NC ST15230ND Hawk 4	ST15230W ST15230WC ST15230WD Hawk 4	ST410800N ST410800ND Elite 9
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film			Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 4,880 F: 4,100	U: 4,880 F: 4,100	U: 5,200 F: 4,294	U: 5,200 F: 4,294	U: 10,800 F: 9,080
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	21	21	19	19	27
Tracks per surface	3620	3620	3898	3898	4921
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	9 RD/10.5 WR	9 RD/10.5 WR	11 RD/12 WR
Average rotational delay (msec)	4.17	4.17	5.6	5.6	5.6
Average access time (msec)	12.17/13.17	12.17/13.17	14.6/16.1	14.6/16.1	16.6/17.6
Data transfer rate (KBytes/sec)	10000 synch.	20000 synch.	10000 synch.	20000 synch.	10000 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 151.6	41.3 x 101.6 x 151.6	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q94	2Q94	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEIKO EPSON	SEQUEL	SEQUEL	SEQUEL
DRIVE	ST410800W ST410800WD Elite 9	EHDD170 Hard Disk Card	XT-1085	806	XT-1120R
DISK/TREND GROUP	9	3	2	3	3
MARKET	OEM	PCM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	48 mm OD 12 mm ID	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film*	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	PCMCIA-ATA	ST412	Priam,SMD,SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 10,800 F: 9,080	--	U: 85.32	U: 227	U: 127.99*
REMOVABLE	--	F: 170.8	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	U: 10,416	U: 20,160	U: 15,624*
Data surfaces per spindle	27	4	8	11	8
Tracks per surface	4921	1370	1024	1023	1024
Track density (TPI)		3800	1070	1040	1070
Maximum linear density (BPI)		84000	9934	9167	14901
(FCI)		63000			9934
Recording code	1,7 RLL	1,7 RLL	MFM	MFM	2,7 RLL*
Rotational speed (RPM)	5400	4500	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11 RD/12 WR	12	27	20	27
Average rotational delay (msec)	5.6	6.7	8.3	8.3	8.3
Average access time (msec)	16.6/17.6	18.7	35.3	28.3	35.3
Data transfer rate (KBytes/sec)	20000 synch.	12000	625	1210	937.5*
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	10.5 x 54 x 85.6	82.6 x 146.1 x 208.3	--	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	2Q94	3/94	2Q83	5/84	2Q87
COMMENTS		PCMCIA Type III Ramp loaded heads. *Untextured disks. Mfg. by Integral Periph			*With RLL controller

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-1140	XT-1240R	XT-2190	XT-4170E	XT-4170S
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ST412	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 143.42	U: 239.98*	U: 191.23	U: 179.45	F: 157.93
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	U: 10,416	U: 20,940	F: 18,432
Data surfaces per spindle	15	15	15	7	7
Tracks per surface	918	1024	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI) (FCI)	9280	14901 9934	11155	21064 14043	21064 14043
Recording code	MFM	2,7 RLL*	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25.8	27	28.9	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	34.1	35.3	37.2	22.3	22.3
Data transfer rate (KBytes/sec)	625	937.5*	625	1250	4800 synch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	2Q83	2Q87	3Q84	2Q87	2/86
COMMENTS		*With RLL controller			

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-4230E	807	XT-4380E	XT-4380S	XT-8380EH
DISK/TREND GROUP	3	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	200 mm OD 63.5 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Thin Film	Thin Film	Ferrite
Interface	ESDI	Priam,SMD,SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 230.6	U: 344	U: 384.53	F: 338.41	U: 410.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,940	U: 20,160	U: 20,940	F: 18,432	U: 31,410
Data surfaces per spindle	9	11	15	15	8
Tracks per surface	1224	1552	1224	1224	1632
Track density (TPI)	1070	1040	1070	1070	1376
Maximum linear density (BPI) (FCI)	21064 14042	12096	21064 14043	21064 14043	31596 21064
Recording code	2,7 RLL	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	25	16	16	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	33.3	24.3	24.3	22.8
Data transfer rate (KBytes/sec)	1250	1210	1250	4800 synch.	1875
SIZE: (mm) H x W x D	82.6 x 146.1 x 208.3	--	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	3Q90	6/84	2Q87	4Q87	1Q87
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-8380SH	XT-8760EH	XT-8760SH	5350	5400
DISK/TREND GROUP	5	6	6	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 360.31	U: 768.9	F: 675.58	F: 3,572	F: 4,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	U: 31,410	F: 27,648	Varies by zone	Varies by zone
Data surfaces per spindle	8	15	15	25	26
Tracks per surface	1632	1632	1632	3055	3055
Track density (TPI)	1376	1376	1376	2756	2756
Maximum linear density (BPI) (FCI)	31596 21064	31596 21064	31596 21064	44000 33000	49000 36750
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14.5	16.5	16.5	11.5	11.5
Average rotational delay (msec)	8.3	8.3	8.3	5.6	5.6
Average access time (msec)	22.8	24.8	24.8	17.1	17.1
Data transfer rate (KBytes/sec)	4800 synch.	1875	4800 synch.	20000 synch. 10000 asynch.	20000 synch. 10000 asynch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146.1 x 208.3	82.6 x 146 x 208.8	82.6 x 146 x 208.8
FIRST CUSTOMER SHIPMENT	1Q88	1Q87	1Q88	1Q93	8/93
COMMENTS					

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	SQ555	SQ1080	SQ3105A	SQ3105S	SQ3270A
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	130 mm OD 40 mm ID	48 mm OD 12 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	MIG	MIG	
Interface	SCSI	PCMCIA-ATA	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 44.39	F: 80	F: 110	F: 110	F: 270
Capacity per track (Bytes)	F: 17,408	F: 36,864	Varies by zone	Varies by zone	F:
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	1275	1472	2043	2043	3140
Track density (TPI)	1086	3200	2100	2100	3280
Maximum linear density (BPI) (FCI)	23642 15761	72000 54330	40000 30000	40000 30000	60000 45000
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3220	5400	3600	3600	3600
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)	20	16	14.5	14.5	13.5
Average rotational delay (msec)	9.32	5.6	8.3	8.3	8.3
Average access time (msec)	29.32	21.6	22.8	22.8	21.8
Data transfer rate (KBytes/sec)	1250	10000	4000	4000 synch.	4000
SIZE: (mm) H x W x D	41.3 x 146.1 x 203.2	10.5 x 54 x 85.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 150
FIRST CUSTOMER SHIPMENT	1Q88	4Q93	3Q92	3/93	4Q93
COMMENTS	Removable data cartridge	PCMCIA Type III	Removable data cartridge	Removable data cartridge	Removable data cartridge

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	SQ3270S	SQ5110	SQ5200C	SyDOS 44e SyDOS 44i	SyDOS 88e SyDOS 88i
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	SCSI	SCSI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 270	F: 88.8	F: 200	F: 44.39	F: 88.8
Capacity per track (Bytes)	F:	Varies by zone	Varies by zone	F: 17,408	Varies by zone
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	3140	1774	2260	1275	1774
Track density (TPI)	3280	1470	1875	1086	1475
Maximum linear density (BPI) (FCI)	60000 45000	28546 19031	49820 37365	23642 15761	28546 19031
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3220	3220	3220	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)	13.5	20	18	20	20
Average rotational delay (msec)	8.3	9.32	9.32	9.32	9.32
Average access time (msec)	21.8	29.32	27.32	29.32	29.32
Data transfer rate (KBytes/sec)	4000	4000 synch. 1250 asynch.	5000 synch. 3000 asynch.	4000 synch. 1250 asynch.	4000 synch. 1250 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 150	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2/94	2/91	2Q94	7/91	7/91
COMMENTS	Removable data cartridge	Removable data cartridge Read & write compatible with 44 MB & 88 MB cartridges	Removable data cartridge Read & write compatible with 44 MB, 88 MB & 200 MB cart.	Removable data cartridge	Removable data cartridge

MANUFACTURER	SYQUEST TECHNOLOGY	TEAC	TEAC	TEAC	TOSHIBA
DRIVE	SyDOS 105e SyDOS 105i	SD-3250N	SD-3360N	SD-3540N	MK-1422FCV
DISK/TREND GROUP	1	4	5	6	2
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Thin Film
Interface	SCSI, IDE	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	F: 86
REMOVABLE	F: 110	F: 251.9	F: 362.5	F: 540.05	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 28,672
Data surfaces per spindle	2	4	4	4	2
Tracks per surface	243	1922	3164	1024	1501
Track density (TPI)	2100	2048	3155	3300	2910
Maximum linear density (BPI) (FCI)	40000 30000	43100 32325	41822 31366	56830 42662	69204 52003
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4200	3600
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)	14.5	17	17	11/16.5	15
Average rotational delay (msec)	8.3	8.3	8.3	7.14	8.3
Average access time (msec)	22.8	25.3	25.3	18.14/23.64*	23.3
Data transfer rate (KBytes/sec)	4000 synch. 1250 asynch.	10000	10000	10000	6500
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	12.7 x 101.6 x 146.1	12.7 x 101.6 x 146.1	12.7 x 101.6 x 146.1	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT	7/93	1993	1993		10/92
COMMENTS	Removable data cartridge			*Varies with power supply	

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-1522FCV	MK-1722FCV	MK-1624FCV	MK-1724FCV	MK-2224FB
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	Captive, OEM	OEM	Captive, OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	PC AT	PC AT	PC AT	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 126	F: 131	F: 213	F: 262	F: 213
REMOVABLE	--	--	--	--	--
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	4	4	4
Tracks per surface	1840	1920	1560	1920	1560
Track density (TPI)	3528	3528	3528	3528	2840
Maximum linear density (BPI) (FCI)	66100 49575	68350 51050	68350 51050	68350 51050	70500 52900
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	4000	4000	4000	4000
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	13	13	13	12
Average rotational delay (msec)	8.3	7.5	7.5	7.5	7.5
Average access time (msec)	23.3	20.5	20.5	20.5	19.5
Data transfer rate (KBytes/sec)	4000	11100 PIO*	11100 PIO*	11100 PIO*	10000 synch. 6000 asynch.
SIZE: (mm) H x W x D	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT	7/93	3/94	12/93	1Q94	10/92
COMMENTS		*PIO Mode 3	*PIO Mode 3	*PIO Mode 3	

