1995 DISK/TREND® REPORT

RIGID
DISK
DRIVES

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RIGID DISK DRIVES

October, 1995

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FOREWORD

The rigid disk drive industry is having what most participants consider to be a good year. Customers like the lower prices. Engineers like the higher areal density. Component makers like the increased shipments. Company managements like the increased revenue. Shareholders of some drive manufacturers like the increased profits. The main problem will be to do it all again next year. And that won't be easy, considering the frenzied product development, shortened inventory turnover and inevitable price reductions which somehow must be managed efficiently.

The DISK/TREND Report's product mix was modified slightly in 1995, the nineteenth year of publication. There are four separate volumes this year, instead of five. We've integrated the report on flexible disk drives, which was published separately since 1977, into the new report on removable data storage, which now combines standard floppy drives, new high capacity floppy drives, rigid disk cartridge drives, small optical disk drives, PC Card drives and flash memory cards in one volume, which was published in September. The complete report on optical disk drives was published in August, and the report on disk drive arrays, the most complete coverage on the subject, was released in April. Please note that we plan to make a scheduling change in 1996: The 1996 report on rigid disk drives will be published earlier in the year, probably in May.

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

No change in this year's product groups -- but wait 'till next year!

We're always reluctant to change the product groups used in the DISK/TREND Report, since we are aware that many companies organize their industry data accordingly. However, the industry's principal clusters of product activity are again going through a period of rapid change, so next year we'll revise the groups we use in collecting data and for use in the published reports. Since shipments have dropped very rapidly in the lower capacity ranges, we will combine three existing product groups into a single "less than 300 megabytes" group. The existing top capacity group will be split into "3-6 gigabytes", "6-10 gigabytes" and "more than 10 gigabytes". These plans will remain in tentative form for a month or two, so if you have any comments, please let us know.

Please note the duplication

For the second year, we have published a separate report on removable data storage. The removable data storage report 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 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 PC Card or comparable formats, while the 1.8" data included in several sections of this report includes all 1.8" or smaller drives, not just the ones in PC Card format.

If you're a new DISK/TREND Report user, please note

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

The rigid disk drive industry is maintaining its pattern during the last two decades of increasing shipments each year. In fact, stronger than expected growth rates will push worldwide 1995 unit shipments to an estimated 87.8 million drives. An average annual growth rate of 14.7% during the 1996-98 period will boost 1998 total shipments to more than 132.3 million drives.

The industry's pattern of revenue growth is less consistent. Markets for rigid disk drives have a history of excellent growth in most years, but the product mix is constantly moving to higher capacity drives at lower average prices, due to the rapid rate at which improvements in recording density are achieved. Unfortunately, prices go down in some years faster than shipments go up, yielding occasional years in which sales revenues decline even when drive unit shipments increase.

In 1994 total sales revenues increased 6.9% to $23.2 billion, buoyed by a 35% increase in unit shipments, and in 1995 revenues are projected to grow 10.6%, while shipments are up 25.5%. However, unit shipments are forecasted to rise only 17.7% in 1996, while revenues suffer a 1.4% decline. The situation underlying the 1996 drop in overall revenues is a change in the drive product mix for manufacturers of captive drives, as new lower cost drives replace older, costly models, and as traditionally high prices are brought closer to competitive levels. Despite continuing growth in unit shipments and very rapid migration to higher capacities, the forecasted revenue increases during 1997-98 will be minimal.

The industry's movement to higher capacities continues at an impressive pace. As production below 200 megabytes approaches end of life, the 500 megabyte - 1 gigabyte product group has become the shipment leader in 1995, with a total estimated at more than 42.1 million drives. In 1998, the 2-3 gigabyte product group is expected to lead the industry, with a projected 58.4 million drives. Expanding disk drive usage with major markets such as mainframe computers, network file servers and workstations is pushing shipments up, but the personal computer market has become the dominant influence, both in boosting shipments and in pushing typical disk capacities to constantly higher levels.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994		Forecast							
	Revenues		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3,485.4	5,177.2	3,558.0	5,350.3	3,100.4	4,626.4	3,072.3	4,663.1	3,081.2	4,640.6
Other U.S. Captive	676.5	1,062.5	493.5	611.5	149.0	190.7	116.7	153.4	96.2	137.4
TOTAL U.S. CAPTIVE	4,161.9	6,239.7	4,051.5	5,961.8	3,249.4	4,817.1	3,189.0	4,816.5	3,177.4	4,778.0
PCM/Reseller	2,197.8	3,879.2	2,671.0	4,708.7	3,206.7	5,372.3	3,178.8	5,218.3	3,131.3	5,058.2
OEM/Integrator	5,747.3	9,710.7	7,448.5	11,503.3	7,436.5	11,502.5	7,785.8	11,805.4	7,871.2	11,852.5
TOTAL U.S. NONCAPTIVE	7,945.1	13,589.9	10,119.5	16,212.0	10,643.2	16,874.8	10,964.6	17,023.7	11,002.5	16,910.7
TOTAL U.S. REVENUES	12,107.0	19,829.6	14,171.0	22,173.8	13,892.6	21,691.9	14,153.6	21,840.2	14,179.9	21,688.7
Non-U.S. Manufacturers										
Captive	113.9	1,394.5	143.7	1,313.8	138.3	1,223.7	190.9	1,385.0	247.2	1,596.1
PCM/Reseller	504.5	916.6	401.9	755.9	274.7	603.8	326.8	729.6	384.5	841.7
OEM/Integrator	416.3	1,090.7	578.1	1,442.8	839.9	1,796.0	976.7	2,087.6	1,084.1	2,364.6
TOTAL NON-U.S. REVENUES	1,034.7	3,401.8	1,123.7	3,512.5	1,252.9	3,623.5	1,494.4	4,202.2	1,715.8	4,802.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	13,141.7	23,231.4	15,294.7	25,686.3	15,145.5	25,315.4	15,648.0	26,042.4	15,895.7	26,491.1

Marketing channels

Nine companies left the rigid disk drive industry in the last year, and only 3 new participants initiated disk drive manufacturing programs, leaving 24 companies active in the industry. The total has shrunk from 47 drive manufacturers in 1992, to 40 in 1993, and in 1994 the list was already 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 major exception in 1994 was the acquisition of Digital Equipment's disk drive business by Quantum, removing a company with an estimated $678 million in rigid disk drive revenues as an independent entity. Asian manufacturers deleted from the list this year all suffered from inadequate rigid disk drive sales levels, a problem which also affected most of the U.S. companies which are no longer on the list. The three additions this year include Iomega and Nomai, both of which will produce new high-end 3.5" disk cartridge drives, and Gigastorage International, which will revisit the 5.25" drive market with a new low cost drive.

During the 1990's, captive drive revenues have declined from 64.3% of the industry's overall total in 1990, to 43.3% in 1994, with 37.9% projected for 1998. The reduction in captive share is traced to a combination of factors, including departure of system manufacturers such as DEC and the rapid movement from very expensive high-end drives for mainframe and midrange computers to industry standard, low cost drives. PCM/Reseller revenues have climbed several percentage points, as the upgrade aftermarket has blossomed, especially in the personal computer field. OEM/Integrator revenues have grown the most rapidly, and are expected to climb to more than half of the industry's 1998 revenues.

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 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 1994 totaled $7.6 billion, 32.9% of the overall revenue worldwide total. But 1994 captive shipments totaled 6.3 million drives, only 9.1% of the worldwide total. 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 many 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	1994 Revenues $M	1994 Revenues %	Forecast 1995 $M	Forecast 1995 %	Forecast 1996 $M	Forecast 1996 %	Forecast 1997 $M	Forecast 1997 %	Forecast 1998 $M	Forecast 1998 %
U.S. Manufacturers										
IBM Captive	5,177.2 -28.0%	22.2%	5,350.3 +3.3%	20.8%	4,626.4 -13.5%	18.2%	4,663.1 +.8%	17.9%	4,640.6 -.5%	17.5%
Other U.S. Captive	1,062.5 +2.4%	4.5%	611.5 -42.4%	2.3%	190.7 -68.8%	.7%	153.4 -19.6%	.5%	137.4 -10.4%	.5%
PCM/Reseller	3,879.2 +23.3%	16.6%	4,708.7 +21.4%	18.3%	5,372.3 +14.1%	21.2%	5,218.3 -2.9%	20.0%	5,058.2 -3.1%	19.0%
OEM/Integrator	9,710.7 +34.5%	41.7%	11,503.3 +18.5%	44.7%	11,502.5 --	45.4%	11,805.4 +2.6%	45.3%	11,852.5 +.4%	44.7%
Total U.S. Manufacturers	19,829.6 +6.6%	85.0%	22,173.8 +11.8%	86.1%	21,691.9 -2.2%	85.5%	21,840.2 +.7%	83.7%	21,688.7 -.7%	81.7%
Non-U.S. Manufacturers										
Captive	1,394.5 +17.5%	6.0%	1,313.8 -5.8%	5.1%	1,223.7 -6.9%	4.8%	1,385.0 +13.2%	5.3%	1,596.1 +15.2%	6.0%
PCM/Reseller	916.6 -9.1%	3.9%	755.9 -17.5%	2.9%	603.8 -20.1%	2.3%	729.6 +20.8%	2.8%	841.7 +15.4%	3.1%
OEM/Integrator	1,090.7 +16.2%	5.1%	1,442.8 +32.3%	5.9%	1,796.0 +24.5%	7.4%	2,087.6 +16.2%	8.2%	2,364.6 +13.3%	9.2%
Total Non-U.S. Manufacturers	3,401.8 +8.6%	15.0%	3,512.5 +3.3%	13.9%	3,623.5 +3.2%	14.5%	4,202.2 +16.0%	16.3%	4,802.4 +14.3%	18.3%
Worldwide Recap										
Captive	7,634.2 -18.9%	32.9%	7,275.6 -4.7%	28.3%	6,040.8 -17.0%	23.9%	6,201.5 +2.7%	23.8%	6,374.1 +2.8%	24.1%
PCM/Reseller	4,795.8 +15.5%	20.6%	5,464.6 +13.9%	21.3%	5,976.1 +9.4%	23.6%	5,947.9 -.5%	22.8%	5,899.9 -.8%	22.3%
OEM/Integrator	10,801.4 +32.4%	46.5%	12,946.1 +19.9%	50.4%	13,298.5 +2.7%	52.5%	13,893.0 +4.5%	53.4%	14,217.1 +2.3%	53.6%
Total All Manufacturers	23,231.4 +6.9%	100.0%	25,686.3 +10.6%	100.0%	25,315.4 -1.4%	100.0%	26,042.4 +2.9%	100.0%	26,491.1 +1.7%	100.0%

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

Product mix

During the 1990's, the disk drive industry's widely discussed pattern of 60% annual increases in typical recording density has revolutionized the industry's product mix. The average drive capacities utilized for each major application area have been raised as fast as the individual markets have been ready to buy, and the evolution to drives with smaller diameter disks has been accelerated. In 1990, more than half the drives produced had capacities in the range of 30-60 megabytes, but in 1998 2-3 gigabyte drives are projected to be the leading product group, with 44.1% of total shipments. In 1990, less than 20 million 3.5" and one million 2.5" drives were shipped, but DISK/TREND Report forecasts for 1998 predict shipments of more than 110 million 3.5" and 18 million 2.5" drives.

Growing demand for higher disk drive capacities for all of the industry's major application areas is expected to continue beyond the current forecast period. Individual personal computer users are using more disk capacity for Windows and application programs, 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.

As average disk capacities move up, product groups which once dominated the industry are fading away. Drives with 100-200 megabyte capacities once led in industry shipments, but peaked in 1993, with 20 million units, and all drives with capacities below 200 megabytes are expected to be out of production after 1996. Declining shipments are now forecasted for all drives below 1 gigabyte by the end of 1995.

The three product groups with capacities over 1 gigabyte will have high growth rates through 1997, and growth will continue past 1997 for drives with capacities above 2 gigabytes. Personal computer markets have become a significant factor in the markets for drives over a gigabyte, as users continue to want immediate access to a wide variety of applications, plus all of their old files. Growth for all three product 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" drives have now become the dominant factor in all of the DISK/TREND Report product groups, and 1994 shipments of 60.3 million 3.5" drives represent 86.2% of the overall worldwide total. An expected average annual growth rate of 16.5% for the 1994-98 period will push 1998's shipments to 110.6 million 3.5" drives, representing 83.6% 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 1998, as each year's improvements in recording density extend the usefulness of 2.5" and 1.8" drives into new territory. In 1998, 2.5" drives are projected to hold 14.1% of the industry's unit shipments, with 18.7 million drives. 1.8" drives will secure only .8% of the total by 1998, but this share represents a four times increase in the 1994 shipment level, to 990,000 drives. DISK/TREND Report forecasts for 5.25" drives currently assume that shipments will increase from current shipment levels, then peak in 1997, as new low-cost models develop a market with selected personal computer manufacturers. The forecast may have to be enlarged if the concept proves to be popular.

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 1998, 2.5" disk drives with more than 3 gigabytes capacity will be available. 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 PC Card configurations, while waiting for the subnotebook computer market to actually materialize. Forecasts for 1.8" drives have had to be lowered, as subnotebook computers are still minor products and most notebook computer manufacturers prefer lower cost 2.5" drives.