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-2224FC	MK-1824FBV	MK-1824FCV	MK-2326FB	MK-2326FC
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
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	PC AT	SCSI-2	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 213	F: 353	F: 353	F: 340	F: 340
REMOVABLE	--	--	--	--	--
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	6	6
Tracks per surface	1560	2050	2050	1830	1830
Track density (TPI)	2840	3810	3810	3528	3528
Maximum linear density (BPI) (FCI)	70500 52900	87630 65532	87630 65532	62200 46650	62200 46650
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	4200	4200	4200	4200
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	13	12
Average rotational delay (msec)	7.5	7.1	7.1	7.1	7.1
Average access time (msec)	19.5	19.1	19.1	20.1	19.1
Data transfer rate (KBytes/sec)	4000	10000 synch. 6000 asynch.	11100 PIO*	10000 synch. 6000 asynch.	4000
SIZE: (mm) H x W x D	19 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100	19 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT	10/92	9/94	9/94	3Q93	2Q93
COMMENTS			*PIO Mode 3		

MANUFACTURER	TOSHIBA	TOSHIBA	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	MK-2428FB	MK-2428FC	WDAC1170 Caviar	WDAL2170 Caviar Lite	WDAC1210 Caviar
DISK/TREND GROUP	6	6	3	3	4
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film/MIG	Thin Film	Thin Film/MIG
Interface	SCSI-2	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 524	F: 524	F: 170.6	F: 170.6	F: 212.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	8	2	4	2
Tracks per surface	1920	1920	2233	1781	2720
Track density (TPI)	3528	3528	2481	2950	2985
Maximum linear density (BPI) (FCI)	68355 51266	68355 51266	55200 41400	53170 39900	55900 41920
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	4000	3322	3600	3314
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	16	13
Average rotational delay (msec)	7.5	7.5	9	8.3	9
Average access time (msec)	19.5	19.5	22	24.3	22
Data transfer rate (KBytes/sec)	10000 synch. 6000 asynch.	6000	11100 PIO*	5500	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	19 x 70 x 100	19 x 70 x 100	25.4 x 101.6 x 146.1	15 x 70.3 x 101.6	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	12/93	12/93	4Q92	1Q93	2Q93
COMMENTS			*PIO Mode 3		*PIO Mode 3 **DMA Mode 1

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAC1270 Caviar	WDAL2200 Caviar Lite	WDAC2340 Caviar	WDAC2420 Caviar	WDAC2540 Caviar
DISK/TREND GROUP	4	4	5	5	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film/MIG	Thin Film/MIG	Thin Film/MIG	Thin Film/MIG	Thin Film/MIG
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 270.4	F: 200	F: 341.3	F: 425.3	F: 540.8
REMOVABLE	--	--	--	--	--
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	4	4
Tracks per surface	3132	1900	2233	2720	3132
Track density (TPI)	3300	3146	2481	2985	3300
Maximum linear density (BPI) (FCI)		55255 41441	55200 41400	55900 41920	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3600	3322	3314	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)	11 RD/13 WR	17	13	13	11 RD/13 WR
Average rotational delay (msec)	6.67	8.3	9	9	6.67
Average access time (msec)	17.67/19.67	25.3	22	22	17.67/19.67
Data transfer rate (KBytes/sec)	11100 PIO*	5400	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	15 x 70.3 x 101.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/93	11/93	3Q92	1Q93	9/93
COMMENTS	*PIO Mode 3		*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	ZENTEK	ZENTEK	ZENTEK
DRIVE	WDAC2700 Caviar	WDAC31000 Caviar	ZQ 2140	ZM 3272	ZQ 2260
DISK/TREND GROUP	6	7	3	4	4
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 730.8	F: 1,083.8	F: 124	F: 252	F: 240
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 17,408	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	4	4	4
Tracks per surface			935	1996	1807
Track density (TPI)	4000	4000	1300	2500	3200
Maximum linear density (BPI) (FCI)			27500 18333	42667 32000	64000 48000
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4495	4495	3600	3600	4200
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 RD/12 WR	18	13	13
Average rotational delay (msec)	6.67	6.67	8.3	8.3	7.1
Average access time (msec)	16.67/18.67	16.67/18.67	26.3	21.3	20.1
Data transfer rate (KBytes/sec)	11100 PIO* 13300 DMA**	11100 PIO* 13300 DMA**	4500	9000	8000
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	19 x 69.9 x 101.6	25.4 x 101.6 x 146.1	19 x 69.8 x 100.8
FIRST CUSTOMER SHIPMENT	4/94	4/94	2Q93	4Q93	4Q93
COMMENTS	*PIO Mode 3 **DMA Mode 1	*PIO Mode 3 **DMA Mode 1			

MANUFACTURER	ZENTEK	ZENTEK	ZENTEK	ZENTEK	ZENTEK
DRIVE	ZM 3370	ZM 3480	ZQ 2390	ZM 3560	ZM 3580
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	PC AT	PC AT	PC AT	Enhanced IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 340	F: 440	F: 360	F: 510	F: 530
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	6	6	6	4
Tracks per surface	2149	2001	1807	2149	2849
Track density (TPI)	2500	2500	3200	2500	3200
Maximum linear density (BPI) (FCI)	54667 41000	53333 40000	64000 48000	54667 41000	65333 49000
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	4200	3600	4200
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	13	14	13	13
Average rotational delay (msec)	8.3	8.3	7.1	8.3	7.1
Average access time (msec)	20.3	21.3	21.1	21.3	20.1
Data transfer rate (KBytes/sec)	8000	9000	8000	8000	11000
SIZE: (mm) H x W x D	25.6 x 101 x 145.8	25.6 x 101 x 145.8	19 x 69.8 x 100.8	25.6 x 101 x 145.8	25.6 x 101 x 145.8
FIRST CUSTOMER SHIPMENT	3Q94	3Q94	4Q93	3Q94	1Q95
COMMENTS					

MANUFACTURER	ZENTEK	ZENTEK			
DRIVE	ZM 3870	ZM 31160			
DISK/TREND GROUP	6	7			
MARKET	OEM, PCM	OEM, PCM			
MEDIA: Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID			
Recording medium	Thin Film	Thin Film			
DRIVE: Heads	MIG	MIG			
Interface	Enhanced IDE	Enhanced IDE			
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 795	F: 1,060			
REMOVABLE	--	--			
Capacity per track (Bytes)	Varies by zone	Varies by zone			
Data surfaces per spindle	6	8			
Tracks per surface	2849	2849			
Track density (TPI)	3200	3200			
Maximum linear density (BPI) (FCI)	65333 49000	65333 49000			
Recording code	1,7 RLL	1,7 RLL			
Rotational speed (RPM)	4200	4200			
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil			
Servo type	Embedded	Embedded			
Average positioning time (msec)	13	13			
Average rotational delay (msec)	7.1	7.1			
Average access time (msec)	20.1	20.1			
Data transfer rate (KBytes/sec)	11000	11000			
SIZE: (mm) H x W x D	25.6 x 101 x 145.8	25.6 x 101 x 145.8			
FIRST CUSTOMER SHIPMENT	1Q95	1Q95			
COMMENTS					

MANUFACTURER PROFILES

1994 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing moving head rigid magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1993 disk sales" refers only to the DISK/TREND estimate of moving head rigid disk drive sales for the calendar year -- no sales of other drive types are included, nor are sales of parts or other related products such as controllers. "1993 total net sales" covers the fiscal year ending December 31, 1993, for each firm unless noted otherwise, or for the parent company if the disk drive manufacturer is a subsidiary that does not report financial data separately.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars is given below. The average exchange rates for 1993 are used, as reported by the U.S. Federal Reserve Bulletin, and rounded to three significant figures.

Country	Currency	Currency units per U.S. dollar
France	Franc	5.67
Germany	Deutschmark	1.65
Italy	Lira	1573.0
Japan	Yen	111.0
South Korea	Won	806.0
Taiwan	Dollar	26.4
United Kingdom	Pound	0.666

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

AREAL TECHNOLOGY, INC.
2075 Zanker Road
San Jose, CA 95131

Areal Technology was founded in February, 1988 by Jack Swartz, an industry veteran and cofounder of Maxtor. The initial target was development of a 3.5" single disk 105 megabyte drive for production start in the fourth quarter of 1989. A 2.5" 50 megabyte drive was also announced. The drives were to be among the first to use glass substrates. Nippon Sheet Glass is one of Areal's major investors. In 1990, management reorganizations resulted in Swartz leaving the company, along with the 3.5" development effort, and Areal is now concentrating on 2.5" drives. The firm has entered into an agreement with Sanyo Electric to produce Areal's drives in Japan at its Tottori facility, and Sanyo has acquired an equity position in Areal. Production of a 2.5" single disk 62 megabyte drive began at Areal's factory and at Sanyo in 1991, with the current product line of 2.5" drives covering the range from 85 to 700 megabytes.

AURA ASSOCIATES
2605 South Winchester Boulevard
Campbell, CA 95008

Aura Associates, founded by 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 are now in production by NEC, but for which Aura also retains manufacturing and sales rights. The company also announced an agreement with DZU, the Bulgarian state-owned disk drive manufacturing organization, under which DZU would produce 1.8" drive head/disk assemblies for Aura on a contract basis, but the arrangement is not yet in operation.

Aura's current 1.8" product line includes PCMCIA Type III drives from 85 to 170 megabytes, and the company has acquired rights to an electronic camera which will use Aura PCMCIA 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. Drive development is centered in Milpitas, with manufacturing in Thailand expected to begin in late 1994.

CONNER PERIPHERALS, INC.
3081 Zanker Road
San Jose, CA 95134

1993 disk sales: $1,800,700,000
1993 total net sales: $2,151,672,000 Net income: ($445,314,000)

By any measure, the initial growth of Conner Peripherals remains one of the industry's outstanding success stories. The firm is headed by Finis Conner, co-founder of Seagate Technology, and the first product was designed by a development company organized by John Squires, who was a key member of the MiniScribe technical staff until early 1985. Shortly after its founding, Conner attracted a minority investment by Compaq Computer and built a production facility to make 3.5" 40 megabyte drives.

By mid-1987, shipments, mostly to Compaq, had reached high levels, and facilities were rapidly expanded. In addition to adding another facility at the original site, Conner established high volume production in Singapore, and in 1989 moved into a new headquarters building. Conner also entered into a joint venture with Olivetti, resulting in construction of a new manufacturing facility in Italy making a portion of the Conner product line for captive use by Olivetti and for OEM sales in Europe, with complete ownership later assumed by Conner. Conner also established an additional wholly owned factory in Scotland in 1990, but has since discontinued production of new drives at the site. In 1992, Conner established a subsidiary, Conner Technology, Inc., to manufacture small tape drives using technology obtained from 3M. In September, 1992, Conner completed arrangements to manufacture drives in China via a joint venture with Shenzen CPC, a subsidiary of China Electronics Corporation. Conner currently holds 90% ownership in this investment.

In December, 1992, Conner acquired Archive Corporation, a leading tape drive manufacturer, and undertook a difficult integration of the two organizations. Archive's tape, software and distribution products were rebranded with the Conner logo. Conner then formed Conner Storage Systems to market not only the Archive products, but additional offerings such as disk drive arrays, through large-scale retailers and a network of commercial and industrial distributors. In 1994, Conner combined the Archive software products with the product line of the recently acquired Quest Development Corporation to form Arcada Software, in which Conner has a majority ownership position.

While Conner Peripherals has indicated its desire to concentrate upon drive assembly rather than become vertically integrated, the firm has made acquisitions of what it believes are key technologies, including the sputtered disk

production facilities of bankrupt Domain Technology, now expanded with two new sputtering lines, and the 1991 purchase of VISqUS Corporation, a development firm working on a method of near-contact recording using a continuous lubrication technique. Conner has sold off its head stack assembly operation.

Because of the firm's early entrance into the 2.5" market, combined with the ability to deliver large quantities of drives, Conner secured a major share of the market for hard disk drives in the notebook computer market in 1991, but later slowed its development efforts for 2.5" drives and relinquished market leadership. Conner subsequently purchased many of the patents developed by PrairieTek for its 2.5" drives.

After a period of delayed product development for its core product lines, coupled with an intense industry price war, Conner suffered reduced revenue and significant losses in 1993. The firm announced plans for dropping older products and began an extensive new product introduction program in the second half of 1993. As a result of the new introductions, by mid-1994 Conner had announced capacities up to 4 gigabytes for its 3.5" drive family, with the top of the line targeted to video-on-demand as well as computer applications. With the end of the industry price war and with the help of the newer products, the company returned to profitability in late 1993.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1993 disk sales: $601,300,000
1994 total net sales: $2,224,702,000 (FY ending 7/03/94) Net income: ($1,746,360,000)

Digital has maintained internal disk drive manufacturing programs for more than 20 years, initially with disk cartridge drives, but did not venture into designing high end drives until 10 years ago. The RA80 series of 14" drives and the 9" RA90 series are now out of production. In recent years Digital has also been a major customer for OEM 5.25" and 3.5" SCSI drives for use with engineering workstations and personal computers.

In a major departure from its previous policy of limiting its disk drive activities to captive programs, Digital announced an OEM marketing program for new high end 5.25" and 3.5" drives in late 1991. The 5.25" drives were produced at Digital's manufacturing facility in Kaufbeuren, Germany, which was closed in 1993, in favor of a new manufacturing plant since established at Penang, Malaysia. The high-end 3.5" drives have been manufactured for several years at Colorado Springs, using Digital's internally manufactured thin film heads. The new drives represented a renewed Digital effort to stay with the disk drive industry leaders, with reorganized management and manufacturing organizations, and utilizing vertical integration in production of critical components. While there was initially

skepticism concerning Digital's viability as an OEM supplier, Digital established a position as a major OEM supplier of 1 and 2 gigabyte 3.5" drives, plus 5.25" drives up to 4 gigabytes. In June, 1994, Digital established a separate identity for the company's OEM disk drive products using the "Avastor" brand name.

In mid-1994, needing cash to revitalize Digital's processor and network product families, the firm reached an agreement with Quantum to sell its OEM storage products business, including the designs and manufacturing facilities for disk drives, tape drives, and thin film heads, and the deal was completed on October 3, 1994. Digital retained its StorageWorks data storage subsystem business and Video Interactive Information Services units, for which Quantum is expected to be a drive supplier. In this edition of the DISK/TREND Report, Digital's estimated disk drive sales, in both captive and noncaptive marketing channels, are credited to Digital for 1993 and 1994. All sales of the appropriate drives are included in the estimates of noncaptive disk drive shipments by Quantum for 1995 and later. The disk drive products in the Digital product line at the time of the sale to Quantum are shown in the specifications section of this report, for reference.

DMA TECHNOLOGIES
95 South La Patera
Goleta, CA 93117

DMA Systems started shipments of its 5.25" 5/5 megabyte fixed-removable disk cartridge drive in 1982, and established an early leadership position in the 5.25" disk cartridge field, despite relatively high prices compared to fixed disk drives. Manufacturing licenses were sold to Memorex, Newbury Data, and Ricoh, all of which later discontinued all OEM disk drive operations, and also to MFM, which is still producing disk cartridge drives. However, the market was slower to respond to DMA's product and pricing than the firm had anticipated. DMA ran out of funds and was forced to cease operations by its bank in August, 1985. By mid-1986, the bank had been paid off and the firm restarted operations as DMA Technologies. After several years of producing the earlier DMA disk drive products, the new organization ended disk drive production in 1993, and concentrated on storage subsystem products.

GIGASTORAGE TECHNOLOGY, INC.
12930 Saratoga Avenue
Saratoga, CA 95070

Gigastorage is the latest reincarnation of high-end 5.25" drive designs originally undertaken at Priam, later purchased from the bankruptcy court by Orca, then subsequently purchased from the Orca bankruptcy by a combination of disk drive industry veterans and German investors. The disk drives were assem-

bled in small quantities in Germany during 1993, and a deal was later struck to conduct manufacturing operations in the currently inactive Bull plant in Belfort, France. Manufacturing startup plans were under way in the second half of 1994.

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

1993 disk sales: $943,800,000
1993 total net sales: $20,317,000,000 (FY ending 10/31/93) Net income: $1,177,000,000

Hewlett-Packard has an extensive manufacturing operation for disk drives at Boise, Idaho, established in 1977, supplemented in mid-1983 with a facility in Bristol, England. H-P has made disk cartridge, disk pack, and fixed Winchester disk drives at Boise. In 1987, the company launched an OEM sales program for rigid disk drives, spearheaded by new 5.25" models. In 1989, H-P startled the industry by announcing 150,000 hour MTBF and a five year warranty for its 5.25" drives, an action which substantially improved H-P's visibility in the OEM market. The OEM disk drive program proved to be successful for H-P, and the product line has been expanded to include 3.5" drives with capacities over 2 gigabytes.

H-P's received widespread attention with its announcement of the pioneering 1.3" drive in 1992. The original 21 megabyte "Kittyhawk" drive was supplemented with a 42 megabyte model, and a contract manufacturing arrangement was established with Citizen Watch. The Kittyhawk's market, which depended upon sales of personal digital assistants, personal communicators, pen based computers and other mobile computing equipment, was slow to take off, and although the program was executed well, and some OEM accounts were obtained, H-P decided in mid-1994 to terminate the Kittyhawk line due to its disappointing sales.

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 Prairie-Tek. 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 85 megabyte models in production since mid-1992. The existing 1.8" drives use ramp loaded MIG heads, and are designed to high operating shock and vibration specifica-

tions, with low power requirements, in anticipation of wide usage in subnotebook computers and other portable computer applications. Integral began its high volume manufacturing in Singapore in mid-1992. A 105 megabyte PCMCIA Type III drive began shipping in late 1993, a 170 megabyte version in early 1994, and 260, 340 and 420 megabyte models were announced in October, 1994.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1993 disk sales: $7,504,200,000
1993 total net sales: $62,716,000,000 Net income: ($7,987,000,000)

IBM shipped the world's first moving head disk drive in 1956, and the company has provided a large share of the industry's advanced technology during the following 38 years. Until the end of the 1970's, most of IBM's product designs were routinely copied by the rest of the industry. However, the advent of personal computers and engineering workstations intensified the development race and inspired the appearance of dozens of new disk drive manufacturers intent upon producing smaller drives, using new interfaces and exploring new marketing approaches.

After a flurry of activity during the first half of the 1980's resulted in various 14", 8", 5.25" and 3.5" drives without much distinction, IBM since 1989 has introduced a series of drives which place it in the first tier of midrange and low-end disk drive manufacturers, as well as maintaining its traditional leadership in high-end disk drives. For PC's and notebook computers, several generations of drives developed at the Fujisawa plant have now matched the industry's current standards for personal computers, with 1" high 3.5" drives offering up to 1 gigabyte on 2 platters and 2.5" drives using MR heads with up to 810 megabytes. After taking 5.25" drives up to 1.5 gigabytes in capacity, IBM has stopped 5.25" development, in favor of smaller disk diameter drives.

The 1993 introduction of the 3390-9, offering 17 gigabytes per spindle with comparatively low prices for mainframe disk drives, but at the expense of slow performance, is destined to be a short-lived product. It will be impacted by the advent of new generations of disk subsystems and arrays, such as the RAMAC array introduced in 1994, using new families of small diameter disk drives. The RAMAC shipped on schedule at the end of September, 1994, using 2 gigabyte Allicat 3.5" drives, and an upgrade to 4 gigabyte Starfire drives is expected in the first half of 1995, with a further upgrade to 8 gigabyte Scorpion drives, probably a year later. The Scorpion 3.5" drives with capacities up to 10.8 gigabytes and areal densities up to 865 megabits per square inch are scheduled for first production in the second half of 1995.

IBM manufactures 10.8", 5.25", 3.5" and 2.5" fixed disk drives at several factories in the United States, Europe and Japan, but major changes are under way.

The original San Jose facility has converted manufacturing space to make 3.5" and smaller drives in addition to the 10.8" 3390 series. Fujisawa (Japan) is reducing staffing levels and transferring a significant portion of its manufacturing activities to a contract manufacturing organization in Thailand. Mainz (Germany), traditionally the internal IBM second source for mainframe drives, is reorganizing to make smaller drives. The Havant (U.K.) plant is scrambling to maintain its disk drive manufacturing role and announced a contract manufacturing deal, since cancelled, to make the Western Digital disk drive product line.