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue

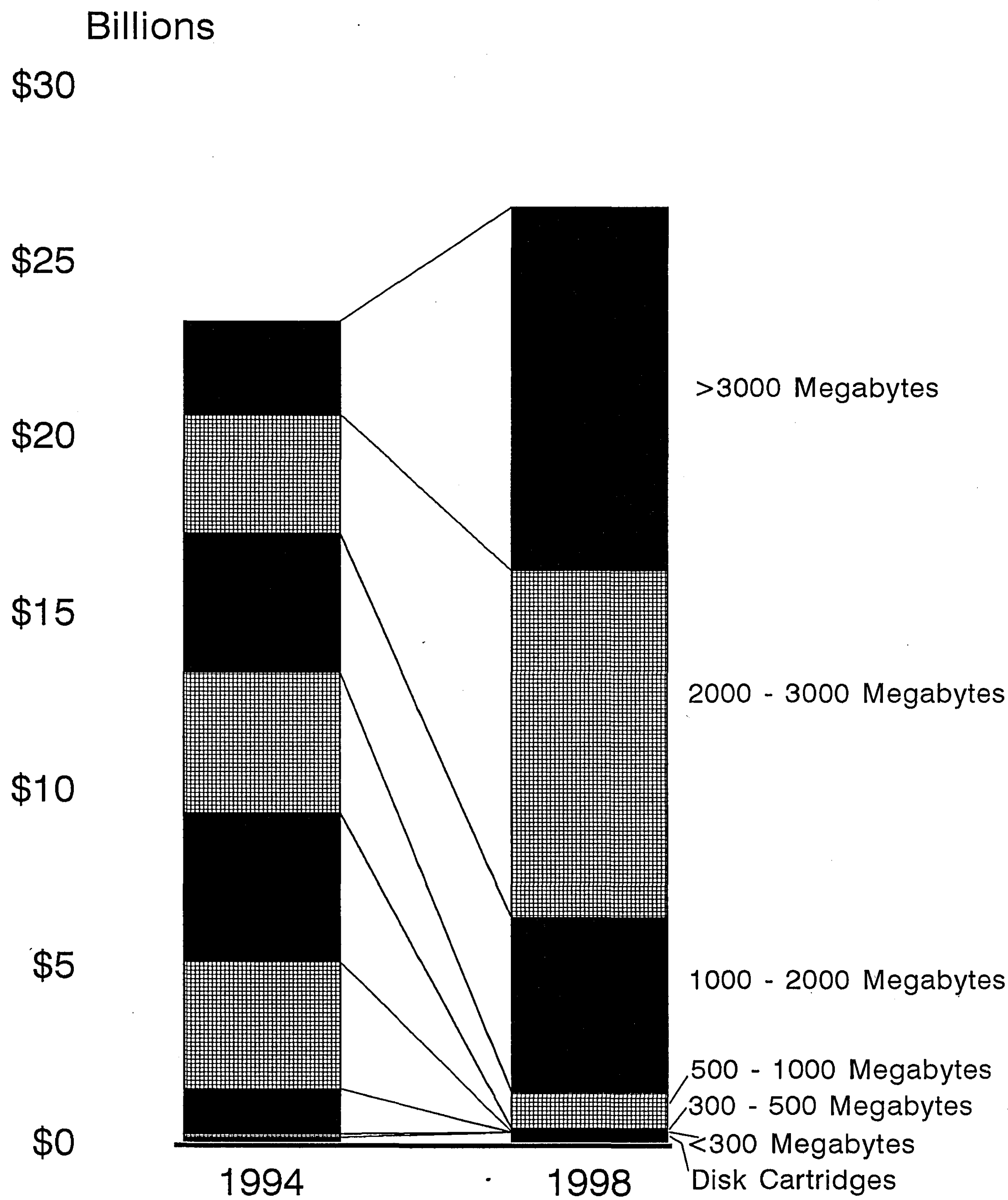


TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1994 Revenues		Forecast							
			1995		1996		1997		1998	
	$M	%	$M	%	$M	%	$M	%	$M	%
CARTRIDGE DISK DRIVES	111.9	.5%	162.3	.6%	250.8	1.0%	270.5	1.0%	267.9	1.0%
	+29.5%		+45.0%		+54.5%		+7.9%		-1.0%	
FIXED DISK DRIVES less than 100 Megabytes	99.2	.4%	32.1	.1%	.6	--	--	--	--	--
	-91.2%		-67.6%		-98.1%		--		--	
FIXED DISK DRIVES 100 - 200 Megabytes	1,259.2	5.4%	192.9	.8%	21.0	.1%	--	--	--	--
	-68.5%		-84.7%		-89.1%		--		--	
FIXED DISK DRIVES 200 - 300 Megabytes	3,602.6	15.5%	851.6	3.3%	163.9	.6%	36.6	.1%	23.2	.1%
	+3.4%		-76.4%		-80.8%		-77.7%		-36.6%	
FIXED DISK DRIVES 300 - 500 Megabytes	4,209.5	18.1%	2,734.6	10.6%	1,010.7	4.0%	317.9	1.2%	91.7	.3%
	+142.7%		-35.0%		-63.0%		-68.5%		-71.2%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	4,001.0	17.2%	9,152.9	35.6%	7,140.1	28.2%	3,220.8	12.4%	999.2	3.8%
	+166.6%		+128.8%		-22.0%		-54.9%		-69.0%	
FIXED DISK DRIVES 1 - 2 Gigabytes	3,919.6	16.9%	4,838.1	18.8%	7,619.2	30.1%	8,627.7	33.1%	4,951.6	18.7%
	+19.9%		+23.4%		+57.5%		+13.2%		-42.6%	
FIXED DISK DRIVES 2 - 3 Gigabytes	3,381.4	14.6%	4,478.4	17.4%	3,946.5	15.6%	6,517.2	25.0%	9,840.2	37.1%
	+48.6%		+32.4%		-11.9%		+65.1%		+51.0%	
FIXED DISK DRIVES more than 3 Gigabytes	2,647.0	11.4%	3,243.4	12.6%	5,162.6	20.4%	7,051.7	27.1%	10,317.3	38.9%
	-37.7%		+22.5%		+59.2%		+36.6%		+46.3%	
Total Worldwide Revenue	23,231.4	100.0%	25,686.3	100.0%	25,315.4	100.0%	26,042.4	100.0%	26,491.1	100.0%
	+6.9%		+10.6%		-1.4%		+2.9%		+1.7%	

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

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Millions of Units

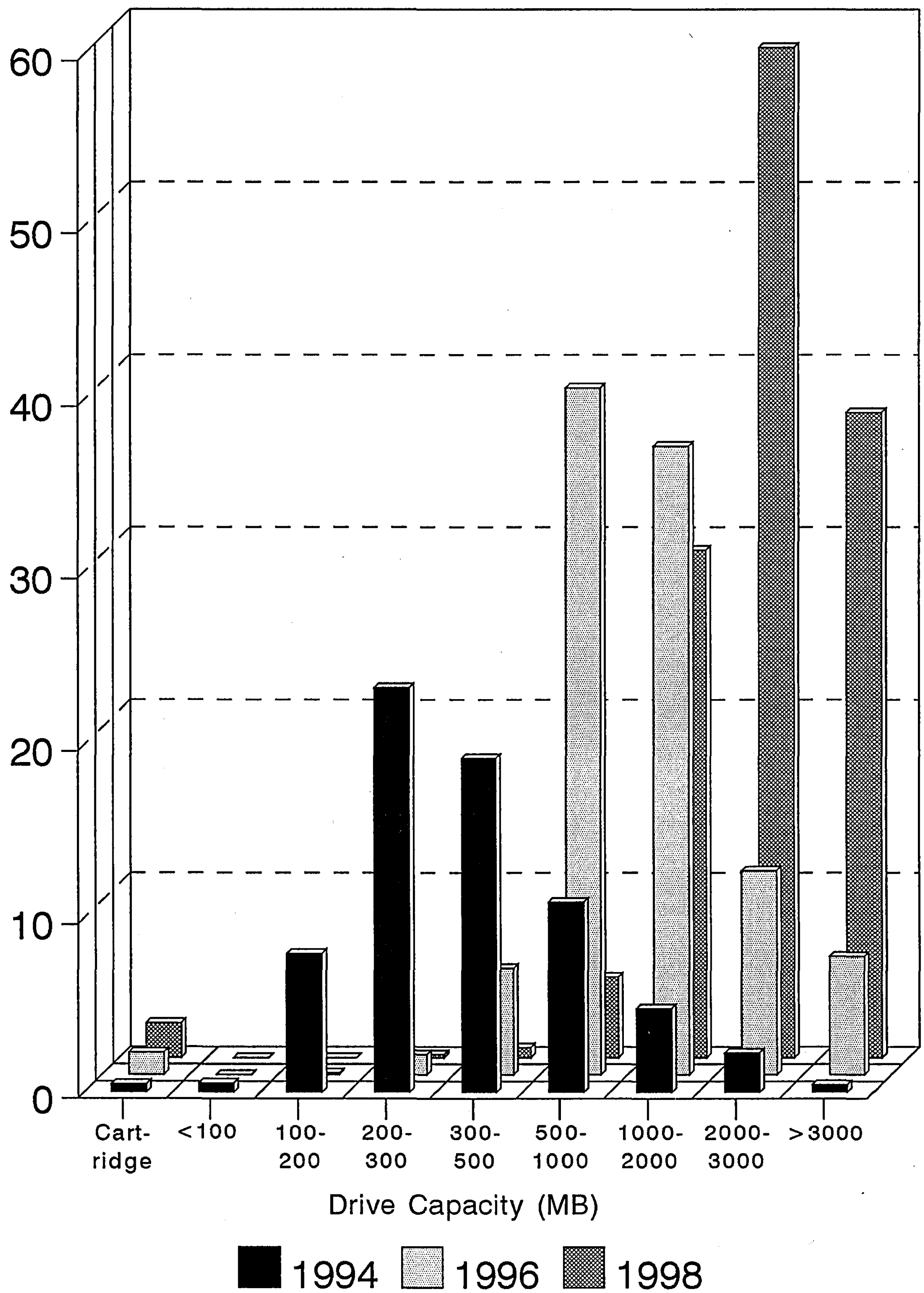


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1994 Shipments Units	1994 Shipments %	Forecast 1995 Units	1995 %	1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %
CARTRIDGE DISK DRIVES	468.4	.7%	742.0	.8%	1,300.0	1.3%	1,680.0	1.4%	1,985.0	1.5%
	+25.0%		+58.4%		+75.2%		+29.2%		+18.2%	
FIXED DISK DRIVES less than 100 Megabytes	520.1	.7%	177.3	.2%	5.0	--	--	--	--	--
	-93.0%		-65.9%		-97.2%		--		--	
FIXED DISK DRIVES 100 - 200 Megabytes	8,007.3	11.4%	906.4	1.0%	115.0	.1%	--	--	--	--
	-60.0%		-88.7%		-87.3%		--		--	
FIXED DISK DRIVES 200 - 300 Megabytes	23,312.6	33.3%	5,291.2	6.0%	1,180.0	1.1%	235.0	.2%	185.0	.1%
	+65.7%		-77.3%		-77.7%		-80.1%		-21.3%	
FIXED DISK DRIVES 300 - 500 Megabytes	19,241.2	27.5%	15,976.9	18.2%	6,150.5	5.9%	1,870.0	1.6%	580.0	.4%
	+322.1%		-17.0%		-61.5%		-69.6%		-69.0%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	10,925.1	15.6%	42,178.4	48.0%	39,700.5	38.4%	18,230.0	15.5%	4,640.0	3.5%
	+398.5%		+286.1%		-5.9%		-54.1%		-74.5%	
FIXED DISK DRIVES 1 - 2 Gigabytes	4,815.3	6.9%	16,062.3	18.3%	36,351.0	35.2%	49,430.0	42.0%	29,300.0	22.1%
	+103.8%		+233.6%		+126.3%		+36.0%		-40.7%	
FIXED DISK DRIVES 2 - 3 Gigabytes	2,276.3	3.3%	4,347.3	5.0%	11,750.0	11.4%	28,750.0	24.4%	58,400.0	44.1%
	+219.7%		+91.0%		+170.3%		+144.7%		+103.1%	
FIXED DISK DRIVES more than 3 Gigabytes	432.5	.6%	2,132.4	2.4%	6,841.0	6.6%	17,600.0	14.9%	37,300.0	28.2%
	+170.3%		+393.0%		+220.8%		+157.3%		+111.9%	
Total Worldwide Shipments	69,998.8	100.0%	87,814.2	100.0%	103,393.0	100.0%	117,795.0	100.0%	132,390.0	100.0%
	+35.0%		+25.5%		+17.7%		+13.9%		+12.4%	
% U.S. Manufacturers	91.0%		90.3%		87.6%		85.5%		83.8%	
Total Capacity (Terabytes)	32,933.0		74,461.2		135,410.8		259,668.0		464,465.2	

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

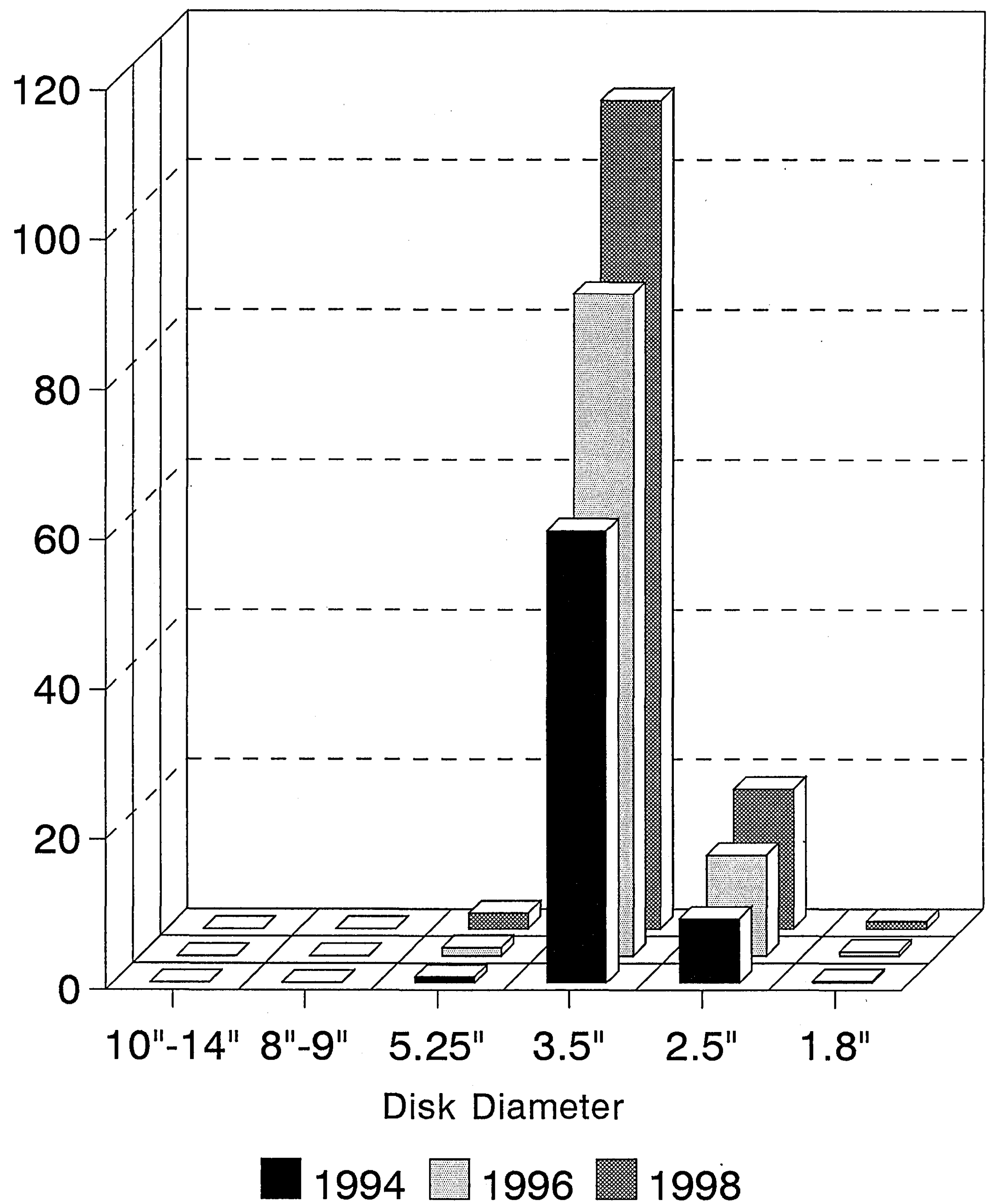


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
SUMMARY BY DISK DIAMETER

UNIT SHIPMENTS IN THOUSANDS	1994 Shipments Units	1994 Shipments %	Forecast 1995 Units	1995 %	1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %
10 - 14 INCH	46.1 -42.0%	.1%	6.0 -87.0%	--	-- --	--	-- --	--	-- --	--
6.5 - 9.5 INCH	75.4 -25.0%	.1%	38.7 -48.7%	--	9.6 -75.2%	--	-- --	--	-- --	--
5.25 INCH	791.6 -38.1%	1.1%	670.3 -15.3%	.8%	1,103.4 +64.6%	1.1%	2,570.0 +132.9%	2.2%	2,095.0 -18.5%	1.6%
3.5 INCH	60,343.2 +37.3%	86.2%	75,805.5 +25.6%	86.3%	88,315.0 +16.5%	85.4%	98,415.0 +11.4%	83.6%	110,620.0 +12.4%	83.6%
2.5 INCH	8,507.2 +35.3%	12.2%	10,822.7 +27.2%	12.3%	13,395.0 +23.8%	13.0%	16,025.0 +19.6%	13.6%	18,685.0 +16.6%	14.1%
1.8 INCH OR LESS	235.3 +49.7%	.3%	471.0 +100.2%	.5%	570.0 +21.0%	.6%	785.0 +37.7%	.7%	990.0 +26.1%	.8%
Total Worldwide Shipments	69,998.8 +35.0%	100.0%	87,814.2 +25.5%	100.0%	103,393.0 +17.7%	100.0%	117,795.0 +13.9%	100.0%	132,390.0 +12.4%	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

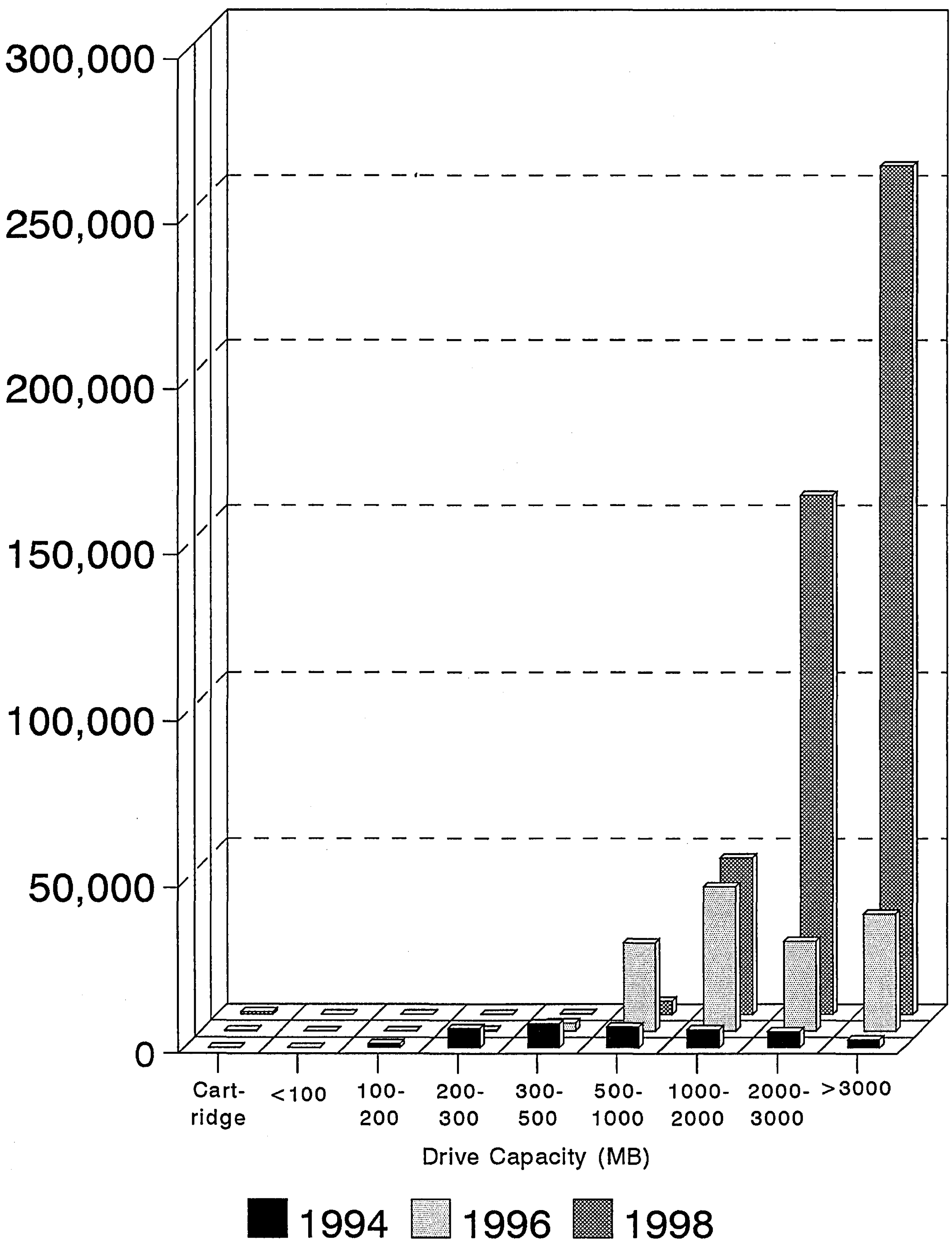


TABLE 6

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1994 Shipments Tbytes	1994 %	Forecast 1995 Tbytes	1995 %	1996 Tbytes	1996 %	1997 Tbytes	1997 %	1998 Tbytes	1998 %
CARTRIDGE DISK DRIVES	77.6 +135.2%	.2%	126.9 +63.5%	.2%	232.9 +83.6%	.2%	398.1 +70.9%	.2%	714.0 +79.4%	.2%
FIXED DISK DRIVES less than 100 Megabytes	31.9 -93.6%	.1%	6.2 -80.6%	--	.4 -93.5%	--	-- --	--	-- --	--
FIXED DISK DRIVES 100 - 200 Megabytes	1,189.3 -57.5%	3.6%	134.1 -88.7%	.2%	15.4 -88.5%	--	-- --	--	-- --	--
FIXED DISK DRIVES 200 - 300 Megabytes	5,760.5 +75.4%	17.5%	1,350.7 -76.6%	1.8%	286.7 -78.8%	.2%	60.4 -78.9%	--	48.1 -20.4%	--
FIXED DISK DRIVES 300 - 500 Megabytes	7,092.2 +324.3%	21.5%	6,101.5 -14.0%	8.2%	2,404.4 -60.6%	1.8%	712.1 -70.4%	.3%	231.4 -67.5%	--
FIXED DISK DRIVES 500 Megabytes - 1 GB	6,223.0 +389.9%	18.9%	27,563.7 +342.9%	37.0%	26,496.7 -3.9%	19.6%	14,115.2 -46.7%	5.4%	4,015.7 -71.6%	.9%
FIXED DISK DRIVES 1 - 2 Gigabytes	5,390.9 +94.9%	16.4%	19,801.6 +267.3%	26.6%	43,577.4 +120.1%	32.2%	65,286.0 +49.8%	25.1%	47,236.0 -27.6%	10.2%
FIXED DISK DRIVES 2 - 3 Gigabytes	4,761.1 +201.1%	14.5%	9,060.5 +90.3%	12.2%	26,957.1 +197.5%	19.9%	71,213.0 +164.2%	27.4%	156,100.0 +119.2%	33.6%
FIXED DISK DRIVES more than 3 Gigabytes	2,406.5 +151.1%	7.3%	10,316.0 +328.7%	13.8%	35,439.7 +243.5%	26.1%	107,883.1 +204.4%	41.5%	256,120.0 +137.4%	55.1%
Total Capacity (Terabytes)	32,933.0 +121.7%	100.0%	74,461.2 +126.1%	100.0%	135,410.8 +81.9%	100.0%	259,668.0 +91.8%	100.0%	464,465.2 +78.9%	100.0%

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

Price per megabyte

Several factors have combined to force down average noncaptive prices per megabyte faster than previously expected. The biggest influence is the very high shipments which have resulted from exceptional growth in the personal computer market. Another major influence on the higher capacity product groups has been the rapid migration to higher capacities for personal computers, driven by new system software, expanded application programs, multimedia and storage of data downloaded from the Internet. As higher capacity drive groups are overwhelmed by the personal computer market, high performance disk drives at relatively high prices become minor contributors to the pricing averages.

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 dropped to $.68 in 1994, and is projected at $.03 in 1998.

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 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. The summary tables in this section display separately the worldwide price per megabyte of captive and noncaptive drives. 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)

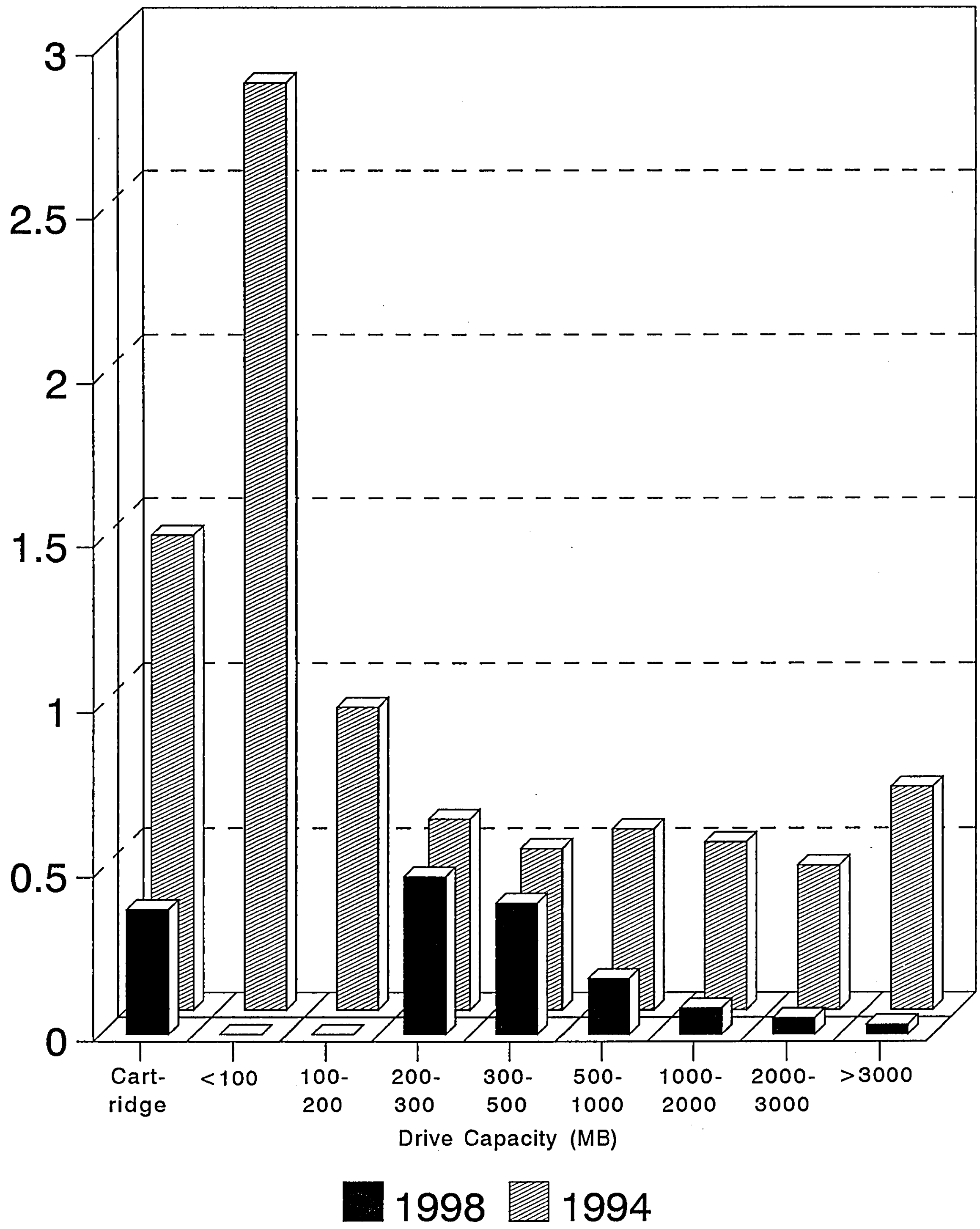


TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

	1994	Forecast 1995	1996	1997	1998
CARTRIDGE DISK DRIVES	1.44 -44.9%	1.28 -11.3%	1.08 -15.8%	.68 -36.9%	.38 -44.8%
FIXED DISK DRIVES less than 100 Megabytes	2.82 +39.5%	5.18 +83.3%	1.50 -71.0%	-- --	-- --
FIXED DISK DRIVES 100 - 200 Megabytes	.92 -20.3%	1.04 +13.5%	1.14 +9.1%	-- --	-- --
FIXED DISK DRIVES 200 - 300 Megabytes	.58 -37.9%	.52 -9.7%	.52 -1.0%	.61 +16.6%	.48 -20.4%
FIXED DISK DRIVES 300 - 500 Megabytes	.49 -40.4%	.38 -21.9%	.36 -5.7%	.39 +7.9%	.40 +1.5%
FIXED DISK DRIVES 500 Megabytes - 1 GB	.55 -43.9%	.28 -48.3%	.23 -19.4%	.18 -22.7%	.17 -1.0%
FIXED DISK DRIVES 1 - 2 Gigabytes	.51 -35.2%	.20 -61.7%	.15 -25.7%	.11 -24.8%	.08 -22.6%
FIXED DISK DRIVES 2 - 3 Gigabytes	.44 -37.4%	.27 -38.5%	.13 -52.1%	.08 -38.5%	.05 -33.1%
FIXED DISK DRIVES more than 3 Gigabytes	.68 -74.6%	.24 -63.9%	.11 -55.4%	.05 -50.4%	.03 -37.9%

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			
	1994	1995	1996	1997	1998
CARTRIDGE DISK DRIVES	--	--	--	--	--
	--	--	--	--	--
FIXED DISK DRIVES	4.27	--	--	--	--
less than 100 Megabytes	+11.3%	--	--	--	--
FIXED DISK DRIVES	2.46	4.16	3.77	--	--
100 - 200 Megabytes	-21.8%	+69.3%	-9.5%	--	--
FIXED DISK DRIVES	1.53	1.48	1.55	--	--
200 - 300 Megabytes	-31.9%	-3.6%	+4.6%	--	--
FIXED DISK DRIVES	1.60	1.40	1.02	.92	--
300 - 500 Megabytes	-43.0%	-12.7%	-26.8%	-10.4%	--
FIXED DISK DRIVES	1.49	.96	.68	.52	.43
500 Megabytes - 1 GB	-70.7%	-35.4%	-29.3%	-24.3%	-16.6%
FIXED DISK DRIVES	1.58	.89	.48	.32	.26
1 - 2 Gigabytes	-35.4%	-44.0%	-45.3%	-33.2%	-20.4%
FIXED DISK DRIVES	1.66	1.67	.40	.24	.16
2 - 3 Gigabytes	-40.0%	+.9%	-75.9%	-41.6%	-31.6%
FIXED DISK DRIVES	2.22	1.39	.50	.28	.16
more than 3 Gigabytes	-60.5%	-37.2%	-64.1%	-44.9%	-42.9%

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

The earliest DISK/TREND Report data on rigid disk drives covered the industry's sales results for 1976, before the advent of networks, engineering workstations or personal computers as major markets for disk drives. 20 years ago sales of captive drives provided 70% of the industry's disk drive revenues. By contrast, in today's industry noncaptive drives accounted for 67.1% of the overall industry's 1994 sales revenues, and the noncaptive share is forecasted to increase to 75.9% in 1998. Today's higher revenue share for noncaptive drives is rooted in the growing noncaptive share of higher capacity drives, at relatively higher prices, which are sold through noncaptive channels, plus the fact that the relative 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.

Most segments of the market for noncaptive disk drives are dominated by U.S. based 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. Most of the surviving U.S. start-up companies of the 1980's are now large firms, with multibillion dollar annual sales.

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, forced by acquisitions, vertical integration programs and technology advances.

TABLE 9

NONCAPTIVE WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1994 Revenues $M	1994 %	Forecast 1995 $M	1995 %	1996 $M	1996 %	1997 $M	1997 %	1998 $M	1998 %
CARTRIDGE DISK DRIVES	111.9 +29.5%	.7%	162.3 +45.0%	.9%	250.8 +54.5%	1.3%	270.5 +7.9%	1.4%	267.9 -1.0%	1.3%
FIXED DISK DRIVES less than 100 Megabytes	72.3 -91.6%	.5%	32.1 -55.6%	.2%	.6 -98.1%	--	-- --	--	-- --	--
FIXED DISK DRIVES 100 - 200 Megabytes	993.5 -64.2%	6.4%	122.1 -87.7%	.6%	16.1 -86.8%	.1%	-- --	--	-- --	--
FIXED DISK DRIVES 200 - 300 Megabytes	3,188.0 +14.8%	20.5%	629.9 -80.2%	3.4%	141.4 -77.6%	.7%	36.6 -74.1%	.1%	23.2 -36.6%	.1%
FIXED DISK DRIVES 300 - 500 Megabytes	3,163.9 +157.3%	20.3%	2,193.5 -30.7%	12.1%	793.0 -63.8%	4.1%	248.5 -68.7%	1.3%	91.7 -63.1%	.5%
FIXED DISK DRIVES 500 Megabytes - 1 GB	3,055.0 +159.9%	19.6%	7,233.4 +136.8%	39.2%	5,483.7 -24.2%	28.6%	2,106.0 -61.6%	10.6%	496.8 -76.4%	2.5%
FIXED DISK DRIVES 1 - 2 Gigabytes	2,204.6 +32.1%	14.1%	3,615.0 +64.0%	19.7%	5,814.3 +60.8%	30.2%	6,412.5 +10.3%	32.4%	3,547.2 -44.7%	17.7%
FIXED DISK DRIVES 2 - 3 Gigabytes	1,623.8 +128.2%	10.4%	2,055.5 +26.6%	11.1%	3,275.3 +59.3%	16.9%	5,239.1 +60.0%	26.4%	7,560.8 +44.3%	37.6%
FIXED DISK DRIVES more than 3 Gigabytes	1,184.2 +15.5%	7.5%	2,366.9 +99.9%	12.8%	3,499.4 +47.8%	18.1%	5,527.7 +58.0%	27.8%	8,129.4 +47.1%	40.3%
Total Worldwide Revenues	15,597.2 +26.7%	100.0%	18,410.7 +18.0%	100.0%	19,274.6 +4.7%	100.0%	19,840.9 +2.9%	100.0%	20,117.0 +1.4%	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	1994 Shipments		Forecast 1995		Forecast 1996		Forecast 1997		Forecast 1998	
	Units	%	Units	%	Units	%	Units	%	Units	%
CARTRIDGE DISK DRIVES	468.4	.7%	742.0	.9%	1,300.0	1.4%	1,680.0	1.6%	1,985.0	1.7%
	+25.0%		+58.4%		+75.2%		+29.2%		+18.2%	
FIXED DISK DRIVES less than 100 Megabytes	413.3	.7%	177.3	.2%	5.0	--	--	--	--	--
	-93.6%		-57.1%		-97.2%		--		--	
FIXED DISK DRIVES 100 - 200 Megabytes	7,329.2	11.6%	782.2	1.0%	105.0	.1%	--	--	--	--
	-57.4%		-89.3%		-86.6%		--		--	
FIXED DISK DRIVES 200 - 300 Megabytes	22,280.4	35.0%	4,721.2	5.8%	1,120.0	1.2%	235.0	.2%	185.0	.1%
	+76.1%		-78.8%		-76.3%		-79.0%		-21.3%	
FIXED DISK DRIVES 300 - 500 Megabytes	17,401.7	27.3%	14,895.4	18.6%	5,575.5	5.9%	1,670.0	1.6%	580.0	.5%
	+330.2%		-14.4%		-62.6%		-70.0%		-65.3%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	9,876.1	15.5%	39,259.7	48.5%	36,267.5	38.3%	15,485.0	14.6%	3,315.0	2.8%
	+370.4%		+297.5%		-7.6%		-57.3%		-78.6%	
FIXED DISK DRIVES 1 - 2 Gigabytes	3,832.5	6.1%	14,801.2	18.3%	33,247.0	35.1%	44,290.0	41.6%	25,895.0	21.7%
	+114.7%		+286.2%		+124.6%		+33.2%		-41.5%	
FIXED DISK DRIVES 2 - 3 Gigabytes	1,742.6	2.7%	3,543.0	4.4%	11,011.0	11.7%	26,500.0	24.9%	53,005.0	44.3%
	+298.1%		+103.3%		+210.8%		+140.7%		+100.0%	
FIXED DISK DRIVES more than 3 Gigabytes	319.3	.4%	1,961.4	2.3%	6,101.0	6.3%	16,600.0	15.5%	34,785.0	28.9%
	+293.2%		+514.3%		+211.1%		+172.1%		+109.5%	
Total Worldwide Shipments	63,663.5	100.0%	80,883.4	100.0%	94,732.0	100.0%	106,460.0	100.0%	119,750.0	100.0%
	+40.9%		+27.0%		+17.1%		+12.4%		+12.5%	
% U.S. Manufacturers	91.5%		90.8%		88.2%		86.4%		84.8%	
Total Capacity (Terabytes)	28,456.5	100.0%	68,454.5	100.0%	124,029.9	100.0%	239,623.3	100.0%	429,777.2	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