IBM's first significant OEM sales of disk drives were made in 1984, when the firm began selling the 3380 to both Siemens and Honeywell. Some low-end 3.5" drives with Microchannel interfaces were also sold to European system manufacturers who chose to offer personal computer models with the Microchannel bus. For disk drives broadly sold on an OEM basis, it was more difficult for IBM to establish significant sales, due to tough competition. Despite the difficulties, IBM has had gradually increasing success in marketing 3.5" drives in the personal computer aftermarket through distribution, and in sales to other system manufacturers of both 2.5" and 3.5" drives offered early in their life cycles.

IBM has been confused as to how to label all of this activity. After changing from more than 20 years of "General Products Division" to "Storage Systems Products Division" (which also included the separate "Low End Disk Operations') in 1990, the name became "AdStaR" in early 1992 -- with the general plan to establish the entity as a separate, wholly owned IBM subsidiary. However, with new corporate management and a new spirit of corporate togetherness, the AdStaR name and the separate subsidiary status were quietly abandoned, in favor of the more conventional title of "Storage Systems Division".

JTS (formerly Kalok Corporation)
1287 Anvilwood Avenue
Sunnyvale, CA 94089

Kalok was founded in 1987 to participate in the market for 20 and 40 megabyte 3.5" drives, designed for very low manufacturing cost. Unable to obtain adequate funding from U.S. venture capital sources, the firm negotiated a manufacturing and inventory financing arrangement with Oriental Precision Company of South Korea. OPC started manufacturing Kalok drives in mid-1988 with substantial shipment levels, but dropped out of the game a few years later after being acquired. In order to broaden its production base, Kalok in 1989 also established a plant in the Philippines, the first hard disk drive producer to do so.

In late 1991, Kalok sold its Philippines factory to Xebec Co. Ltd, a Japanese firm based in Tokyo, and announced a contract manufacturing relationship with Xebec. Subsequently, Kalok sold its entire stepping motor drive product line to Xebec, retaining only the design for a .5" high 250 megabyte 3.5" drive. After a series of management changes, a Chapter 11 filing, and negotiation of contract

manufacturing arrangements with TEAC in Japan and DZU in Bulgaria, Kalok began actively selling a removable version of the .5" high drive. 270 megabyte, 420 megabyte and 540 megabyte versions now make up the product line.

In February, 1994, Kalok was reorganized as JTS with investment from Jugi Tandon, one of the disk drive industry's pioneers in developing high volume disk drive manufacturing for both floppy and rigid disk drives. TEAC also has a 10% ownership share. Much of the manufacturing of the JTS drives will be done in India, permitting JTS to refocus its efforts on OEM markets. Production in Madras is expected to start in the second half of 1994.

MAXTOR CORPORATION
150 River Oaks Parkway
San Jose, CA 95134

1993 disk sales: $1,204,100,000
1994 total net sales: $1,152,615,000 Net income: ($257,589,000)
(FY ending 3/26/94)

Maxtor startled its competitors in 1982 by announcing a family of 5.25" drives with up to 140 megabyte capacity. These drives went into production in mid-1983, later joined by 190 megabyte drives in 1984 and the industry's first 380 megabyte drives in 1985. Maxtor became the first company to find space in the standard 5.25" form factor for eight disks, and thus was able to achieve high capacities while maintaining the standard Seagate transfer rate of five megabits per second -- a strategy which proved successful with OEMs wishing to use standard ST412 controllers. In preparation for the ten megabit per second transfer rate required by the 380 megabyte drive, Maxtor became the industry leader in establishing the ESDI interface standard, initially widely used for high performance 5.25" drives.

Maxtor maintained its place in the spotlight by announcing a 760 megabyte 5.25" drive, with first shipments in 1987. A 3.5" drive with 200 megabyte capacity was announced in 1988, along with a magneto-optical 5.25" drive produced by a joint venture with Kubota, maintaining the Maxtor role as a leading edge supplier of OEM disk drives. In 1990, Maxtor acquired the MiniScribe product line and manufacturing facilities, providing the firm with a 1" high 3.5" drive product line and a 2.5" 85 megabyte drive that was ready to be announced.

Starting with the departure of several key employees in 1987, a continuing succession of management changes, combined with the numerous internal changes which followed, disrupted Maxtor's ability to continue the pioneering product development activities upon which most of the company's growth was based. In 1994, Maxtor improved its financial status when Hyundai invested heavily in the company, acquiring a 40% share of the firm.

All of the 5.25" drives have been sold off or phased out. Most of Maxtor's current revenues are derived from 3.5" drives sold for personal computer applica-

tions, with a strong initiative under way in 1.8" PCMCIA disk drives. Maxtor was the first of the major disk drive manufacturers to launch a major effort to develop products for the 1.8" drive market. Following the initial 105 megabyte PCMCIA Type III drive in 1993, a 131 megabyte model was announced in April, 1994. A 171 megabyte PCMCIA Type III drive announced in August was upstaged in October, when Maxtor announced the first PCMCIA Type II drive, a 121 megabyte single disk model that operates on 3.3 or 5 volts.

MEMOREX TELEX CORPORATION
Subsidiary of Memorex Telex N.V.
4343 S. 118th East Avenue
Tulsa, OK 74146

1994 total net sales: $1,015,574,000 (FY ending 3/31/94) Net income: $227,005,000

The pioneer magnetic media and plug compatible disk drive producer originally known as Memorex Corporation was acquired by Burroughs in late 1981, and Burroughs placed all disk drive development and manufacturing responsibility for the entire company in the Memorex organization. In late 1986, however, Burroughs sold the plug compatible disk drive sales and service operations of Memorex to a group of Memorex executives, retaining only the rigid disk development and manufacturing operations. Telex was acquired by Memorex in early 1988 and the firm adopted its new name. Plug compatible disk drive subsystems now sold and serviced by Memorex Telex use various purchased disk drive mechanisms. In 1993, the company phased out of new disk drive installations in the mainframe market. Memorex Telex, now headquartered in Europe, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations.

MFM TECHNOLOGY, INC.
North Andover, MA 01845

MFM started manufacturing 5.25" disk cartridge drives in 1985 under license from DMA Systems. The firm had previously been involved in providing service for DMA drives, and offered controller development services. A 24 megabyte version of the drive was introduced in 1987, and a fixed/removable version with 24 megabytes capacity in each category was shipped in 1990. The 24 megabyte drives were subsequently discontinued, although production of lower capacity models is ongoing.

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1993 disk sales: $371,500,000
1993 total net sales: $382,926,000 Net income: ($19,916,000)

Known as the originator of what were then considered high capacity 5.25" flexible disk drives, Micropolis started production of 8" Winchester disk drives in 1979 and became a factor in the marketplace, after the usual Winchester early production problems. Micropolis was the 5.25" industry leader at 85 megabytes and 170 megabytes, and a close contender for leadership at 380 megabytes, 760 megabytes, and the 1-2 gigabyte range. Heavy price competition in lower capacity "cash cow" products and delays in getting newer products into volume production hurt Micropolis' financial results during the late 1980's, and the firm had to cancel its 3.5" development program in order to concentrate on 5.25" drives. After returning to profitability in 1990, Micropolis reentered the 3.5" drive market in 1991 with the first announced 1 gigabyte 3.5" drive. Although an earlier effort had been aborted, Micropolis succeeded in entering the disk array market in late 1991, creating a separate division to market a modular array in the subsystem market.

Although disk drive sales growth has stagnated in recent years, Micropolis hopes that its high end 5.25" and 3.5" disk drives will give it a strong position in the nascent video-on-demand server market and that VOD related sales will reignite company growth.

MINISTOR PERIPHERALS CORPORATION
2801 Orchard Parkway
San Jose, CA 95134

1993 total net sales: $8,454,000 Net income: ($11,003,000)

Founded in 1991 by former Maxtor executives and funded by seed money from venture capitalists, MiniStor started production of 32 and 64 megabyte 1.8" drives in late 1992. Despite management changes and a skeptical venture capital market, the firm has managed to acquire the necessary resources to continue its program and establish manufacturing in Singapore. As of mid-1994, MiniStor offered 1.8" drives up to 170 megabytes, plus 260 megabyte and 340 megabyte models that incorporate data compression. In September, 1993, MiniStor and Hitachi announced agreements under which MiniStor licensed Hitachi to use the firm's 1.8" drive technology. The two companies then jointly developed a new family of high capacity 2.5" disk drives based on the MiniStor technology, manufactured by Hitachi, and sold by both firms. 2.5" models with up to 680 megabytes native capacity are scheduled for production in Autumn, 1994. MiniStor became a public company in July, 1994.

QUANTUM CORPORATION
500 McCarthy Boulevard
Milpitas, CA 95035

1993 disk sales: $2,001,100,000
1994 total net sales: $2,131,054,000 Net income: $2,674,000
(FY ending 3/31/94)

Quantum's original product strategy was to manufacture an upgrade to the Shugart Associates 8" Winchester drives. The Quantum plan worked well, and 5.25" drives with capacities up to 40 megabytes were added in 1983, becoming the company's major product. As the Quantum full-size 40 megabyte 5.25" drives peaked, the firm announced half high OEM 5.25" drives with up to 80 megabytes capacity. First shipment of these drives was late, however, and Quantum's sales growth flattened out.

In 1985, the company established Plus Development as a wholly owned subsidiary, to pioneer development and marketing of the Plus Hardcard, an innovative plug-in card for the IBM personal computer aftermarket, combining a 3.5" Winchester and all controller electronics on a single add-in card. The original version was first shipped in October, 1985. Quantum set up Plus as a separately operated subsidiary, in order to provide concentration on the special design requirements involved, and to establish a specialized marketing and sales organization targeted at the PC market. Manufacturing was contracted out to Matsushita-Kotobuki Electronics.

Quantum was able to reestablish growth in OEM drive shipments in 1987, through successful implementation of an emergency plan to quickly develop an OEM 3.5" drive using the Hardcard design and tooling, with manufacturing by Matsushita-Kotobuki Electronics. While Quantum has designed all of its 3.5" drives, manufacturing of low-end models is done in Japan by MKE. MKE has rights to distribute the drives it manufactures within Japan, under a Quantum license. High-end 3.5" drives are manufactured in Quantum's own plant in Milpitas. MKE has established a factory in Dundalk, Ireland, to manufacture Quantum drives for the European market, with production since October, 1992. The Quantum-MKE relationship is successful and has contributed to gross margins typically higher than the industry averages, until the price wars of 1993.