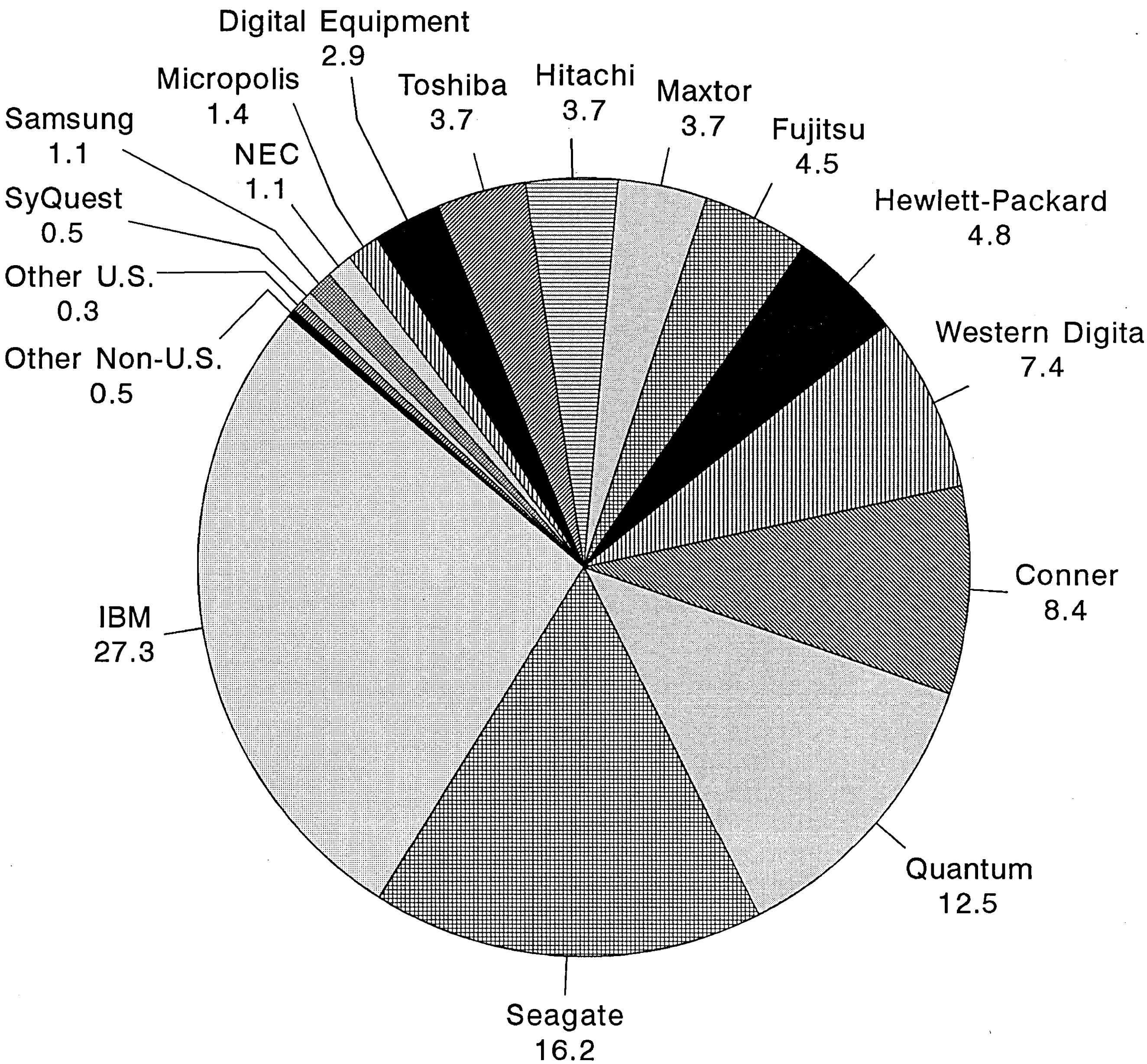
CAPACITY SHIPPED IN TERABYTES	1994 Capacity Units	1994 %	Forecast 1995 Units	1995 %	1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %
CARTRIDGE DISK DRIVES	77.6	.3%	126.9	.2%	232.9	.2%	398.1	.2%	714.0	.2%
	+135.2%		+63.5%		+83.6%		+70.9%		+79.4%	
FIXED DISK DRIVES less than 100 Megabytes	25.6	.1%	6.2	--	.4	--	--	--	--	--
	-94.0%		-75.8%		-93.5%		--		--	
FIXED DISK DRIVES 100 - 200 Megabytes	1,081.3	3.8%	117.1	.2%	14.1	--	--	--	--	--
	-55.1%		-89.2%		-87.9%		--		--	
FIXED DISK DRIVES 200 - 300 Megabytes	5,490.2	19.4%	1,200.8	1.7%	272.1	.2%	60.4	--	48.1	--
	+84.9%		-78.1%		-77.3%		-77.8%		-20.4%	
FIXED DISK DRIVES 300 - 500 Megabytes	6,438.6	22.6%	5,714.1	8.4%	2,191.4	1.8%	636.4	.3%	231.4	--
	+331.6%		-11.3%		-61.6%		-71.0%		-63.6%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	5,588.7	19.6%	25,571.1	37.4%	24,062.9	19.5%	11,952.4	4.9%	2,847.2	.7%
	+363.3%		+357.6%		-5.9%		-50.3%		-76.2%	
FIXED DISK DRIVES 1 - 2 Gigabytes	4,307.8	15.2%	18,421.2	26.9%	39,851.8	32.1%	58,442.0	24.5%	41,788.0	9.7%
	+104.0%		+327.6%		+116.3%		+46.6%		-28.5%	
FIXED DISK DRIVES 2 - 3 Gigabytes	3,699.5	13.0%	7,610.2	11.1%	25,292.6	20.4%	65,784.0	27.5%	141,939.5	33.1%
	+264.8%		+105.7%		+232.4%		+160.1%		+115.8%	
FIXED DISK DRIVES more than 3 Gigabytes	1,747.2	6.0%	9,686.9	14.1%	32,111.4	25.8%	102,350.0	42.6%	242,209.0	56.3%
	+354.2%		+454.4%		+231.5%		+218.7%		+136.6%	
Total Capacity (Terabytes)	28,456.5	100.0%	68,454.5	100.0%	124,029.9	100.0%	239,623.3	100.0%	429,777.2	100.0%
	+136.3%		+140.6%		+81.2%		+93.2%		+79.4%	
% U.S. Manufacturers	92.2%		91.3%		89.1%		88.0%		86.3%	

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

Figure 6

1994 ESTIMATED MARKET SHARE

Worldwide Percentage Revenues



1994 Revenues: $23,231,400,000

TABLE 12

1994 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1994 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Conner Peripherals	--	--	414.6	8.6	1,547.6	14.3	1,962.2	8.4
Digital Equipment	420.5	5.5	115.1	2.4	142.4	1.3	678.0	2.9
Hewlett-Packard	642.1	8.4	55.6	1.2	405.8	3.8	1,103.5	4.8
IBM	5,177.0	67.8	103.1	2.1	1,052.2	9.7	6,332.3	27.3
Maxtor	--	--	457.9	9.5	403.4	3.7	861.3	3.7
Micropolis	--	--	183.6	3.8	146.4	1.4	330.0	1.4
Quantum	--	--	606.9	12.7	2,293.7	21.2	2,900.6	12.5
Seagate Technology	--	--	1,299.2	27.1	2,471.2	22.9	3,770.4	16.2
SyQuest Technology	--	--	109.7	2.3	1.3	--	111.0	.5
Western Digital	--	--	523.8	10.9	1,194.1	11.1	1,717.9	7.4
Other U.S.	--	--	9.7	.2	52.6	.5	62.4	.3
U.S. Total	6,239.7	81.7	3,879.2	80.9	9,710.7	89.9	19,829.6	85.4
NON-U.S. MANUFACTURERS								
Fujitsu	515.3	6.7	168.0	3.5	355.4	3.3	1,038.7	4.5
Hitachi	239.8	3.1	549.0	11.4	75.2	.7	864.0	3.7
NEC	217.9	2.9	--	--	48.9	.5	266.8	1.1
Samsung Electronics	46.0	.6	150.0	3.1	57.7	.5	253.7	1.1
Toshiba	375.2	4.9	46.8	1.0	443.4	4.1	865.4	3.7
Other Non-U.S.	.3	--	2.8	.1	110.1	1.0	113.2	.5
Non-U.S. Total	1,394.5	18.3	916.6	19.1	1,090.7	10.1	3,401.8	14.6
WORLDWIDE TOTAL	7,634.2	100.0	4,795.8	100.0	10,801.4	100.0	23,231.4	100.0

Note: 1. Mainframe 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

DISK/TREND PRODUCT GROUP		1	2	3	4	5	6	7	8	9
U.S. Manufacturers (16)	Type	Disk Cartridge Drives	Fixed Disk Drives <100 MB	Fixed Disk Drives 100-200 MB	Fixed Disk Drives 200-300 MB	Fixed Disk Drives 300-500 MB	Fixed Disk Drives 500 MB-1 GB	Fixed Disk Drives 1 GB-2 GB	Fixed Disk Drives 2 GB-3 GB	Fixed Disk Drives >3 GB
Avatar Systems	O	2								
Conner Peripherals	P,O					3	3	3	3	3
Gigastorage International	P,O							5		
Hewlett-Packard	C,P,O							3	3	3
IBM	C,P,O				2	2	2,3	2,3	3	3,10
Integral Peripherals	P,O			1.8	1.8	1.8		2		
Iomega	P,O	3								
JTS	P,O						3			
Maxtor	P,O				3	3	2,3	2,3		
Micropolis	P,O							3	3	3,5
Quantum	P,O			2	2,3	2,3	2,3	2,3	3	3
Raymond Engineering	O		3			3				
Seagate Technology	P,O			2	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					3	3	3		
Asian Manufacturers (5)										
Fujitsu	C,P,O		3	2,3	2,3	2,3,5	2,3,5,8,10	2,3,5,8	3,5,8	3
Hitachi	C,P,O			5	2,3	2,3	2,3,5,8	2,3,5,8	3,5,8	3,8
NEC	C,O			3	3	2,3	3	3	3	
Samsung Electronics	C,P,O						3	3		
Toshiba	C,P,O			2	2	2	2	2		
European Manufacturers (3)										
Calluna Technology	O		1.8	1.8	1.8					
Nomai	P,O	3								
Sagem	O				5					

TECHNICAL REVIEW

Competing technologies

During the 1990's, it will be almost impossible for any competing storage technology to seriously challenge the rigid magnetic disk drive, except in a few niche applications, as a result of the continuing rapid improvements in disk drive capacity, performance and cost. 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 (at the now "standard" 60% average annual rate), provide thinner disk substrates, greater functionality chips, smaller heads, lower flying heights, smaller motors and many other improvements in disk drive and recording technology. With disk drive development on a fast track, 10 gigabit per square inch areal density by the end of the decade appears likely.

A few alternatives to magnetic disk recording have found a degree of acceptance in specialized markets and applications, but 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 has offered 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. Most issues regarding software support of the PCMCIA interface have been worked out, but the use of the PCMCIA interface does not yet fully guarantee functional interchange among older devices that are electrically and physically PCMCIA compliant. In many industrial applications, flash memory cards are used in configurations that are not PCMCIA compliant or only partially compliant, as such applications rarely require the full PCMCIA feature set and design simplification can significantly reduce costs. Some of these memories are packaged to fit within the physical envelope of the now discontinued 1.3" Hewlett-Packard Kittyhawk disk drive.

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.

* <u>Volatile semiconductor memories</u>: 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 (shipments seem to be peaking in 1995) and production of 16 megabit configurations is substantial and growing. Large quantity production of 64 megabit DRAM chips is not expected until the 1997-1998 period, as fabrication facilities are just entering the construction phase.

  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.

* <u>Nonvolatile semiconductor memories</u>: 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, 3.3 volts, or both.

Flash memories using 1, 4, 8, and 16 megabit chips are currently in production, manufactured by Intel, AMD, SanDisk, Samsung, Atmel, Seeq Technology, Toshiba and other firms. Most flash memory cards have capacities under 10 megabytes. SanDisk offers a range of flash disk cards, some with capacities in excess of 100 megabytes, that mimic the 512 byte sector organization of a magnetic disk drive and include an IDE interface, appearing as a disk drive to the host system. These cards use 8 and 16 megabit chips.

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 to $40 per megabyte range in 1994. Realistic 1995 flash memory OEM prices are in the range of 15 to 30 dollars per megabyte, still much higher than 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, Maxtor and Quantum, formed alliances with flash memory producers to bring flash memory modules organized as low capacity disk drives to market. These alliances proved ineffective, and most have been allowed to lapse.

Ferroelectric memories (FRAM) 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 are 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, and more recently added Rohm, IBM and Toshiba as licensees.

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 is currently in production on 4 and 16 kilobit chips, and with its licensees hopes to produce 64 kilobit chips in the near future. The chips are currently being sold for a variety of applications, including electronic games, where they can provide a "save game" function. Rohm expects to produce 4 kilobit, 16 kilobit, and 64 kilobit chips in 1996, some of which will be resold by Ramtron. Hitachi expects to supply 256 kilobit chips in 1996, 4 megabit chips in 1998, and 16 megabit chips in 1999.

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 industrial 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 technology is lagging that of flash memory, and it isn't clear that both can succeed.

* <u>Holographic storage</u>: 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 after the turn of the century.

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 supporters 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 planned product were not quite so impressive: It was to 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. In early 1995, Tamarack announced ARPA funding for development of a 128 gigabyte system based upon its technology.

IBM, NTT and other organizations have revealed research efforts using holographic storage techniques in conjunction with a variety of media, including organic as well as inorganic materials. However, these materials must be used at very low temperatures. NTT has succeeded in storing short video files in holographic systems. Stanford University also has a research effort aimed at storing video images holographically.

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.

* <u>Optical disk drives</u>: 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 900 megabits per square inch areal density have all but closed the gap. However, techniques such as land and groove recording may allow optical recording technology to keep its areal density edge for a little longer.

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, the red lasers now appearing in newer optical drives are expected to provide a 40 percent improvement in areal density over 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, high capacity 3.5" magnetic cartridge drives compete strongly with 3.5" optical drives, offering better performance, lower price and higher capacity. Future magnetic disk cartridge products with capacity in the gigabyte range will disadvantage optical drives even further. 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. 12 centimeter (4.72") drives are highly standardized due to the success of the CD-ROM format.

Large automated libraries provide random access to many disks, making 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 storage management software and operating system support make optical storage practical in the larger system environments typical of networks.

* 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 12 centimeter 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 centimeter write-once drives from Philips, Sony and JVC entered the market in 1992. 12 centimeter 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.

  The market for "pure" write-once optical disk drive systems is limited to the niches which emphasize nonreversibility. In some applications, the ability of write-once optical disk 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. Apple's use of a Fujitsu 17 millimeter high 3.5" MO drive may indicate greater future acceptance of optical drives by OEMs and integrators.

  Magneto-optical (MO) recording has been evolving 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 some models of magneto-optic drives without overwrite latencies should 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 20 milliseconds, 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 several drives with over 1.3 gigabyte per side are anticipated in 1995. MOST has already introduced such a drive, while Pinnacle Micro has announced a 2.3 gigabyte per side drive. 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.

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 640 megabyte per side range is anticipated in the late 1995 time frame, as 3.5" drives with over 600 megabytes per side are being actively considered by a number of firms. 3.5" drives are expected to move above the 1 gigabyte per side mark towards the end of the decade, and Fujitsu has demonstrated an experimental 4 gigabyte 3.5" drive.

Sony has announced a 140 megabyte 2.5" drive. Production began in late 1994, but the drive has not received wide acceptance due to its relatively high price, power consumption and excessively large package.

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. NEC has also announced phase change drives, and other firms now appear positioned to introduce phase change optical drives in the next year. Companies producing CD format drives have indicated that they expect to ship rewritable drives using phase change media beginning in late 1996. If produced at a low enough price, such drives could achieve significant market penetration as auxiliary storage, but are unlikely to displace rigid disk drives because of limitations in performance and reliability.

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 technical problems, that include 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. NEC, Sony, Mitsumi, Matsushita and others introduced CD-ROM drives operating at doubled (2X) or quadrupled (4X) data transfer rates (obtained by increasing RPM), improving average access time as well as data transfer rate. 6X drives are now being introduced by several firms. The next generation of CD-ROM drives, often described generically as DVD (digital video disk) drives, will extend capacity to the multigigabyte range in 1996. A potential conflict between proponents of differing media standards was resolved in the fall of 1995. Write-once and rewritable versions of DVD drives are also anticipated, but they will probably appear in the marketplace some months after the read-only versions are introduced, as additional standards issues must be resolved.

  It is technically feasible to develop read-only media for read/write drives, but aside from CD-R drives which can read CD-ROM disks, there has been little industry interest in this capability.

  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.

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

* High capacity flexible disk drives: 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. It is within the capabilities of today's technology to produce 3.5" floppy disk drives offering over 100 megabytes of storage capacity, and the 100 megabyte Iomega Zip drive is already in volume production.

The 3.5" "Floptical" drives with capacity in the 20 megabyte range produced by Insite Peripherals (now a subsidiary of Ocean Radio) and for a while by Iomega achieved a degree of acceptance, especially in the aftermarket. By early 1996, the older floptical 20 megabyte drive is expected to be replaced by a 120 megabyte version to be manufactured by Matsushita-Kotobuki Electronics and used by Compaq Computer in selected personal computer applications. Like the 20 megabyte version, these drives are expected to be backward compatible with 1.44 megabyte floppy drives.

Unfortunately, none of the 3.5" high capacity flexible disk drive formats are compatible with each other, although some provide read and write downward compatibility with one and two megabyte 3.5" floppy disks. Aggressively priced, high capacity floppy drives are expected to compete in the low end of magnetic and optical disk drive markets, and against tape drives for backup applications. High capacity 3.5" flexible disk drives are expected to have a successful role in the marketplace, competing with various low-end rigid disk cartridge drive and optical disk drive formats, each of which will be attractive for specific applications.

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 1980's, 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 has maintained its leadership position, recently introducing the "Scorpion" family of 3.5" disk drives with areal densities of up to 828 megabits per square inch and the 2.5" "Sonata" drives at 923 megabits per square inch -- and still more to come. Other manufacturers are following IBM's lead and moving to higher areal densities based on magnetoresistive heads and improved data channels. IBM introduced the first disk drives using magnetoresistive heads in 1991. 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.

Several approaches to contact recording are being developed. Censtor has developed 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 "water-skiing" 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, but it is uncertain when either technology will be used in production disk drives.

* Recording heads: Monolithic ferrite heads patterned after IBM's 3350 designs were dominant in early Winchester disk drive designs. In following years, PCM disk 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. After several years of dominance, the 70% form factor microslider (70% of the volume of a minislider) has been replaced in most drives by the 50% form factor nanoslider, which is now in wide use in 3.5", 2.5", and 1.8" disk drives. The 30% form factor picoslider is now being used by Toshiba in a limited number of 2.5" drives, but 50% sliders are expected to be used with the majority of drives for several years in the future. As the form factor decreases in size, the difficulties in connecting MR heads, which have more leads, will begin to mount.

  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.

  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 sometimes 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. The choice of head type depends upon the flying height, desired areal density, the characteristics of the media, and cost.

  The ability of inductive thin film heads to operate at areal densities well above those achievable by ferrite head technologies guarantees them a role in the majority of current drive 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. While internally generated noise, vulnerability to electrostatic discharge and low yield remain challenges to be overcome before MR heads are widely available from multiple vendors, MR heads are needed to achieve the areal densities targeted for later in this decade.

IBM introduced the first disk drives using MR heads, using them in 3.5" drives and in 2.5" disk drives in 1993, as well as in the 3390-9. A few drive manufacturers introduced drives with MR heads in 1994, and others have followed in 1995. Seagate, Fujitsu, Quantum, Hewlett-Packard and Hitachi are among the companies that have 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. IBM has demonstrated recording at 3 gigabits per square inch in the laboratory. Giant magnetoresistance is still in the laboratory stage at IBM and other firms. Utilization in a production disk drive is probably at least two 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, except for IBM, 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 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 surfaces tend to be inherently smooth and texturing can be added in the process of making the basic substrate.

The oxide coated media of early disk drives has mostly 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 for disk magnetic surfaces. 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 2,000 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 2,000 oersteds is expected to increasingly appear in new drive designs.

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 are 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.

Some high capacity 2.5" disk drives, such as those of IBM and Toshiba, use glass or glass/ceramic as a substrate material, and some 1.8" drives have also used 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 industry 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 assumed the lead position since IBM introduced them in the "Lightning" 3.5" drive in 1989. 2.5" drive substrates, now predominantly at 25 and 35 mils, will also migrate to thinner disks, probably 15 mils, but that is likely to take several years. The 1.3" H-P Kittyhawk drive used 15 mil thick substrates.

* 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 has increased to over 900 megabits per square inch in late 1995, and 10 gigabits per square inch is expected 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.

  TPI in excess of 4,000 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, while the "Sonata" operates at 7,257 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 1989 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 new 2.5" Sonata operates at 127,200 BPI. 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 Scorpion operates with BPI up to 134,500, not too distant from the IBM demonstration BPI.

Another factor increasing disk capacity is the ability of more intelligent drives to dispense with much of the sector formatting information, reducing overhead and increasing the available area for user data.

* 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 semiconductors 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 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, has developed a standardized nomenclature for disk drive arrays.

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 could 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. Important factors in initiating these improvements will be the increase in disk rotation rate, (which both decreases latency and increases data transfer rate) and increases in linear bit density (which also increases data transfer rate at a given RPM), 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 considering using motors operating in the 9,600 to 10,000 RPM range. The heat, power consumption and bearing wear problems generated by higher spin rates present a significant challenge to both disk drive and system designers.

The availability of high speed data channels that connect the heads to the drive controller may be a factor that paces the rate of performance advances. While the electronics used to write data is fairly straightforward, readback circuitry can be quite complex and is usually the limiting factor in establishing the bandwidth of the data channel. While the majority of drive read channels currently use peak detection and have bandwidths under 100 megabits per second, advanced drives employ PRML (Probable Response, Maximum Likelihood) channels and are moving past 100 megabits per second in read channel bandwidth. The fastest read channel generally available is offered by Silicon Systems, which specifies operation at up to 200 megabits per second. While PRML channels are fast, they also require significant power, making them less desirable in small drives destined for use in notebook computers.

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 was achieved by Seagate's Sabre PTD, an 8" 2.4 gigabyte 9 head parallel transfer drive introduced in 1990, but now out of production.

Average seek times have now dipped down to the 6-7 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. Drives employing embedded servo tracking schemes may have an inherent advantage in providing an uninterrupted data flow.

* 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. Maxtor announced 1.8" drives in the 5 millimeter high PCMCIA Type II card format in 1995, but the product was discontinued when Maxtor withdrew from the 1.8" drive market.

  Despite the move to smaller form factors, 5.25" drives are not dead yet. Two companies are expected to bring out single platter 5.25" drives with capacities of a gigabyte or above, taking advantage of minimal parts count and the larger surface area of the disk to obtain a lower cost per megabyte. Such drives have the potential to be shipped in large numbers over the next several years.

  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 drive designs requiring only 5 chips (or less) on the circuit board are expected to be common in the future.

* 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 func-

tions 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 may 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: All of the current 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 IDE to substitute for SCSI if only a few peripheral devices are needed in a system. Enhanced IDE 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. IDE interfaces far outnumber SCSI interfaces in the IBM compatible personal computer market. 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, SanDisk 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 Arbitrated Loop (FC-AL) 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 and less expensive connectors and cables, and data transfer rates exceeding IDE 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 is supported by IBM, Conner, Micropolis, Dell, Adaptec and many others and seems destined for a major role in large and midrange systems, provided that the market perceives SSA as truly "open" and not an IBM marketing ploy. Fibre channel has been championed by Seagate, Quantum, Hewlett-Packard and many supporters of open systems (but still has some cost, power and standards issues to be resolved), while Apple and video equipment producers have been the most visible supporters of P1394. SSA has already appeared in drives and controllers, and FC-AL drives have been announced 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 (usually implemented with microcode) permit 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, exclusive-OR computations, 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. Digital servo chips may 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 1,7 RLL are the most often used currently, but the Probable Response Maximum Likelihood (PRML) code introduced by IBM 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.

  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.

* Storage management software: As rigid disk drives move to higher capacity levels and are attached in large numbers to individual systems and network file servers, the ability of system managers to control and monitor the flow, availability, and residence time of data in data storage subsystems is becoming increasingly important. While such software is not an integral part of the drive, its presence, availability and usability are becoming important influences in determining market acceptance rates for high capacity, high performance 3.5" drives in networked systems.

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 IBM, Hewlett-Packard or Hitachi with computer systems to 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 disk 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 Toshiba are noncaptive, except for drives sold with systems made by the parent company or other subsidiaries.

* Shipments made by Conner Peripherals 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 Quantum 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 Maxtor 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. disk 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 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 1995 constant dollars.

Forecasts: Expected shipments and revenues for current or announced disk drives in new production. Evolutionary improvements within existing disk drive formats are included, but completely new configurations or technologies are not included.

Examples:

* Product 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: Dell Dimension, 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.

DISK CARTRIDGE DRIVES

1995 DISK/TREND REPORT

DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

SyQuest Technology	SQ5110, SQ5200C

3.5" disk diameter

Iomega	Jaz
Nomai	MCD-I, MCD-M
SyQuest Technology	EZ135A/S, SQ3270A/S

2.5" disk diameter

Avatar Systems	AR-2170NI

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 section, which includes data also published in the 1995 DISK/TREND Report on removable data storage. 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, with capacities now up to 270 megabytes, and the 3.5" drives are now challenging the 5.25" form factor for shipment leadership.

In response to the Iomega initial market success with the Zip 100 megabyte high capacity 3.5" floppy drive, SyQuest announced in 1995 the "EZ" single head 3.5" rigid disk cartridge drive designed for very low cost. Iomega has announced the Jaz 3.5" rigid disk cartridge drive, promised for delivery by the end of 1995, and which will offer 1 gigabyte capacity using a two disk cartridge. SyQuest has indicated that it will announce a 3.5" drive with a capacity of 1.3 megabytes using a two disk cartridge, for delivery in 1996.

Avatar Systems' 2.5" disk cartridge drives, including models combining removable disk drives with floppy drives, have been available in limited production quantities since 1993. 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 PC Card format, which uses 1.8" disks in a cartridge which may be removed from the removable drive.

Market status

Disk cartridge drives enjoyed strong shipments in 1994, and the outlook for 1995 is even better. New SyQuest drives with increased capacity in both 5.25" and 3.5" models made the difference in 1994 shipments. Total 1994 shipments for the product group were 468,400 drives, up 25.0%, and the DISK/TREND estimate for 1995 is 742,000 drives, up another 58.4%, bolstered by high volume sales of SyQuest's new low cost "EZ" 3.5" drive. 1994 total sales revenues of $111.9 million for the product group are forecasted to jump to 162.3 million in 1995, up 45.0%.

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.

Overall 5.25" drive shipments declined 4.9% in 1994, but the higher capacity models are stimulating an increase in overall 5.25" drive shipments in 1995, with the total now estimated at 310,000 drives, up 11.8%. 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.

For years the most aggressive competition for SyQuest's rigid disk cartridge drives was provided by optical disk drives and by the Iomega 5.25" high capacity Bernoulli floppy disk drive. Iomega's Bernoulli drives also increased in capacity over the years, now up to 230 megabytes, with the result that SyQuest and Iomega have been 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, with a much stronger market response. In terms of unit shipments, the new SyQuest EZ 3.5" drive is expected to generate even stronger sales. The EZ is SyQuest's response to the excellent market reaction to the Iomega Zip 100 megabyte floppy drive. The initial EZ drive offers 135 megabytes using only one recording head, and carries an announced end user price identical to that of the Iomega Zip. Total 3.5" rigid disk cartridge drive shipments for 1995 are forecasted to reach 410,000 units, up 115.8% over the previous year.

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 a 2.5" rigid disk cartridge drive, with capacity now up to 170 megabytes, intended for a variety of personal computer and specialized system applications. In the meantime, SyQuest's 1.8" drive in the PCMCIA Type III form factor 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. 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 99.7% of the worldwide unit shipments of rigid disk cartridge drives in 1994, with 467,000 drives, the majority of which were 5.25" models. In 1994 all disk cartridge drives were shipped in noncaptive market channels.

Marketing trends

The new surge in demand for low cost 3.5" cartridge disk drives in the 100+ megabyte range, both rigid disk and floppy disk types, combined with the outlook for a new generation of high capacity 3.5" rigid disk cartridge drives in the 1+ gigabyte range, is expected to stimulate an increase in shipment levels to higher levels than experienced in the past for this product group. 1998 unit shipments are projected at almost 2 million drives, an average annual increase of 40.9% for the 1996-98 period. During the same period, sales revenues are forecasted to reach $267.9 million, but the 1998 total will actually suffer a slight decline due to falling prices and a continuing shift in product mix to lower priced 3.5" drives, as sales of 5.25" models drop off after 1996. By 1998, 5.25" drives are expected to account for only 8.1% of unit shipments, as 3.5" drives climb to 67.9%. In 1998, shipments of drives using 2.5" or smaller disks are projected at 24.0% of the worldwide total.

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. The new battle between SyQuest's EZ rigid disk cartridge drive and Iomega's Zip high capacity floppy drive for direct aftermarket attachment to personal computers will favor sales through classic distribution sales channels. However, the majority of 2.5" and smaller drives will probably be sold to system manufacturers, the first time in many years that disk cartridge drives have had a major opportunity to achieve significant OEM sales, and some of the planned new high capacity rigid disk cartridge drives may have a similar opportunity to develop specialized OEM markets.