In August, 1993, Quantum formed separate operating groups for high capacity storage, to manage the development, production and marketing of the high-end 3.5" drives manufactured at Milpitas, and desktop and portable storage, to manage the development and marketing of 3.5" and 2.5" drives manufactured by MKE. The product lines for both groups have been aggressively expanded and Quantum succeeded in becoming the highest volume disk drive manufacturer in the world during the past year, measured in unit shipments.

Quantum gave its high capacity product line a boost in 1994 when the firm purchased Digital's OEM storage products business, adding Digital's lines of high capacity disk drives, tape drives, and thin film heads (including Digital's 80%

share of MR head producer Rocky Mountain Magnetics) to its product portfolio. Along with the products came major design and manufacturing facilities in the U.S. and Southeast Asia, plus approximately 5,000 employees, providing Quantum with a major management challenge to digest all of the new resources without losing momentum. With the Digital acquisition, Quantum will challenge IBM and Seagate for leadership in disk drive industry sales revenues, as well as in unit shipments.

RAYMOND ENGINEERING (Subsidiary of Kaman)
217 Smith Street
Middletown, CT 06457

Raymond Engineering was founded in 1938 as a specialty electromechanical components supplier, and is today a subsidiary of Kaman, a large military electronics contractor. The Memory Systems Division of Raymond Engineering provides ruggedized and mil-spec data storage subsystems, including repackaged disk and tape drive mechanisms and flash memory based subsystems. Disk drive capacities range from 30 megabytes to 1 gigabyte.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1993 disk sales: $2,940,100,000
1994 total net sales: $3,500,103,000 Net income: $225,110,000
(FY ending 7/1/94)

In 1981, Seagate shipped two thirds of the 5.25" drives produced worldwide, with 35,000 units -- and another de facto standard was created. Seagate took the lead in moving production for its high volume drives offshore to secure lower manufacturing costs. But the world changed for Seagate in mid-1984, with a sharp reduction in sales to its largest customer, IBM -- and an up-and-down buying pattern which continued in 1985. Through tough management, Seagate stayed profitable, rebuilt its revenues, and starting in 1986 became the worldwide leader in OEM disk drive revenues.

After 1985, a major part of Seagate's growth came from the personal computer aftermarket. IBM cut back purchases of Seagate drives in favor of internal captive production, but Seagate launched a successful campaign to take the business away from IBM at the dealer level, with phenomenal success. But the company was vulnerable to IBM's "bundling" hard disk drives with systems at the factory instead of giving dealers an easy opportunity to upgrade with independent disk drives. The effect of this bundling, plus Seagate's late arrival in the 3.5" marketplace, cut into Seagate's shipment rate. The firm overestimated the

market in early 1988, causing excess inventory accumulation and disappointing financial results. However, Seagate demonstrated the resiliency likely to be necessary for future survival, and returned to profitability in 1989.

In October, 1989, Seagate completed an agreement with Control Data to acquire Imprimis Technology in a deal valued at $450 million. There was little overlap between the product lines of Seagate and Imprimis, or between Seagate's predominantly aftermarket distribution and Imprimis' predominantly OEM sales. In late 1991, the company made key changes in executive management in an attempt to reassert product leadership and has been successful in establishing an aggressive product development program.

The new Seagate has maintained an aggressive pace of product development and market leadership with the high-end 5.25" and 3.5" drives developed at the Oklahoma and Minneapolis operations. But because its lower capacity 5.25" drives were fading fast, and in order to improve penetration of the OEM market for its small diameter products, Seagate undertook a "time to market strategy" to catch up with the industry leaders in the 2.5" and low end 3.5" markets. High-end full size 3.5" drives in both 5,400 and 7,200 RPM models offer capacities up to 4.2 gigabytes. 1" high 3.5" drives at the 1 gigabyte level went into production in the first half of 1993 and were subsequently extended to 2.5 gigabytes. 341 megabyte and 455 megabyte 2.5" drives using ceramic media substrates went into production in late 1993. The Elite 5.25" drive series reached 9 gigabytes with an extremely competitive price per megabyte.

During the 1993 disk drive price wars, Seagate, alone among the major independent drive producers, maintained consistent profitability as a result of the firm's strength in high end drives and a notable disinclination to price below levels, returning a reasonable gross margin. As of mid-1994, Seagate's sales topped the $1 billion per quarter mark. In recent months, Seagate has begun diversifying into additional markets, acquiring several firms specializing in storage related software.

SEQUEL, INC.
2300 Central Expressway
Santa Clara, CA 95054

Sequel was created in November, 1989, as the result of a management buyout of the Unisys rigid disk drive and media production facilities. Sequel supplies new drives to other companies on a contract manufacturing basis, as well as refurbishing older drives. The firm also supplies some media on an OEM basis. Shortly after its establishment, Sequel acquired the rights to manufacture several of Priam's product lines, and has since acquired rights to most of Maxtor's older 5.25" drives and a few of Digital's older drives.

STORAGE TECHNOLOGY CORPORATION
2270 South 88th Street
Louisville, CO 80027

1993 total net sales: $1,404,752,000 Net income: ($77,796,000)

After great success in the second half of the 1970's as the leader in plug compatible disk drives, STC's shipments dropped in 1982-1983, as IBM 3380 shipments started in earnest. STC's volume shipments of 3380 equivalent drives didn't start until 1984, too late to save the company from failures in its other new business areas. The firm's management had launched expensive programs to build mainframe computers and optical disk drives -- and had acquired firms in other areas, with extensive bank borrowing. In October, 1984, the bankers wouldn't wait, and the company was thrown into Chapter 11. After a series of complex negotiations with creditors, the firm emerged from bankruptcy in mid-1987.

Orders for STC's innovative 1/2" tape cartridge library system were strong, and were instrumental in restoring STC's position in the storage products industry. However, shipments of drives equivalent to IBM's 3380K did not start until 1989, and the firm never regained its earlier share of the IBM plug compatible disk drive market. Production of disk drives ceased in 1991. In 1990, the firm began discussing new products incorporating disk drive arrays to be sold into the PCM marketplace. The high-end "Iceberg" array project, initially using purchased 5.25" drives and later 3.5" drives, was to be available in the first half of 1992, but suffered several slips and the company finally began revenue shipments in 1994. STC also purchased Amperif, acquiring yet another disk drive array program intended for introduction in the IBM mainframe market, and is preparing to offer a midrange array based on the Data General CLARiiON.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

1993 disk sales: $83,700,000
1993 total net sales: $206,632,000 Net income: $15,212,000
(FY ending 9/30/93)

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 early 1991, SyQuest began shipping an 88 megabyte 5.25" cartridge disk drive, which was the firm's major product in recent years,

supplemented in 1994 with a 200 megabyte model. A 3.5" disk cartridge drive program resulted in first shipments of 105 and 270 megabyte models in 1993. A unique 1.8" drive was introduced in late 1993, utilizing a disk cartridge which is removable from a PCMCIA Type III disk drive. In 1989, SyQuest began operations in Singapore. SyQuest also manufactures the disk cartridges for the drives, and cartridges accounted for a majority of the firm's revenue.

WESTERN DIGITAL CORPORATION
8105 Irvine Center Drive
Irvine, CA 92718

1993 disk sales: $1,098,800,000
1994 total net sales: $1,539,680,000 (FY ending 6/30/94) Net income: $73,136,000

Western Digital, a major supplier of controllers and specialized semiconductor components, entered the rigid disk drive market by purchasing the rigid disk drive operations of Tandon at the end of 1987. Western Digital plans to be a broad-line disk drive producer, and maintains a disk drive development facility in San Jose. The company has aggressively moved from heavy dependence on aftermarket distribution with the original product line purchased from Tandon to a primary emphasis on OEM sales. WD's early development and shipment of a two platter 340 megabyte 3.5" drive in the first half of 1992 boosted the firm's share of the personal computer disk drive market, and impacted the product development plans of most competitors. Western Digital's 3.5" product line has since been enhanced with 425, 540 and 730 megabyte versions of the same 2 disk design, plus a single disk model, all shipped long before competitive products. A 1 gigabyte, three platter drive began shipping in April, 1994.

The company has passed through a difficult period of several losing quarters and has undergone significant structural and management changes, and WD returned to profitability in mid-1992. Although the impact of the 1993 disk drive price wars resulted in further losses, the firm has been profitable in recent quarters.

Asian Manufacturers

(All fiscal years end in March, 1994, unless otherwise noted. All companies are in Japan unless otherwise noted.)

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

1994 total net sales: $3,548,622,000 Net income: ($83,261,000)

Alps Electric, founded in 1948, is a manufacturer of electronic components and subassemblies for television, audio, instruments and computer applications. The firm builds floppy disk drives on an OEM basis, and started production in the U.S. in 1987. In 1988, a facility to make various computer peripherals was established in Ireland. About 19% of Alps' shipments are computer peripherals, mostly disk drives and printers. In 1985, Alps introduced a line of 5.25" half high and 3.5" rigid disk drives and in 1986, Alps became the first manufacturer to announce a 30 mm high 3.5" drive. The company has continued the development of its rigid disk drives, and the 3.5" product line now includes a 2 disk 545 megabyte drive, plus a 246 megabyte model.

Alps entered into an agreement with PrairieTek to produce the PrairieTek 2.5" drives on a contract basis, and production under this contract began in 1990. Alps produced the 2.5" drives for a short time after PrairieTek's demise, phasing them out in 1992.

EPSON (See Seiko Epson)

DAEYOUNG ELECTRONICS IND. CO., LTD.
352 Dangjeong-Dong
Gunpo-Si
Kyoungki-Do
Korea

Daeyoung was founded in 1968 to manufacture telecommunications equipment. The firm's products now include consumer alarm systems, industrial control equipment and military electronics. In 1991, Daeyoung acquired EsPerT, a manufacturer of rigid drives that was the successor to Peripheral Technology.