Technical trends

It is possible to increase density in removable disk drives. Major improvements will be significantly helped by the availability of heads, disks, semiconductors and other components developed to achieve the 60% per year increase in areal density now considered normal for the high volume manufacturers of fixed rigid 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, and will be able to exploit the rapid advances in recording technology from other segments of the disk drive industry. The 3.5" and 2.5" disk cartridge drives now available, 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 1996, 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)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	68.6	109.7	97.3	154.6	138.1	215.8	145.0	224.5	144.0	218.5
OEM/Integrator	1.8	2.2	5.7	7.7	27.8	35.0	35.8	46.0	37.5	49.4
TOTAL U.S. REVENUES	70.4	111.9	103.0	162.3	165.9	250.8	180.8	270.5	181.5	267.9
Non-U.S. Manufacturers										
TOTAL NON-U.S. REVENUES	--	--	--	--	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	70.4	111.9	103.0	162.3	165.9	250.8	180.8	270.5	181.5	267.9
OEM Average Price ($000)		.343		.220		.179		.146		.117

TABLE 15

CARTRIDGE DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994 Shipments		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Reseller	288.0	462.0	446.0	707.0	710.0	1,105.0	885.0	1,365.0	1,035.0	1,565.0
OEM/Integrator	5.2	6.4	26.0	35.0	155.0	195.0	245.0	315.0	320.0	420.0
TOTAL U.S. SHIPMENTS	293.2	468.4	472.0	742.0	865.0	1,300.0	1,130.0	1,680.0	1,355.0	1,985.0
Non-U.S. Manufacturers										
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	293.2	468.4	472.0	742.0	865.0	1,300.0	1,130.0	1,680.0	1,355.0	1,985.0
Total Capacity (Terabytes)	49.4	77.6	80.9	126.9	153.4	232.9	263.9	398.1	479.5	714.0
Cumulative Shipments (Units in thousands)										
WORLDWIDE TOTAL	2,197.8	3,530.2	2,669.8	4,272.2	3,534.8	5,572.2	4,664.8	7,252.2	6,019.8	9,237.2

TABLE 16

CARTRIDGE DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues			Forecast 1995			1996			1997			1998		
	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"
U.S. MANUFACTURERS															
PCM/Reseller	60.9	48.8	--	76.0	78.2	.4	74.8	130.5	10.5	54.2	155.6	14.7	24.1	175.0	19.4
OEM/Integrator	.5	1.4	.3	--	3.0	4.7	--	6.2	28.8	--	9.8	36.2	--	12.0	37.4
TOTAL U.S. REVENUES	61.4	50.2	.3	76.0	81.2	5.1	74.8	136.7	39.3	54.2	165.4	50.9	24.1	187.0	56.8
NON-U.S. MANUFACTURERS															
TOTAL NON-U.S. REVENUES	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WORLDWIDE RECAP															
PCM/Reseller	60.9	48.8	--	76.0	78.2	.4	74.8	130.5	10.5	54.2	155.6	14.7	24.1	175.0	19.4
	-.8%	+158.2%	--	+24.8%	+60.2%	--	-1.6%	+66.9%	--	-27.5%	+19.2%	+40.0%	-55.5%	+12.5%	+32.0%
OEM/Integrator	.5	1.4	.3	--	3.0	4.7	--	6.2	28.8	--	9.8	36.2	--	12.0	37.4
	-81.5%	-33.3%	--	--	+114.3%	--	--	+106.7%	+512.8%	--	+58.1%	+25.7%	--	+22.4%	+3.3%
Total Revenues	61.4	50.2	.3	76.0	81.2	5.1	74.8	136.7	39.3	54.2	165.4	50.9	24.1	187.0	56.8
	-4.2%	+139.0%	-76.9%	+23.8%	+61.8%	--	-1.6%	+68.3%	+670.6%	-27.5%	+21.0%	+29.5%	-55.5%	+13.1%	+11.6%
ANNUAL SHARE, BY DIAMETER	55.0%	44.9%	.1%	46.9%	50.0%	3.1%	29.8%	54.6%	15.6%	20.0%	61.2%	18.8%	9.0%	69.9%	21.1%

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

TABLE 17

CARTRIDGE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments			Forecast 1995			Forecast 1996			Forecast 1997			Forecast 1998		
	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"	5.25"	3.5"	<=2.5"
U.S. MANUFACTURERS															
PCM/Reseller	277.0	185.0	--	310.0	395.0	2.0	325.0	725.0	55.0	285.0	985.0	95.0	160.0	1,250.0	155.0
OEM/Integrator	.4	5.0	1.0	--	15.0	20.0	--	35.0	160.0	--	65.0	250.0	--	95.0	325.0
TOTAL U.S. SHIPMENTS	277.4	190.0	1.0	310.0	410.0	22.0	325.0	760.0	215.0	285.0	1,050.0	345.0	160.0	1,345.0	480.0
NON-U.S. MANUFACTURERS															
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
WORLDWIDE RECAP															
PCM/Reseller	277.0	185.0	--	310.0	395.0	2.0	325.0	725.0	55.0	285.0	985.0	95.0	160.0	1,250.0	155.0
	-3.8%	+164.3%	--	+11.9%	+113.5%	--	+4.8%	+83.5%	--	-12.3%	+35.9%	+72.7%	-43.9%	+26.9%	+63.2%
OEM/Integrator	.4	5.0	1.0	--	15.0	20.0	--	35.0	160.0	--	65.0	250.0	--	95.0	325.0
	-89.5%	-37.5%	--	--	+200.0%	--	--	+133.3%	+700.0%	--	+85.7%	+56.3%	--	+46.2%	+30.0%
Total Shipments	277.4	190.0	1.0	310.0	410.0	22.0	325.0	760.0	215.0	285.0	1,050.0	345.0	160.0	1,345.0	480.0
	-4.9%	+143.6%	-80.0%	+11.8%	+115.8%	--	+4.8%	+85.4%	+877.3%	-12.3%	+38.2%	+60.5%	-43.9%	+28.1%	+39.1%
ANNUAL SHARE, BY DIAMETER	59.3%	40.6%	--	41.9%	55.3%	2.8%	25.0%	58.6%	16.4%	17.0%	62.6%	20.4%	8.1%	67.9%	24.0%
TOTAL CAPACITY (Terabytes)	29.9	47.6	.1	49.6	73.8	3.5	65.0	136.8	31.2	77.0	262.5	58.6	56.0	538.0	120.0

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

TABLE 18

CARTRIDGE DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 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	447.3	95.5	1,945.3	98.0
WORKSTATIONS Engineering and office, single user	21.1	4.5	39.7	2.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	468.4	100.0	1,985.0	100.0

TABLE 19

CARTRIDGE DISK DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	1995 (Forecast)	1996 (Forecast)	1997 (Forecast)	1998 (Forecast)
PCM/Reseller					
5.25"	2.03	1.53	1.15	.70	.42
3.5"	1.05	1.10	1.00	.63	.35
2.5" or less	--	2.20	1.31	.91	.50
PCM/Reseller Average	1.44	1.27	1.06	.66	.36
OEM/Integrator					
5.25"	--	--	--	--	--
3.5"	1.01	1.10	.97	.60	.31
2.5" or less	2.75	1.39	1.24	.85	.46
OEM/Integrator Average	1.51	1.26	1.18	.78	.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 20

CARTRIDGE DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 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	167.0	125.0	--	292.0	99.6	277.0	190.0	--	467.0	99.7
Other U.S.	.4	--	.8	1.2	.4	.4	--	1.0	1.4	.3
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	167.4	125.0	.8	293.2	100.0	277.4	190.0	1.0	468.4	100.0

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

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Sequel	XT-1085

3.5" disk diameter

Fujitsu	M2612ES*
Raymond Engineering	8440

1.8" disk diameter

Calluna Technology	CT-80MC**

*Maximum 41.3 mm height, or less.
**PCMCIA Type III (10.5 mm height).

Shipments of rigid disk drives with less than 100 megabytes capacity are approaching end of life in 1995, and this is the last year that the product group will be included in the DISK/TREND Report. Next year, any remaining active products will be combined in a new product group with other disk drives with higher capacities.

Although numerous manufacturers shipped fixed disk drives with less than 100 megabytes capacity using 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. In recent years, 3.5" and 2.5" drives also found rapidly shrinking markets below 100 megabytes, due to the current demand for higher capacities for most applications, and the continually dropping prices for drives with higher capacities. 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 last of the Hewlett-Packard 1.3" "Kittyhawk" disk drives are expected to be shipped in 1995, following the company's 1994 announcement that it was dropping the product, due to lower than expected sales.

Market status

Annual shipments for this product group exceeded 7 million drives as recently as 1993, but 1994 unit shipments sank to 520,000, and the 1995 total is estimated at 177,000. 1995 is expected to be the last year of significant shipments for disk drives with less than 100 megabytes capacity. Sales revenues have dropped from $1.1 billion in 1993 to $99 million in 1994, with 1995 revenues estimated at only $32 million.

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.

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 95.4% in 1994.

A similar trend occurred in the notebook computer market, with capacities rapidly moving to higher levels, and reduced demand for 2.5" drives in this capacity range. Shipments of 2.5" drives were down 87.6% in 1994, and all of the drive manufacturers previously active in this product group with 2.5" drives have discontinued their products. The most active sales programs during 1995 have been close-out programs for 1.8" and 1.3" drives.

Quantum continued to lead the product group in worldwide noncaptive drive unit shipments in 1994 with 24.1%, but this total represented only 99,800 drives, down sharply from 2.3 million the previous year.

Marketing trends

1996 is expected to be the last year of disk drive shipments for this product group, with 1.8" drives receiving all of the modest sales activity. As the longstanding 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.

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 the form of PCMCIA PC Cards. The most significant market for 1.8" drives has become the subnotebook computer market, with most users demanding disk drive capacities well above the 100 megabyte level, a capacity range in which flash memory's high price does not compete effectively with disk drives.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
5.25"	21.0 4.0%	2.2 1.2%	-- --	-- --	-- --
3.5" 1.625" high	21.3 4.1%	11.0 6.2%	-- --	-- --	-- --
3.5" 1" high or less	217.2 41.8%	13.1 7.4%	-- --	-- --	-- --
2.5" more than .5" high	73.5 14.1%	10.0 5.6%	-- --	-- --	-- --
2.5" .5" high or less	97.3 18.7%	11.0 6.2%	-- --	-- --	-- --
1.8" PCMCIA Type III	20.6 4.0%	20.0 11.3%	5.0 100.0%	-- --	-- --
1.8" or less, other formats	69.2 13.3%	110.0 62.0%	-- --	-- --	-- --
Total	520.1	177.3	5.0	--	--

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 did not occur until this year, to allow customers to purchase product inventories necessary to continue existing programs. No other disk drive manufacturer is known to be currently developing 1.3" 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 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 guided the development work on 1.3" and 1.8" drives in this capacity range. The objective was 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. 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.

2. 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)									
	1994 Revenues		Forecast							
			1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	15.0	22.9	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	15.0	22.9	--	--	--	--	--	--	--	--
PCM/Reseller	3.0	5.4	.9	1.8	--	--	--	--	--	--
OEM/Integrator	14.1	30.8	12.6	19.8	.4	.6	--	--	--	--
TOTAL U.S. NONCAPTIVE	17.1	36.2	13.5	21.6	.4	.6	--	--	--	--
TOTAL U.S. REVENUES	32.1	59.1	13.5	21.6	.4	.6	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	4.0	--	--	--	--	--	--	--	--
PCM/Reseller	--	.1	--	--	--	--	--	--	--	--
OEM/Integrator	1.0	36.0	.2	10.5	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	1.0	40.1	.2	10.5	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	33.1	99.2	13.7	32.1	.4	.6	--	--	--	--
OEM Average Price ($000)		.180		.181		.120		--		--

TABLE 22

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	62.0	95.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	62.0	95.0	--	--	--	--	--	--	--	--
PCM/Reseller	25.7	43.0	5.0	10.0	--	--	--	--	--	--
OEM/Integrator	95.8	210.3	76.7	122.2	3.0	5.0	--	--	--	--
TOTAL U.S. NONCAPTIVE	121.5	253.3	81.7	132.2	3.0	5.0	--	--	--	--
TOTAL U.S. SHIPMENTS	183.5	348.3	81.7	132.2	3.0	5.0	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	11.8	--	--	--	--	--	--	--	--
PCM/Reseller	--	.3	--	--	--	--	--	--	--	--
OEM/Integrator	4.7	159.7	1.0	45.1	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	4.7	171.8	1.0	45.1	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	188.2	520.1	82.7	177.3	3.0	5.0	--	--	--	--
Total Capacity (Terabytes)	11.3	31.9	2.4	6.2	.2	.4	--	--	--	--
Cumulative Shipments (Units in millions)										
IBM	9.7	14.3	9.7	14.3	9.7	14.3	9.7	14.3	9.7	14.3
Non-IBM	63.6	117.7	63.7	117.9	63.7	117.9	63.7	117.9	63.7	117.9
WORLDWIDE TOTAL	73.4	132.1	73.4	132.3	73.4	132.3	73.4	132.3	73.4	132.3

TABLE 23

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues				Forecast 1995				1996	1997	1998
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	<=1.8"	All Dia.	All Dia.
U.S. MANUFACTURERS											
IBM Captive	--	15.4	7.5	--	--	--	--	--	--	--	--
PCM/Reseller	.9	1.6	1.3	1.6	--	--	--	1.8	--	--	--
OEM/Integrator	2.7	4.6	5.5	18.0	1.6	--	--	18.2	.6	--	--
TOTAL U.S. REVENUES	3.6	21.6	14.3	19.6	1.6	--	--	20.0	.6	--	--
NON-U.S. MANUFACTURERS											
Captive	.2	3.3	--	.5	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	.1	--	--	--	--	--	--	--
OEM/Integrator	4.2	16.4	15.3	.1	--	6.7	3.8	--	--	--	--
TOTAL NON-U.S. REVENUES	4.4	19.7	15.3	.7	--	6.7	3.8	--	--	--	--
WORLDWIDE RECAP											
Captive	.2	18.7	7.5	.5	--	--	--	--	--	--	--
	-87.5%	-89.0%	-92.4%	-83.9%	--	--	--	--	--	--	--
PCM/Reseller	.9	1.6	1.3	1.7	--	--	--	1.8	--	--	--
	-86.2%	-99.2%	-92.6%	-67.3%	--	--	--	+5.9%	--	--	--
OEM/Integrator	6.9	21.0	20.8	18.1	1.6	6.7	3.8	18.2	.6	--	--
	-11.5%	-95.2%	-87.2%	-42.0%	-76.8%	-68.1%	-81.7%	+.6%	-96.7%	--	--
Total Revenues	8.0	41.3	29.6	20.3	1.6	6.7	3.8	20.0	.6	--	--
	-49.7%	-94.8%	-89.4%	-48.6%	-80.0%	-83.8%	-87.2%	-1.5%	-97.0%	--	--
ANNUAL SHARE, BY DIAMETER	8.1%	41.7%	29.8%	20.4%	5.0%	20.9%	11.8%	62.3%	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

	1994 Shipments				Forecast 1995				1996	1997	1998
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	<=1.8"	All Dia.	All Dia.
U.S. MANUFACTURERS											
IBM Captive	--	70.0	25.0	--	--	--	--	--	--	--	--
PCM/Reseller	5.2	20.8	10.0	7.0	--	--	--	10.0	--	--	--
OEM/Integrator	9.3	70.0	50.0	81.0	2.2	--	--	120.0	5.0	--	--
TOTAL U.S. SHIPMENTS	14.5	160.8	85.0	88.0	2.2	--	--	130.0	5.0	--	--
NON-U.S. MANUFACTURERS											
Captive	.1	10.5	--	1.2	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	.3	--	--	--	--	--	--	--
OEM/Integrator	6.4	67.2	85.8	.3	--	24.1	21.0	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	6.5	77.7	85.8	1.8	--	24.1	21.0	--	--	--	--
WORLDWIDE RECAP											
Captive	.1	80.5	25.0	1.2	--	--	--	--	--	--	--
	-91.7%	-87.3%	-91.1%	-76.0%	--	--	--	--	--	--	--
PCM/Reseller	5.2	20.8	10.0	7.3	--	--	--	10.0	--	--	--
	-85.6%	-98.7%	-90.9%	-66.4%	--	--	--	+37.0%	--	--	--
OEM/Integrator	15.7	137.2	135.8	81.3	2.2	24.1	21.0	120.0	5.0	--	--
	-31.4%	-96.1%	-86.3%	-36.0%	-86.0%	-82.4%	-84.5%	+47.6%	-95.8%	--	--
Total Shipments	21.0	238.5	170.8	89.8	2.2	24.1	21.0	130.0	5.0	--	--
	-65.1%	-95.9%	-87.6%	-41.6%	-89.5%	-89.9%	-87.7%	+44.8%	-96.2%	--	--
ANNUAL SHARE, BY DIAMETER	4.0%	46.0%	32.8%	17.2%	1.2%	13.6%	11.8%	73.4%	100.0%	--	--
TOTAL CAPACITY (Terabytes)	1.0	16.3	10.4	4.2	.1	1.1	1.4	3.6	.4	--	--

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

TABLE 25

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 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	471.2	90.6	--	--
WORKSTATIONS Engineering and office, single user	3.1	.6	--	--
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	45.8	8.8	--	--
Total	520.1	100.0	--	--

TABLE 26

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
5.25"	--	--	--	--	--
3.5"	3.02	--	--	--	--
2.5"	--	--	--	--	--
1.8" or less	4.80	--	--	--	--
Captive Average	4.27	--	--	--	--
PCM/Reseller					
5.25"	4.05	--	--	--	--
3.5"	1.06	--	--	--	--
2.5"	1.93	--	--	--	--
1.8" or less	4.13	4.25	--	--	--
PCM/Reseller Average	1.93	4.25	--	--	--
OEM/Integrator					
5.25"	8.45	15.40	--	--	--
3.5"	2.45	6.07	--	--	--
2.5"	2.14	2.69	--	--	--
1.8" or less	4.88	5.66	1.50	--	--
OEM/Integrator Average	2.92	5.19	1.50	--	--

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

TABLE 27

FIXED DISK DRIVES, LESS THAN 100 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 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	--	42.0	6.0	--	48.0	38.0	--	74.8	25.0	--	99.8	24.1
Fuji Electric	--	--	--	--	--	--	--	25.6	34.3	--	59.9	14.5
Toshiba	--	--	--	--	--	--	--	--	46.0	--	46.0	11.1
Other U.S.	10.0	12.5	10.0	41.0	73.5	58.2	14.5	16.0	35.0	88.0	153.5	37.1
Other Non-U.S.	--	1.4	3.3	--	4.7	3.8	6.4	41.6	5.5	.6	54.1	13.2
TOTAL	10.0	55.9	19.3	41.0	126.2	100.0	20.9	158.0	145.8	88.6	413.3	100.0

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

FIXED DISK DRIVES, 100 - 200 MEGABYTES

1995 DISK/TREND REPORT

FIXED DISK DRIVES, 100 - 200 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Sequel	806

5.25" disk diameter

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

3.5" disk diameter

Fujitsu	M2614ES*, M2616ET**
NEC	D3765**

2.5" disk diameter

Fujitsu	M2635T/S***
Quantum	170A/S Daytona****
Seagate Technology	ST9190AG****
Toshiba	MK-1722FCV****

1.8" disk diameter

Calluna Technology	CT-105*****, CT-170*****
Integral Peripherals	8105PA*****, 8170PA*****

*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).