Peripheral Technology was founded in 1985 to develop a 3.5" drive first shipped in 1986, with founders who had worked together at Dataproducts. 70% of PTI was owned by Haitai International, a Korean consumer products company, but in mid-1987, this interest was sold to Live Systems, a Japanese company serving the medical market, and production moved to Korea. In early 1989, control of PTI was assumed by Tongil Machinery Co., a manufacturer of machine tools and auto parts, as a diversification move. In February, 1990, the company was renamed EsPerT. A further change in status occurred in 1991 when the firm

was purchased by Daeyoung, following a financially disastrous year of technical problems with the EsPerT 41 megabyte 3.5" drive. Daeyoung has management with extensive Korean disk drive industry experience and in 1993 transitioned to a 1" high 120 megabyte 3.5" drive. However, disk drive production was halted in late 1993, although the firm is interested in doing contract manufacturing for other firms.

FUJI ELECTRIC CO., LTD.
12-1 Yurakucho 1-Chome
Chiyoda-ku
Tokyo, 100

1994 total net sales: $7,513,649,000 Net income: $32,847,000

Fuji Electric was established in 1923 and is the firm from which Fujitsu was born in 1935. Fuji Electric still owns 13.4% of Fujitsu (which owns 7% of Fuji Electric). The firm manufactures power generating equipment, electrical equipment for the transportation sector, vending machines and instrumentation. Data storage products include sputtered media (of which Fuji Electric is a significant supplier) and 3.5" disk drives. The firm began selling 3.5" drives under its own name in 1985, but cut back on export sales in 1988, squeezed by exchange rates and low priced competition. Fuji Electric's disk drive products currently include 2.5" drives with up to 170 megabytes capacity and 1" high 3.5" drives with up to 540 megabytes. In 1992, Fuji Electric entered into a contract manufacturing agreement with Integral Peripherals for 1.8" drives, in which Fuji Electric may also manufacture 1.8" drives intended for the Japanese market, although it has not yet done so.

FUJITSU LTD.
6-1, Marunouchi 2-chome
Chiyoda-ku, Tokyo 100

1993 disk sales: $886,900,000
1994 total net sales: $28,282,252,000 Net income: ($339,387,000)

Fujitsu derives about 69% of its sales from the computer industry and is known as the leading manufacturer of computers for the Japanese domestic market. Fujitsu is also a major exporter to the worldwide computer market. Since 1982, the company has been among the leaders in worldwide disk drive revenues, and skillfully managed a transition from older removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters. Fujitsu is manufacturing some of its high performance drives at a major facility near Portland, Oregon, and an increasing number of 3.5" drives are produced in Thailand. Over 50% of Fujitsu's rigid drive production is

currently done outside Japan. Intellistor, located in Longmont, Colorado, is a Fujitsu subsidiary developing small diameter disk drives and drive arrays. Fujitsu also has 44% ownership in Amdahl.

Fujitsu has marketed most of its captive drives in OEM versions, using industry standard OEM interfaces, and is a serious contender in the U.S. market for OEM rigid disk drives. Fujitsu is also a participant in the IBM plug compatible disk drive market through Amdahl, with sales first of 10.5" drives, then 8" models, and now with new 5.25" drives. Particularly effective in the OEM market was the series of high performance 8" 48/84/168/337/690/824/1000/2000/2600 megabyte drives. An extensive 3.5" line ranges from 25 megabytes to 3.1 gigabytes. A 240 megabyte 2.5" drive was added in 1993, followed by 350 and 530 megabyte models in early 1994. Fujitsu has joined the "reliability wars" by specifying MTBF for its high capacity 5.25" and 3.5" drives at values up to 500,000 hours.

HITACHI, LTD.
4-6 Kanda-Surugadai
Chiyoda-ku, Tokyo 101

1993 disk sales: $959,900,000
1994 total net sales: $66,668,514,000 Net income: $588,099,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. 44% of the company's sales are in equipment for information systems. The firm currently makes a wide range of Winchester technology fixed disk drives for both captive and noncaptive markets.

In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3380/3390 equivalent drives through Hitachi Data Systems (formerly National Advanced Systems, before acquisition by Hitachi), and in 1983 started selling PCM drives for distribution in the European PCM market through BASF, and currently through Comparex. Hitachi was the first independent disk drive supplier to ship a double capacity drive equivalent to the IBM 3380E, and was an early supplier of 3380K equivalent drives. New IBM plug compatible drive subsystems utilize Hitachi's 6.5" drives, including a 3390-9 equivalent subsystem. In 1987, Hitachi began shipping rigid disk drives from a manufacturing facility in Norman, Oklahoma, which makes high-end rigid disk drives and 5.25" optical disk drives. In September, 1993, MiniStor and Hitachi announced agreements under which MiniStor licensed Hitachi to utilize the firm's 1.8" drive technology. The two companies then jointly developed a new family of high capacity 2.5" disk drives using the MiniStor technology.

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

1994 total net sales: $3,265,036,000 Net income: $78,441,000

During the 1980's, Matsushita-Kotobuki Electronics concentrated on production of VCRs on an OEM basis for a number of U.S. consumer electronics manufacturers and distributors, as well as for sale under the Matsushita "Panasonic" brand name. Matsushita Electric Industrial owns 57.6% of MKE.

In 1985, Plus Development established a contract manufacturing arrangement with MKE for the Hardcard, which evolved into a manufacturing program for the highly successful 3.5" OEM drives offered by Plus' parent company, Quantum Corporation. MKE has the rights to sell the Quantum drives under license in the Japanese domestic OEM market, and activated a marketing program in 1989. MKE has since made other contract manufacturing agreements with other storage product companies. MKE produces rigid disk drives in Japan and a recently expanded Singapore facility, and established a subsidiary in Ireland to manufacture Quantum products for the European market.

MYRICA SINGAPORE Pte. LTD.
Block 3015A, Ubi Road 1
#07-09 Kampong Ubi Industrial Estate
Singapore 1440

In late 1991, a group of Taiwanese investors purchased the corporate shell of Myrica Trading Company and subsequently acquired Rodime's Singapore production facilities and some of Rodime's R&D facilities in Scotland. The firm produced some of Rodime's 3.5" disk drive designs in Singapore, but discontinued production of disk drives in 1993.

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

1993 disk sales: $418,600,000
1994 total net sales: $32,250,333,000 Net income: $59,514,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 52% of the firm's total revenues. Current disk drive production involves fixed disk drives, from large to small configurations, for both captive and OEM markets. Fixed disk drives produced in recent years have included 9", 5.25", 3.5" and 1.8" disk diameters. The 9" and 5.25" drives have been phased out, and the company's first 2.5" drive, a 350

megabyte model, was introduced in 1994. The 1.8" drives were designed by Aura Associates, which also has manufacturing rights. Sales of 3.5" drives have been very strong as a result of NEC's leadership position in the Japanese personal computer market. NEC was the first of the major Japanese drive producers to produce small form factor rigid disk drives offshore, with the establishment of a factory in the Philippines, and the firm increasingly relies upon its offshore production facilities.

RICOH CO., LTD.
15-5 Minami-Aoyama 1-chome
Minato-ku, Tokyo 107

1994 total net sales: $8,723,586,000 Net income: $85,766,000

Copiers, sensitized papers and photographic equipment provide the major portion of Ricoh's revenues, but the firm has invested in a growing line of data processing equipment since 1979. About 24% of revenues are from information processing products. Its first disk drives were 8" floppy drives made under a license from Calcomp. In 1985, Ricoh obtained a license to make the DMA 5.25" cartridge disk drive design, and production began in 1986, with the later introduction of an expanded capacity version. When DMA encountered major financial difficulties, Ricoh became the major source for the drive. In 1989, Ricoh introduced a 50 megabyte removable cartridge drive, but the firm was never able to build its market to significant levels and ceased production of cartridge drives in late 1993.

SAMSUNG ELECTRONICS CO., LTD.
7, Soonwha-dong
Chung-du
Seoul, South Korea

1993 disk sales: $163,000,000
1993 total net sales: $10,121,000,000 Net income: $192,000,000

Samsung Electronics, founded in 1969, is Korea's largest electronics company, producing a variety of consumer, industrial and computer products. Samsung made a minority investment in Comport, a 1977 U.S. startup, and manufactured Comport's 3.5" line of disk drives until Comport went out of business. Samsung's production of disk drives is entirely in 1" high 3.5" models ranging from 213 to 540 megabytes. Samsung maintains an R&D center for disk drive design in San Jose.

SEIKO EPSON CORPORATION
80 Hirooka
Shiojiri-Shi
Nagano 339-07

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 and markets portable computers, displays, and floppy, optical and rigid disk drives. The company also remarkets a PCMCIA Type III rigid disk drive made by Integral Peripherals.

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

1994 total net sales: $1,028,126,000 Net income: ($66,207,000)

TEAC expanded into computer peripherals, in recognition of slow growth in the worldwide market for quality audio tape decks, its previous major product area. Computer peripherals now account for about 76% of sales, mostly in floppy disk drives, with TEAC now the worldwide leader in total shipments of 5.25" and 3.5" floppy drives. Shinano Tokki, a subsidiary producing motors for disk drives, was sold in 1989. In 1982, TEAC acquired a manufacturing license from Seagate Technology for its 5.25" Winchester disk drives, with rights to market the drives in Japan and the Far East. After limited success with 5.25" rigid disk drives, the firm began manufacturing 3.5" drives in 1989, and later licensed the Kalok (now JTS) .5" high 250 megabyte 3.5" drive design. TEAC currently makes 250 megabyte and 540 megabyte drives on a contract manufacturing basis for JTS, as well as offering them under its own name.

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

1993 disk sales: $447,500,000
1994 total net sales: $41,719,883,000 Net income: $109,369,000

Toshiba is a major factor in consumer electric and electronic products, plus a wide range of industrial electronic products and heavy electric power equipment. The company also has a leading position in the Japanese office computer market. Disk drives supplied by Toshiba include rigid, floppy and optical drives. Rigid disk drive production at Toshiba has a history of more than two decades including 14", 8", 5.25", 3.5" and 2.5" disk diameters. Toshiba's presence in the U.S. OEM rigid disk drive market was strongly enhanced when it acquired the OEM disk drive operations of Memorex from Burroughs, and Toshiba has continued to expand its U.S. operations, establishing a design center in Southern

California. The 1991 5.25" product line extended to 765 megabytes, but Toshiba has dropped most of its 5.25" drives in order to concentrate on 3.5" and smaller form factors.

In 1992, the company established a San Jose factory to manufacture high-end 3.5" drives originally developed at its design center in Southern California, but after it became clear that the firm's product designs would be eclipsed by the industry leaders, it phased out the 3.5" San Jose program. Despite the company's problems with the high-end 3.5" program, Toshiba has established a very successful 2.5" drive program at its Ome plant near Tokyo, as a result of an aggressive development program which has provided much of the industry's product leadership in 2.5" drives in the early 1990's. In 1993, the company was the first to produce a single platter 126 megabyte 2.5" drive, plus the first to offer a 340 megabyte 2.5" model.

XEBEC CO., LTD.
15-13 Ochanomizu
Hongo 2-chome
Bunkyo-ku, Tokyo 113

Xebec, founded in 1974, is primarily a producer of hybrid ICs and printed circuit boards. It has no relationship to Xebec Corporation, a onetime U.S. manufacturer of PC boards, drive controllers, and 5.25" disk drives. After purchasing Kalok's factory in the Philippines and agreeing to produce the Kalok drives on a contract basis, in April of 1992 Xebec purchased the rights to manufacture and market all of Kalok's stepping motor disk drives, and the drives were marketed worldwide under Xebec's name. Xebec produced the stepping motor drive until 1993 and announced a 245 megabyte, 3.5" voice coil disk drive, but discontinued production before significant quantities were shipped.

ZENTEK STORAGE, INC.
6, Jen-Te Road, Hu-ku Hsiang
Hsin Chu Hsien
Taiwan

Zentek, which is a joint venture between Universal Scientific Industrial Co., Ltd., and Longshine Electronics, was established in September, 1989. USI is a manufacturer of film hybrid integrated circuits. Much of the original engineering team came from Longshine and Priam. Zentek has manufactured 60 megabyte and 100 megabyte 3.5" drives based on designs developed by ITRI, a government research agency, and has extended the 3.5" product line to 360 megabytes. Newer products with capacities to 1 gigabyte have been announced, with production scheduled in late 1994 to early 1995. The company expanded its manufacturing facilities in 1994, taking over the old Microscience plant in Hsin Chu, and has obtained additional investment capital to finance its expansion.

European 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, 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 85 megabyte drives in the PCMCIA Type III format in mid-1993. The PCMCIA drive product line has since been expanded, with 105 and 130 megabyte drives currently in production. A 170 megabyte PCMCIA Type III drive was added in the last half of 1994, to be followed by a 210 megabyte model.

COMPAREX INFORMATIONSSYSTEME GMBH
Subsidiary of BASF
Gottlieb-Daimler-Strasse 10
D-6800 Mannheim
West Germany

Comparex became operational at the beginning of January, 1987, as a joint venture operation comprising the former BASF and Siemens PCM businesses, marketing systems and peripherals made by Fujitsu and Hitachi, with a concentration in recent years on Hitachi products. In late 1991, the owners announced BASF's assumption of complete ownership. Current disk drive activities involve PCM 3380/3390 equivalent drives produced by Hitachi, plus an optical drive produced by Philips LMS and integrated with a Cygnet jukebox. Semiconductor and cartridge tape systems, both made by third parties, are also offered. In late 1992, Comparex and Hitachi Data Systems announced an agreement under which Comparex would control distribution of Hitachi mainframes and peripherals in Germany and Eastern Europe, and HDS would handle distribution in most of the rest of Europe and in the Middle East.

DZU
6000 Stara Zagora
Bulgaria

DZU is the current name for the Bulgarian organization known for many years as ISOT, following a series of reorganizations in 1989 of the governmental structure which manages Bulgarian technology industries. Under the previous Eastern Bloc Comecon system, disk drives were manufactured since the 1960's by DZU, the Bulgarian state computer organization, and exported throughout

Eastern Bloc countries by Isotimpex, the foreign trade organization for Bulgarian computer equipment and other electronic products. DZU, which operated factories with perhaps the highest level of vertical integration to be found anywhere in the disk drive industry, began production of 14", 8" and 5.25" Winchester drives in late 1985. The disintegration of the Eastern Bloc and the movement of all of its old Comecon trading partners to hard currencies as a basis for international trade left DZU's older products exposed to competition from newer disk drives, and as a result DZU's business declined severely. DZU is actively trying to secure contracts to make components, subassemblies and complete drives, in order to keep its factories busy. The organization announced contract manufacturing programs to manufacture head/disk assemblies for 1.8" drives for Aura Associates and to make 3.5" drives for Kalok (now JTS), but neither agreement has resulted in actual drive production to date.

EZI GMBH
Schmidthuette 9
D-6342 Haiger
Germany

EZI, whose business is primarily in disk drive repair, acquired the rights to manufacture and market Siemens 382 and 310 megabyte 5.25" disk drives, when Siemens discontinued its own disk drive manufacturing activities in 1990. The firm manufactured these drives for the European market until demand sunk to a very low level in 1993.

RODIME LTD.
Nasmyth Road
Southfield Industrial Estates
Glenrothes, Fife KY6 2SD
Scotland

After being formed in late 1980 by key personnel from the Burroughs facility in Glenrothes, Rodime met its schedule for shipments in 1981, and until 1986 continued to achieve a healthy growth rate. With the decline of its older 5.25" models, Rodime's sales increasingly relied on shipments of 3.5" drives, which it was the first to ship in 1983.

Rodime surprised the industry by obtaining patent coverage on the form factor of a 3.5" drive -- claiming no new technology, only a reduction in size. The firm then sued Miniscribe and Conner Peripherals for patent infringement. When IBM announced the PS/2 family, which uses 3.5" drives, it sued Rodime to invalidate the patent, and Rodime bravely met the challenge by countersuing IBM for patent infringement. Miniscribe opted out of the legal proceedings by taking a license. In the meantime, after extensive patent office preliminaries, the affair

began a long tour of the U.S. federal court system which ended when IBM and Conner took licenses. Several other companies have also signed up for Rodime licenses, and others are in negotiation.

In early 1989, top management was completely overhauled as Rodime came perilously near bankruptcy. Rodime obtained refinancing, and its new management hoped to be able to return Rodime to profitability. The retail disk drive subsystem division, Rodime Systems, was sold to Profit Technology, Inc., in May, 1990. Rodime pursued joint ventures with JVC and companies in Taiwan and Korea for design and manufacturing of new products. However, in mid-1991 Rodime announced that these ventures were unlikely to come to fruition and that it would file for bankruptcy and cease manufacturing of drives after using up its current inventory of materials. Rodime continues to actively pursue licensing of its 3.5" disk drive patents, but high legal expenses and falling license revenues are creating financial pressure on the company.

SAGEM
(Societe d'Applications Generales d'Electricite et de Mecanique)
La Ponant, 27, rue Leblanc
75512 Paris CEDEX 15
France

SAGEM is active in the fields of military electronics, telecommunications, office systems, industrial and military equipment and computer peripherals. The firm's earliest disk drives were head-per-track designs. In 1986, SAGEM introduced a unique 5.25" Winchester drive with multiple heads per slider, sold as a military subsystem. The firm's more recent products have focused upon a line of militarized removable disk drives with 200 megabytes capacity.

DISK/TREND ON DISK

1994 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 used on the label of each 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 is shipping version 3.13 or higher of AutoImport. Instructions in this section are written to work with this version. If you have version 2.xx of AutoImport, refer to instruction in previous DISK/TREND reports. You must have AutoImport 3.xx 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 information on the following page.

DISK/TREND ON DISK

Information License

DISK/TREND supplies diskettes containing selected information from the 1994 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1994 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 the terms and conditions provided by White Crane Systems, Inc., 8255 Overview Court, Suite 100, Roswell, GA 30076

Trademarks

IBM is a trademark of International Business Machines Corporation.
Lotus and Lotus 1-2-3 are trademarks of Lotus Development Corporation.
MS-DOS is a trademark of Microsoft Corporation.
AutoImport is a trademark of White Crane Systems, Inc.

1994 DISK/TREND REPORT

Getting started

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

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

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

DISK/TREND ON DISK for the Rigid Disk Drive Report is normally shipped on 3.5" 1.44 megabyte diskettes. 5.25" 1.2 megabyte diskettes are available if requested. There will be two diskettes in a set, one containing statistical tables and one containing specification tables.

STATISTICAL TABLES

Loading and Installation

1. Place the floppy disk marked 'Tables' in a floppy disk drive able to read 5.25" 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 commands are:

   COPY A:*.PRN (if you intend to use Lotus 1-2-3 data parsing)
   COPY A:MASK?2.MSK (if you intend to use AutoImport Version 2.xx)
   COPY A:MASK?3.MSK (if you intend to use AutoImport Version 3.xx)

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

   Installing AutoImport V3.xx: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place AutoImport disk 1 in drive A and type: COPY A:*.* C:\AIMP 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 drive A if required by the security provisions of your spreadsheet program. Start your spreadsheet as usual. When the blank spreadsheet appears on the screen, use the file retrieval command to select a file. An example of a Lotus 1-2-3 command is:

   /FR<filename>

   The file names are in the format XTYY.WK1, where:

   X= Type of data
   - F (Flexible disk drive 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 RT11.WK1 is Rigid Disk Drive Report Table 11
   - File FT2.WK1 is Flexible Disk Drive Report Table 2
   - File OT1.WK1 is Optical Disk Drive Report Table 1
   - File AT3.WK1 is Disk Drive Array Report Table 3
   - File VT4.WK1 is Removable Data Storage Report Table 4

   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:

oFORMLINA.PRN	Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
oFORMLINB.PRN	Used with Table 2.
oFORMLINF.PRN	Used with Tables 3 and 4.
oFORMLIND.PRN	Used with Application tables.
oFORMLINE.PRN	Used with Drive Height, Track Density and Drive Capacity tables in the Flexible Disk Drive Report.

There are no FORMLIN format files for disk diameter tables or market share tables, as these are variable in format. You will have to construct the format line directly, but once familiar with data parsing, 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 as files with .MSK file name suffixes) 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	N/A	Write-Once/ Erasable Analysis	N/A
MASKH	Tables 7,8	Table 31	N/A	N/A
MASKI	<----- Product Group -----> Price/Megabyte		N/A	N/A

N/A = Not applicable to this report

* Variable format depending upon number of disk diameters in the product group.