This product group was dominated in sequence by 14", 8" and 5.25" drives, and eventually by 3.5" models -- but a majority of unit shipments in the 100-200 megabyte capacity range are now 2.5" models. The first 1.8" disk drives in the 100-200 megabyte range were shipped in 1993.

Market forces created a surge in shipments for 3.5" drives in the 100-200 megabyte product group in the early 1990's. 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 started to decline in 1994. 1.8" drives were the beneficiary of the industry's improvements in areal densities, but volume shipments in the 100-200 megabyte range did not commence until 1994, too late to find a significant market at that capacity level.

Market status

As recently as 1993, the 100-200 megabyte product group was the leader in worldwide rigid disk drive shipments, peaking in that year at 20 million units, before sales slumped. The decline in shipments for the product group was driven by continuously increasing demand for more disk drive capacity for desktop personal computers. Total shipments in 1994 were down 60.0%, at 8 million drives, and 1995 shipments are estimated at only 906,000 units, a drop of 88.7%. Sales revenues of almost $4 billion in 1993 were down to $1.3 billion in 1994, and the total of 1995 is projected to reach only $192.9 million.

High level shipments of 3.5" drives for desktop personal computers have dropped faster than any other type of product in this group, as demand for higher capacities accelerates. 3.5" drive shipments were down 67.9% in 1994, with a further decline of 96.6% expected in 1995, reducing the total for the year to 180,400 3.5" drives. 1995 is projected to be the last year of shipments for 3.5" 100-200 megabyte disk drives. Although the decline in shipments of 2.5" drives for notebook computers has not been quite as fast, the total for 1994 was only 2.5 million units, and 1995 shipments are projected to drop to 532,300. Only 1.8" drives, mostly PC Card models, have enjoyed an increase in shipments during 1994-95, but even that growth is ending. After the start of volume shipments in 1994, 1.8" drives in this product group will reach an expected total of only 189,000 units in 1995, before being pushed aside for higher capacity models.

Leadership in 1994 noncaptive shipments for 100-200 megabyte drives was again held by Quantum with 48.1% of the worldwide total, a combination of 3.5 million 3.5" and 2.5" drives. Seagate Technology held second position with 17.9% and Maxtor was third with 16.5%.

Marketing trends

1996 is expected to be the last year of shipment activity for the 2.5" and 1.8" 100-200 megabyte disk drives which remain in production.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
8"	.1 --	.1 --	-- --	-- --	-- --
5.25"	9.4 .1%	4.6 .5%	-- --	-- --	-- --
3.5" 1.625" high	13.0 .2%	3.0 .3%	-- --	-- --	-- --
3.5" 1" high or less	5,314.6 66.4%	177.4 19.6%	-- --	-- --	-- --
2.5" more than .5" high	1,787.3 22.3%	289.5 31.9%	90.0 78.3%	-- --	-- --
2.5" .5" high or less	738.4 ~~134.5~~ 1.7%	127.8 ~~169.0~~ 18.6%	~~25.0~~ ~~21.7%~~	-- --	-- --
1.8" PCMCIA Type III	134.5 1.7%	169.0 18.6%	25.0 21.7%	-- --	-- --
1.8", other formats	10.0 .1%	20.0 2.2%	-- --	-- --	-- --
Total	8,007.3	906.~~3~~4	115.0	--	--

The disappearance 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 saw a sharp increase in shipments of 12.7 millimeter high 2.5" drives, but sales of even the thinner models are declining rapidly in 1995, with all 2.5" drives in the group expected to be out of production in 1996.

For several years, there was a general expectation in the industry that 1.8"

Leadership in 1994 noncaptive shipments for 100-200 megabyte drives was again held by Quantum with 48.1% of the worldwide total, a combination of 3.5 million 3.5" and 2.5" drives. Seagate Technology held second position with 17.9% and Maxtor was third with 16.5%.

Marketing trends

1996 is expected to be the last year of shipment activity for the 2.5" and 1.8" 100-200 megabyte disk drives which remain in production.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
8"	.1 --	.1 --	-- --	-- --	-- --
5.25"	9.4 .1%	4.6 .5%	-- --	-- --	-- --
3.5" 1.625" high	13.0 .2%	3.0 .3%	-- --	-- --	-- --
3.5" 1" high or less	5,314.6 66.4%	177.4 19.6%	-- --	-- --	-- --
2.5" more than .5" high	1,787.3 22.3%	289.5 31.9%	90.0 78.3%	-- --	-- --
2.5" .5" high or less	134.5 1.7%	169.0 18.6%	25.0 21.7%	-- --	-- --
1.8" PCMCIA Type III	134.5 1.7%	169.0 18.6%	25.0 21.7%	-- --	-- --
1.8", other formats	10.0 .1%	20.0 2.2%	-- --	-- --	-- --
Total	8,007.3	906.3	115.0	--	--

The disappearance 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 saw a sharp increase in shipments of 12.7 millimeter high 2.5" drives, but sales of even the thinner models are declining rapidly in 1995, with all 2.5" drives in the group expected to be out of production in 1996.

For several years, there was 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 started an upward growth pattern for 1.8" drives. Drive capacities in the 100-200 megabyte range became available in the 10.5 millimeter thick PC Card Type III format, shipments of subnotebook computers increased, and numerous notebook computers with PC Card slots became available. The result was that shipments of 1.8" drives, especially those in the PCMCIA format, did increase -- but not nearly as much as generally expected. 1996 is expected to be the last year of shipments for 1.8" drives in this product group.

The problem for PC Card drives, in general, was that 1.8" drive prices were significantly higher than 2.5" drives of similar capacities, making it easy for most system manufacturers to decide to stay with 2.5" drives for notebook computers. The specific problem for 1.8" drives in the 100-200 megabyte range was that user preferences and actual software requirements had driven the notebook computer market to higher disk capacities.

Technical trends

With shipments of 1.8" disk drives in this product group expected to peak in 1996, 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 PC Card 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 PC Card Type II thick card format an attractive possibility. Type II drives will be limited to a single 1.8" disk, which could achieve a 200 megabyte capacity in a production drive within the next year or two.

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 announcement of a Type II drive was made by Maxtor, for 1995 delivery, but the company stopped its 1.8" drive program before the Type II drive was shipped. Considering that market demands for increased capacity have increased faster than the industry's ability to provide that capacity on a single 1.8" disk, it may now be a few more years before the Type II disk drive becomes a commercial reality. When it does happen, the drives to be introduced will have capacities several times higher than those in this product group.

Forecasting assumptions

1. 3.5" and 2.5" drive 100-200 megabyte shipments will continue to decline sharply, with the final shipments of 3.5" drives in 1995, and the last shipments of 2.5" drives in 1996.
2. 1.8" drives in the 100-200 megabyte capacity range, which first became available in 1993, will end production in 1996, 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)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	95.5	143.3	3.5	5.0	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	95.5	143.3	3.5	5.0	--	--	--	--	--	--
PCM/Reseller	115.4	226.8	11.7	22.4	--	--	--	--	--	--
OEM/Integrator	333.7	614.5	41.6	85.1	5.0	11.6	--	--	--	--
TOTAL U.S. NONCAPTIVE	449.1	841.3	53.3	107.5	5.0	11.6	--	--	--	--
TOTAL U.S. REVENUES	544.6	984.6	56.8	112.5	5.0	11.6	--	--	--	--
Non-U.S. Manufacturers										
Captive	29.3	122.4	16.2	65.8	1.0	4.9	--	--	--	--
PCM/Reseller	4.3	11.9	1.0	2.9	--	--	--	--	--	--
OEM/Integrator	30.8	140.3	4.0	11.7	3.0	4.5	--	--	--	--
TOTAL NON-U.S. REVENUES	64.4	274.6	21.2	80.4	4.0	9.4	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	609.0	1,259.2	78.0	192.9	9.0	21.0	--	--	--	--
OEM Average Price ($000)		.140		.160		.153		--		--

TABLE 29

FIXED DISK DRIVES, 100 - 200 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994 Shipments		Forecast							
			1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	330.0	495.0	12.0	17.0	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	330.0	495.0	12.0	17.0	--	--	--	--	--	--
PCM/Reseller	951.8	1,913.4	83.1	164.2	--	--	--	--	--	--
OEM/Integrator	2,512.1	4,713.0	279.8	555.3	35.0	80.0	--	--	--	--
TOTAL U.S. NONCAPTIVE	3,463.9	6,626.4	362.9	719.5	35.0	80.0	--	--	--	--
TOTAL U.S. SHIPMENTS	3,793.9	7,121.4	374.9	736.5	35.0	80.0	--	--	--	--
Non-U.S. Manufacturers										
Captive	45.0	183.1	27.0	107.2	2.0	10.0	--	--	--	--
PCM/Reseller	20.0	56.0	5.0	14.0	--	--	--	--	--	--
OEM/Integrator	141.0	646.8	18.5	48.7	16.0	25.0	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	206.0	885.9	50.5	169.9	18.0	35.0	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,999.9	8,007.3	425.4	906.4	53.0	115.0	--	--	--	--
Total Capacity (Terabytes)	599.3	1,189.3	63.5	134.1	7.1	15.4	--	--	--	--
Cumulative Shipments (Units in millions)										
IBM	4.5	6.5	4.5	6.5	4.5	6.5	4.5	6.5	4.5	6.5
Non-IBM	28.0	52.0	28.4	52.9	28.5	53.0	28.5	53.0	28.5	53.0
WORLDWIDE TOTAL	32.6	58.6	33.0	59.5	33.0	59.6	33.0	59.6	33.0	59.6

TABLE 30

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues					Forecast 1995					Forecast 1996		Forecast 1997	Forecast 1998
	8"	5.25"	3.5"	2.5"	1.8"	8"	5.25"	3.5"	2.5"	1.8"	2.5"	1.8"	All Dia.	All Dia.
U.S. MANUFACTURERS														
IBM Captive	--	--	75.0	68.3	--	--	--	.5	4.5	--	--	--	--	--
PCM/Reseller	--	.4	199.8	22.4	4.2	--	.2	4.5	16.3	1.4	--	--	--	--
OEM/Integrator	.1	6.7	327.9	252.0	27.8	.1	2.9	10.6	38.5	33.0	8.4	3.2	--	--
TOTAL U.S. REVENUES	.1	7.1	602.7	342.7	32.0	.1	3.1	15.6	59.3	34.4	8.4	3.2	--	--
NON-U.S. MANUFACTURERS														
Captive	--	2.4	22.4	97.6	--	--	2.2	9.6	54.0	--	4.9	--	--	--
PCM/Reseller	--	--	.5	10.8	.6	--	--	--	2.0	.9	--	--	--	--
OEM/Integrator	--	.4	14.4	125.0	.5	--	--	2.8	6.1	2.8	2.4	2.1	--	--
TOTAL NON-U.S. REVENUES	--	2.8	37.3	233.4	1.1	--	2.2	12.4	62.1	3.7	7.3	2.1	--	--
WORLDWIDE RECAP														
Captive	--	2.4	97.4	165.9	--	--	2.2	10.1	58.5	--	4.9	--	--	--
	--	-61.9%	-85.0%	-70.4%	--	--	-8.3%	-89.6%	-64.7%	--	-91.6%	--	--	--
PCM/Reseller	--	.4	200.3	33.2	4.8	--	.2	4.5	18.3	2.3	--	--	--	--
	--	-20.0%	-73.3%	+.3%	+700.0%	--	-50.0%	-97.8%	-44.9%	-52.1%	--	--	--	--
OEM/Integrator	.1	7.1	342.3	377.0	28.3	.1	2.9	13.4	44.6	35.8	10.8	5.3	--	--
	-50.0%	-49.3%	-77.5%	-17.5%	--	--	-59.2%	-96.1%	-88.2%	+26.5%	-75.8%	-85.2%	--	--
Total Revenues	.1	9.9	640.0	576.1	33.1	.1	5.3	28.0	121.4	38.1	15.7	5.3	--	--
	-50.0%	-52.4%	-78.1%	-45.2%	--	--	-46.5%	-95.6%	-78.9%	+15.1%	-87.1%	-86.1%	--	--
ANNUAL SHARE, BY DIAMETER	--	.8%	50.9%	45.8%	2.5%	.1%	2.7%	14.5%	63.0%	19.7%	74.9%	25.1%	--	--

TABLE 31

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments					Forecast 1995					Forecast 1996		Forecast 1997	Forecast 1998
	8"	5.25"	3.5"	2.5"	1.8"	8"	5.25"	3.5"	2.5"	1.8"	2.5"	1.8"	All Dia.	All Dia.
U.S. MANUFACTURERS														
IBM Captive	--	--	300.0	195.0	--	--	--	2.0	15.0	--	--	--	--	--
PCM/Reseller	--	.4	1,766.0	129.0	18.0	--	.2	45.0	112.0	7.0	--	--	--	--
OEM/Integrator	.1	7.4	3,159.0	1,424.0	122.5	.1	3.2	111.0	275.0	166.0	65.0	15.0	--	--
TOTAL U.S. SHIPMENTS	.1	7.8	5,225.0	1,748.0	140.5	.1	3.4	158.0	402.0	173.0	65.0	15.0	--	--
NON-U.S. MANUFACTURERS														
Captive	--	1.2	31.9	150.0	--	--	1.2	16.0	90.0	--	10.0	--	--	--
PCM/Reseller	--	--	4.0	50.0	2.0	--	--	--	10.0	4.0	--	--	--	--
OEM/Integrator	--	.4	66.7	577.7	2.0	--	--	6.4	30.3	12.0	15.0	10.0	--	--
TOTAL NON-U.S. SHIPMENTS	--	1.6	102.6	777.7	4.0	--	1.2	22.4	130.3	16.0	25.0	10.0	--	--
WORLDWIDE RECAP														
Captive	--	1.2	331.9	345.0	--	--	1.2	18.0	105.0	--	10.0	--	--	--
	--	-62.5%	-79.7%	-70.7%	--	--	--	-94.6%	-69.6%	--	-90.5%	--	--	--
PCM/Reseller	--	.4	1,770.0	179.0	20.0	--	.2	45.0	122.0	11.0	--	--	--	--
	--	-20.0%	-64.3%	+19.9%	--	--	-50.0%	-97.5%	-31.8%	-45.0%	--	--	--	--
OEM/Integrator	.1	7.8	3,225.7	2,001.7	124.5	.1	3.2	117.4	305.3	178.0	80.0	25.0	--	--
	-50.0%	-56.9%	-67.8%	-3.0%	--	--	-59.0%	-96.4%	-84.7%	+43.0%	-73.8%	-86.0%	--	--
Total Shipments	.1	9.4	5,327.6	2,525.7	144.5	.1	4.6	180.4	532.3	189.0	90.0	25.0	--	--
	-50.0%	-56.9%	-67.9%	-25.5%	--	--	-51.1%	-96.6%	-78.9%	+30.8%	-83.1%	-86.8%	--	--
ANNUAL SHARE, BY DIAMETER	--	.1%	66.6%	31.5%	1.8%	--	.5%	19.9%	58.8%	20.8%	78.4%	21.6%	--	--
TOTAL CAPACITY (Terabytes)	--	1.6	825.4	344.7	17.6	--	.8	29.0	74.9	29.4	11.7	3.8	--	--

TABLE 32

FIXED DISK DRIVES, 100 - 200 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 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	7,959.3	99.4	--	--
WORKSTATIONS Engineering and office, single user	8.0	.1	--	--
CONSUMER, GAME AND HOBBY COMPUTERS	32.0	.4	--	--
OTHER APPLICATIONS	8.0	.1	--	--
Total	8,007.3	100.0	--	--