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1994 Rigid Report	1993 Flexible Report	1994 Optical Report	1994 Array Report	1994 Removable Report
1	MASKA	MASKA	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA	MASKB	MASKB
3	MASKC	MASKC	MASKB	MASKC	MASKC
4	MASKC	MASKC	MASKB	MASKC	MASKC
5	MASKC	--	MASKC	MASKC	MASKC
6	MASKC	--	MASKC	MASKC	MASKC
7	MASKH	MASKF	MASKC	MASKC	--
8	MASKH	MASKA	MASKC	--	--
9	MASKC	MASKA	MASKC	--	MASKA
10	MASKC	MASKE	MASKC	MASKA	MASKA
11	MASKC	MASKD	MASKC	MASKA	MASKC
12	--	MASKG	MASKC	--	MASKC
13	--	MASKA	--	--	--
14	MASKA	MASKA	--	--	MASKI
15	MASKA	MASKE	--	MASKA	--
16	--	MASKE	--	MASKA	MASKI
17	--	MASKD	MASKA	--	--
18	MASKD	MASKG	MASKA	--	MASKI
19	MASKI	MASKA	--	--	--
20	--	MASKA	--	MASKA	MASKI
21	MASKA	--	MASKD	MASKA	--
22	MASKA	--	--	--	MASKA
23	--	MASKE	MASKA	--	MASKA
24	--	MASKE	MASKA	--	MASKC
25	MASKD	MASKD	--	MASKA	MASKC
26	MASKI	MASKG	--	MASKA	MASKA
27	--	MASKA	--	--	MASKA
28	MASKA	MASKA	--	--	MASKA
29	MASKA	--	MASKE	--	MASKA
30	--	--	MASKD		MASKA
31	--	MASKD	--		MASKH
32	MASKD	MASKG	MASKA		MASKD
33	MASKI		MASKA		--
34	--		--		MASKA
35	MASKA		--		MASKA
36	MASKA		MASKD		--
37	--		--		--
38	--		MASKA		MASKI
39	MASKD		MASKA		MASKD
40	MASKI		--		--
41	--		--		MASKA
42	MASKA		MASKA		MASKA
43	MASKA		MASKA		--
44	--		--		--
45	--		--		MASKD
46	MASKD		MASKE		--
47	MASKI		MASKA		MASKA

Cross reference (continued)

Table Number	1994 Rigid Report	1993 Flexible Report	1994 Optical Report	1994 Array Report	1994 Removable Report
48	--		MASKA		MASKA
49	MASKA		--		--
50	MASKA		--		--
51	--		MASKE		MASKD
52	--		MASKA		--
53	MASKD		MASKA		
54	MASKI		--		
55	--		--		
56	MASKA		MASKE		
57	MASKA				
58	--				
59	--				
60	MASKD				
61	MASKI				
62	--				
63	MASKA				
64	MASKA				
65	--				
66	--				
67	MASKD				
68	MASKI				
69	--				
70	MASKA				
71	MASKA				
72	--				
73	--				
74	--				
75	MASKD				
76	MASKI				
77	--				

-- indicates that the format of this table is variable. Create a mask using AutoImport if a spreadsheet is needed.

Translation using precomputed masks

1. First, copy the files you wish to translate to the AIMP directory from DISK/TREND ON DISK floppy disk. Go to the AIMP directory, insert the floppy disk in drive A and type the following commands:

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

   These commands copy the data files and mask files you need.

   If you are using a two floppy disk system, copy the files you want to translate to a second floppy disk along with the mask files. Make sure that no more than half of the floppy disk is filled, because you will need space for the converted files.

2. Now start AutoImport. When the opening screen appears, select the "File" menu bar item using the mouse keys or just type /F. (The AutoImport menu system works like the menus in Lotus 1-2-3.)

3. When the next screen appears (File Selection Menu), use the arrow keys or the mouse to select the Mask Name option, then press (or click on) the down arrow to get a list of mask names. If a standard mask is being used, see the mask table above to choose the mask file name to enter. If you used a mask previously, the system defaults to the last mask named. Press 'ENTER' (or double click on the selected name). Now position the cursor on the "RETRIEVE MASK" button and select it to load the mask.

4. Select the Input File Name option on the File Selection Menu.

   Enter the name of the file, <u>including the extension</u>, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.94R FT12.94F OT14.94O AT19.94A VT6.94V

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

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

   Examples: RT4 FT12 OT14 AT19 VT6

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

7. You are ready to translate. Recheck all the file names displayed to be CERTAIN they are correct. Select the "CONVERT" button using the mouse or arrow keys and ENTER. If you are asked "Do you want to load input file named in mask?", answer "NO". You will see the file being translated scroll by as the translation proceeds. If it does not scroll during translation, you may have a damaged mask file. See the next section for details on mask file creation.

8. If you want to do more translations, repeat from step 3.

9. When you are done translating, leave AutoImport by typing /Q (Quit) to leave AutoImport and return to DOS. It will save you some keystrokes if you copy your new spreadsheet files to your spreadsheet directory. If you are using a two floppy system, just remove the AutoImport disk from drive A and substitute your spreadsheet disk.

Mask Generation

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

2. Select the Input file name option on the File Selection Menu and 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, F, O, A or V), nn is the table number and yy is the report year.

   Example: RT50.94R

   The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now select "Lines" from the menu bar, then select "Headings" 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. The area that will be treated as header will be displayed in bright red.

   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, the "Auto Define". This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

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

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

   o Place cursor in left margin of offending line. Select "Column", then "Width & Move". Select the column you wish to adjust with the mouse (or arrows & ENTER), and then use the arrow keys to move the right column margin clear of the column of values. If you need to move an entire column without changing width, use the arrow keys while depressing the CONTROL key.

5. Save the mask in a mask file. Select "File", then "Mask", then the SAVE MASK button. Fill in the name of the mask file when asked.

   Example: RT50MSK

6. Name the output file, as described in the previous section.
   Example: RT50. You don't need to enter the file extender.

   To create the output file, use the "CONVERT" button as before.

7. To make more masks, repeat from step 2. To quit AutoImport and return to DOS, 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

The rigid disk drive specifications may be supplied on two diskettes if 5.25" diskettes were supplied to you or one diskette if otherwise. If you are using two diskettes, specification diskette 1 contains the specifications for DISK/TREND product groups one through five. The other diskette contains specifications for groups six through nine. If your computer has enough memory (it may require expanded memory in some cases) you can load the two data bases sequentially into one large data base for ease of data manipulation. See the comments in the Operating Tips section.

Loading

1. If you have a two floppy disk system: Place the floppy disk marked "Specifications" in a floppy disk drive. 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.

   If you have a hard disk: Log into the hard disk directory in which your spreadsheet normally stores worksheet files. Using the DOS 'COPY' command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?S*.*

2. 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

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 needed for copy protection. 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= F (Flexible disk drive data)
O (Optical disk drive data)
R (Rigid disk drive data)
A (Disk drive array data)
V (Removable Data Storage data)

Y= Table number. Usually, there is only one table, but if the specification file is so large as to need multiple disks to hold it, there may be several.

ZZ= Year of report.

Example: RS194 Rigid disk specification table, Groups 1 to 5
RS294 Rigid disk specification table, Groups 6 to 9
RS394 Complete specification table: supplied on 1.44 megabyte 3.5" or 1.2 megabyte 5.25" diskettes if space permits

Note that the specification tables load directly as a data base. You can use the various 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 DISK/TREND Report.

The data base has been set up for data extraction using Lotus 1-2-3 com-

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

Operating tips

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

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

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

Combining specification data bases: Lotus 1-2-3 allows you to combine worksheets into a larger worksheet. If you think your computer has enough memory, you can combine the specification data bases by doing the following:

1. Load the worksheet RS194 from the specification diskette (specification diskette 1 if you have 1.2 megabyte diskettes) into a new worksheet. Now move the worksheet cursor to column A and the row just under the last manufacturer's name.

2. Load the worksheet from RS294 from the specification diskette (or specification diskette 2) using the Lotus command /FCC.

3. Edit the worksheet to remove the header and criteria range areas that were loaded with the second worksheet.

4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.

5. Copy the column header row using the /C command to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the last column of data.

6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it to a new file name first so that you can easily reload if you make an unrecoverable alteration.

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 into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

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

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

If you are interested in a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and use the second file for analysis. The smaller file will take less time to process.

Special data: The specification data base contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

All specification files have been prepared as Lotus 1-2-3 spreadsheets set up for data extraction. Criterion, Input, and Output ranges are predefined.

If you received more than one specification disk, file RS194.WK1 contains DISK/TREND Product Groups 1 through 5. File RS294.WK1 contains Product Groups 6 through 9. File RS394.WK1 contains the entire specification data base, but the amount of memory required is large and may not allow enough room for large data extractions.

If file RS394.WK1 is present, you are using a 1.2 or 1.44 megabyte diskette, and should have a computer equipped with expanded memory capability.

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. The affected fields have been converted to purely numeric fields as described below. Where multiple values existed, the value representing the highest level of performance or capability has been retained.

Comments and asterisks in the affected fields have been eliminated. A '0' means that no data was available. Asterisks are retained in the comment field so that you will have an indication that one or more characteristics of the drive was referenced to a comment. Check the printed report table for details.

The affected fields are:

Group:	Numeric conversion: You can extract a range of groups.
Surfaces per spindle	Numeric conversion: You can extract a range of values.
Heads per surface	Will be a single numeric value: 1 or 2.

TPI	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the highest TPI is used.
RPM	Numeric conversion: You can extract a range of values.
Tracks per surface	Will be a single numeric value, 0 if data not available. If a drive model has several configurations, the largest value of tracks per surface is used.
Average positioning time	Will be a single numeric value, 0 if data not available. If a drive model is specified as having more than one positioning time, the shortest will be used. Settling time is always included.
Average rotational delay	Numeric conversion: You can extract a range of values.
Average access time	Same as for average positioning time.

A country code field has been added in the last column of the data base. The code explanation is:

1 = U.S. manufacturer
2 = Asian manufacturer
3 = European manufacturer
4 = South American or other manufacturer

Codes are based upon the location of the manufacturer's headquarters.

First ship date has been modified so that the last two characters will always represent the year of shipment. An entry of ??89 in the criterion field for the First Ship Date column will cause all drives first shipped in 1989 to be extracted.

Technical support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: **415-961-6209**
Fax us at: **415-969-2560**

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.