TABLE 33

FIXED DISK DRIVES, 100 - 200 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
8"	--	--	--	--	--
5.25"	12.00	10.80	--	--	--
3.5"	1.76	3.87	--	--	--
2.5"	3.14	4.12	3.71	--	--
1.8"	--	--	--	--	--
Captive Average	2.45	4.16	3.71	--	--
PCM/Reseller					
8"	--	--	--	--	--
5.25"	3.60	--	--	--	--
3.5"	.75	.62	--	--	--
2.5"	1.35	1.03	--	--	--
1.8"	1.95	1.28	--	--	--
PCM/Reseller Average	.82	.94	--	--	--
OEM/Integrator					
8"	--	--	--	--	--
5.25"	5.44	4.80	--	--	--
3.5"	.67	.70	--	--	--
2.5"	1.40	1.03	1.03	--	--
1.8"	1.85	1.29	1.40	--	--
OEM/Integrator Average	.95	1.06	1.13	--	--

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

	1994 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	--	1442.0	345.0	--	1787.0	49.3	--	2885.0	637.0	--	3522.0	48.1
Seagate Technology	--	311.0	396.0	--	707.0	19.5	--	655.0	656.0	--	1311.0	17.9
Maxtor	--	591.0	--	65.0	656.0	18.1	--	1135.0	--	73.0	1208.0	16.5
Toshiba	--	--	130.0	--	130.0	3.6	--	--	550.0	--	550.0	7.5
Conner Peripherals	--	143.0	15.5	--	158.5	4.4	--	250.0	45.0	--	295.0	4.0
Western Digital	--	--	90.0	--	90.0	2.5	--	--	170.0	--	170.0	2.3
Other U.S.	6.9	--	25.0	33.5	65.4	1.8	7.9	--	45.0	67.5	120.4	1.6
Other Non-U.S.	--	.1	28.9	2.0	31.0	.8	.4	70.7	77.7	4.0	152.8	2.1
TOTAL	6.9	2487.1	1030.4	100.5	3624.9	100.0	8.3	4995.7	2180.7	144.5	7329.2	100.0

FIXED DISK DRIVES, 200 - 300 MEGABYTES

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

Fujitsu	M2681S/T**
Hitachi	DK312C-25*,DK324C-21A**
Maxtor	7273A**, 7270AV**
NEC	D3766**
Quantum	270A/S Maverick**
Seagate Technology	ST3250A**, ST3295A**

2.5" disk diameter

Fujitsu	M2637S/T***
IBM	DHAA/S-2270***
Quantum	256A/S Daytona****
Seagate Technology	ST9235AG***, ST9240AG****
Toshiba	MK-1724FCV****

1.8" disk diameter

Calluna Technology	CT-260*****
Integral Peripherals	8260PA*****

*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)

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.

200-300 megabyte drives larger than 3.5" are at the end of their production lives, and the increasing demand for higher capacities is expected to limit the remaining life of 3.5" and 2.5" drives to only one more year. 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 two years ago, moving to single disk models for up to 270 megabytes in 1994. Most of the many 2.5" drives introduced in this capacity range during 1993-94 used two or three disks, but the first of the single platter 2.5" drives in the 200-300 megabyte range were also introduced in 1994.

Initial shipments of 1.8" drives in the 200-300 megabyte range occurred in late 1994, and both of the companies currently remaining in the 1.8" drive market, Integral Peripherals and Calluna Technology, offer drives in the PC Card format, both utilizing two disks.

Market status

After achieving outstanding growth rates since the beginning of the 1990's, and becoming the product group with the industry's largest shipments in 1994, 200-300 megabyte drives are declining even more rapidly in 1995. Total shipments for the product group reached 23.3 million drives in 1994, up 65.7% from the previous year, but shipments are expected to drop 77.3% in 1995, down to 5.3 million.

The disk drive industry's ability to continue the rapid transition to higher drive capacities at low cost has been matched by the market's demand for more disk capacity on personal computers, in order to utilize improved operating systems and application programs, and to add new storage for a wide variety of applications, including graphics, games, multimedia, and downloads from the Internet. The result has been a sharp drop in sales revenues for 200-300 megabyte drives from 1994's peak of $3.6 billion to an estimated $851.6 million in 1995.

Personal computers, including notebook computers, produced 99.5% of 1994's worldwide unit shipments, trailed by nominal shipments for workstations and consumer applications. The personal computer market, including portable system applications, is expected to consume 88% of 1998's shipments. The balance is scattered among workstation, consumer and other applications, which will use the 1.8" drives which are expected to provide all of the 1997-98 shipments for this product group.

Quantum more than doubled its shipments of 200-300 megabyte drives in 1994, to assume leadership in noncaptive shipments, with 31.0% of the worldwide total. Conner Peripherals advanced to second place with 22.4%, while Seagate Technology dropped to third position, at 21.1%.

Marketing trends

As shipments of 3.5" and 2.5" drives reach the end of life in 1996, 1.8" drives are expected to be the only survivors in the 200-300 megabyte product group by the end of the forecast period.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
8"	.2 --	.2 --	-- --	-- --	-- --
3.5" 1.625" high	9.0 --	3.0 .1%	-- --	-- --	-- --
3.5" 1" high or less	21,178.7 90.8%	4,280.0 80.9%	935.0 79.2%	-- --	-- --
2.5" more than .5" high	1,326.6 5.7%	310.0 5.9%	10.0 .8%	-- --	-- --
2.5" .5" high or less	797.1 3.4%	588.0 11.1%	65.0 5.5%	-- --	-- --
1.8" PCMCIA Type III	1.0 --	110.0 2.1%	170.0 14.4%	235.0 100.0%	185.0 100.0%
Total	23,312.6	5,291.2	1,180.0	235.0	185.0

As manufacturers of notebook computers and desktop personal computers abandon the 2.5" and 3.5" disk drives in this product group for drives with higher capacities, with the last shipments of drives in these physical sizes projected for 1996, the only remaining participants in the group are expected to be 1.8" PC Card drives.

1.8" drives are enjoying their first year of volume shipments in the 200-300 megabyte range in 1995. However, it is a lonely product area, with only two active drive manufacturers, after other manufacturers of 1.8" drives dropped out of the field due to a smaller available overall market for 1.8" drives than they expected. 1995's shipments of 110,000 drives are projected to grow to a peak of 235,000 in 1997, then start a decline in 1998, dropping to 185,000 drives, as the market moves to drives in the same format but with higher capacities.

Clearly, the market currently available to 1.8" drives is limited to the manufacturers of a few notebook computer models, plus the manufacturers of a variety of pen-based computers, electronic typewriters, security applications and other specialized applications. The limiting factor continues to be the price at each capacity level, compared to 2.5" drives, and the movement in the notebook computer market to disk capacities above those in this product group. The price comparison is easily seen in the relative price per megabyte levels for 2.5" and 1.8" drives. In 1995, the average OEM/Integrator price per megabyte for 1.8" drives in this product group is estimated at 92 cents, while the average for 2.5" drives is 68 cents.

Technical trends

The inevitable disk drive improvements in recording density made this product group the industry's volume leader in 1994, because the personal computer industry needed 3.5" and 2.5" drives with 200-300 megabytes capacity and the disk drive industry was able to produce them cheaply and reliably. Advances in recording density had made it possible to manufacture the drives routinely with a minimum parts count, using only one disk and two recording heads.

The same market forces will determine the computer industry's potential future interest in 1.8" drives. As noted above, demand for the existing generation of 1.8" Type III PC Card drives in this capacity range is expected to peak in 1997. However, it is reasonable to assume that continuing growth in 1.8" drive shipments might be possible beyond 1997, if the industry puts 5 millimeter thick Type II PC Card drives into production in the 200-300 megabyte capacity range. Type II cards will be limited to a single disk, but by the end of this forecast period in

1998 cost-effective production of Type II drives in this capacity should be feasible, and the available market may be many times larger than that available to the current Type III models, due to the large number of Type II slots now available on notebook computers.

Forecasting assumptions

1. Shipments of both 3.5" and 2.5" drives in this capacity group will continue the decline started in 1995 and will end in 1996.
2. Shipments of 1.8" Type III PC Card drives will peak in 1997, due to a transition to higher capacities. Although production of Type II PC Card drives will be technically possible during this forecast period, it is not yet clear whether they will be introduced by 1998.

TABLE 35

FIXED DISK DRIVES, 200 - 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	196.1	295.7	111.0	170.8	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	196.1	295.7	111.0	170.8	--	--	--	--	--	--
PCM/Reseller	351.4	751.9	56.9	141.1	9.7	18.3	6.4	8.8	5.8	8.4
OEM/Integrator	1,104.0	2,178.6	258.5	433.6	64.2	108.5	16.1	22.2	7.9	11.6
TOTAL U.S. NONCAPTIVE	1,455.4	2,930.5	315.4	574.7	73.9	126.8	22.5	31.0	13.7	20.0
TOTAL U.S. REVENUES	1,651.5	3,226.2	426.4	745.5	73.9	126.8	22.5	31.0	13.7	20.0
Non-U.S. Manufacturers										
Captive	21.7	118.9	5.3	50.9	.8	22.5	--	--	--	--
PCM/Reseller	27.4	66.2	.9	1.8	.6	1.0	1.1	1.6	.9	1.3
OEM/Integrator	59.9	191.3	10.3	53.4	2.6	13.6	2.4	4.0	1.3	1.9
TOTAL NON-U.S. REVENUES	109.0	376.4	16.5	106.1	4.0	37.1	3.5	5.6	2.2	3.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,760.5	3,602.6	442.9	851.6	77.9	163.9	26.0	36.6	15.9	23.2
OEM Average Price ($000)		.143		.133		.125		.154		.122

TABLE 36

FIXED DISK DRIVES, 200 - 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	550.0	830.0	305.0	470.0	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	550.0	830.0	305.0	470.0	--	--	--	--	--	--
PCM/Reseller	2,499.0	5,317.0	429.0	1,065.0	67.0	140.0	40.0	55.0	45.0	65.0
OEM/Integrator	7,854.1	15,425.2	1,944.1	3,278.2	500.0	865.0	105.0	145.0	65.0	95.0
TOTAL U.S. NONCAPTIVE	10,353.1	20,742.2	2,373.1	4,343.2	567.0	1,005.0	145.0	200.0	110.0	160.0
TOTAL U.S. SHIPMENTS	10,903.1	21,572.2	2,678.1	4,813.2	567.0	1,005.0	145.0	200.0	110.0	160.0
Non-U.S. Manufacturers										
Captive	35.0	202.2	10.0	100.0	2.0	60.0	--	--	--	--
PCM/Reseller	190.0	460.0	5.0	10.0	3.0	5.0	7.0	10.0	7.0	10.0
OEM/Integrator	328.8	1,078.2	56.5	368.0	15.0	110.0	15.0	25.0	10.0	15.0
TOTAL NON-U.S. SHIPMENTS	553.8	1,740.4	71.5	478.0	20.0	175.0	22.0	35.0	17.0	25.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	11,456.9	23,312.6	2,749.6	5,291.2	587.0	1,180.0	167.0	235.0	127.0	185.0
Total Capacity (Terabytes)	2,843.9	5,760.5	706.8	1,350.7	142.8	286.7	42.9	60.4	33.0	48.1
Cumulative Shipments (Units in millions)										
IBM	1.7	2.6	2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0
Non-IBM	21.9	41.6	24.3	46.4	24.9	47.6	25.1	47.9	25.2	48.0
WORLDWIDE TOTAL	23.6	44.2	26.4	49.5	26.9	50.7	27.1	50.9	27.2	51.1

TABLE 37

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues				Forecast 1995				Forecast 1996			Forecast 1997	Forecast 1998
	8"	3.5"	2.5"	1.8"	8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS													
IBM Captive	--	273.1	22.6	--	--	91.0	79.8	--	--	--	--	--	--
PCM/Reseller	--	731.3	20.6	--	--	132.5	8.6	--	12.3	--	6.0	8.8	8.4
OEM/Integrator	.2	1,915.2	262.9	.3	.2	330.5	81.3	21.6	75.5	9.9	23.1	22.2	11.6
TOTAL U.S. REVENUES	.2	2,919.6	306.1	.3	.2	554.0	169.7	21.6	87.8	9.9	29.1	31.0	20.0
NON-U.S. MANUFACTURERS													
Captive	--	50.8	68.1	--	--	35.0	15.9	--	18.4	4.1	--	--	--
PCM/Reseller	--	56.9	9.3	--	--	--	1.8	--	--	--	1.0	1.6	1.3
OEM/Integrator	--	72.6	118.7	--	--	26.3	22.2	4.9	10.6	--	3.0	4.0	1.9
TOTAL NON-U.S. REVENUES	--	180.3	196.1	--	--	61.3	39.9	4.9	29.0	4.1	4.0	5.6	3.2
WORLDWIDE RECAP													
Captive	--	323.9	90.7	--	--	126.0	95.7	--	18.4	4.1	--	--	--
	--	-48.9%	+26.0%	--	--	-61.1%	+5.5%	--	-85.4%	-95.7%	--	--	--
PCM/Reseller	--	788.2	29.9	--	--	132.5	10.4	--	12.3	--	7.0	10.4	9.7
	--	-6.4%	+31.7%	--	--	-83.2%	-65.2%	--	-90.7%	--	--	+48.6%	-6.7%
OEM/Integrator	.2	1,987.8	381.6	.3	.2	356.8	103.5	26.5	86.1	9.9	26.1	26.2	13.5
	-33.3%	+17.6%	+72.0%	--	--	-82.1%	-72.9%	--	-75.9%	-90.4%	-1.5%	+.4%	-48.5%
Total Revenues	.2	3,099.9	502.2	.3	.2	615.3	209.6	26.5	116.8	14.0	33.1	36.6	23.2
	-90.5%	-2.1%	+58.7%	--	--	-80.2%	-58.3%	--	-81.0%	-93.3%	+24.9%	+10.6%	-36.6%
ANNUAL SHARE, BY DIAMETER	--	86.1%	13.9%	--	--	72.4%	24.6%	3.0%	71.4%	8.5%	20.1%	100.0%	100.0%

TABLE 38

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments				Forecast 1995				Forecast 1996			Forecast 1997	Forecast 1998
	8"	3.5"	2.5"	1.8"	8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS													
IBM Captive	--	780.0	50.0	--	--	280.0	190.0	--	--	--	--	--	--
PCM/Reseller	--	5,219.0	98.0	--	--	1,015.0	50.0	--	110.0	--	30.0	55.0	65.0
OEM/Integrator	.2	14,155.0	1,269.0	1.0	.2	2,695.0	493.0	90.0	680.0	65.0	120.0	145.0	95.0
TOTAL U.S. SHIPMENTS	.2	20,154.0	1,417.0	1.0	.2	3,990.0	733.0	90.0	790.0	65.0	150.0	200.0	160.0
NON-U.S. MANUFACTURERS													
Captive	--	92.2	110.0	--	--	70.0	30.0	--	50.0	10.0	--	--	--
PCM/Reseller	--	415.0	45.0	--	--	--	10.0	--	--	--	5.0	10.0	10.0
OEM/Integrator	--	526.5	551.7	--	--	223.0	125.0	20.0	95.0	--	15.0	25.0	15.0
TOTAL NON-U.S. SHIPMENTS	--	1,033.7	706.7	--	--	293.0	165.0	20.0	145.0	10.0	20.0	35.0	25.0
WORLDWIDE RECAP													
Captive	--	872.2	160.0	--	--	350.0	220.0	--	50.0	10.0	--	--	--
	--	-33.7%	+64.1%	--	--	-59.9%	+37.5%	--	-85.7%	-95.5%	--	--	--
PCM/Reseller	--	5,634.0	143.0	--	--	1,015.0	60.0	--	110.0	--	35.0	65.0	75.0
	--	+44.1%	+61.6%	--	--	-82.0%	-58.0%	--	-89.2%	--	--	+85.7%	+15.4%
OEM/Integrator	.2	14,681.5	1,820.7	1.0	.2	2,918.0	618.0	110.0	775.0	65.0	135.0	170.0	110.0
	-33.3%	+89.3%	+102.1%	--	--	-80.1%	-66.1%	--	-73.4%	-89.5%	+22.7%	+25.9%	-35.3%
Total Shipments	.2	21,187.7	2,123.7	1.0	.2	4,283.0	898.0	110.0	935.0	75.0	170.0	235.0	185.0
	-75.0%	+63.2%	+95.4%	--	--	-79.8%	-57.7%	--	-78.2%	-91.6%	+54.5%	+38.2%	-21.3%
ANNUAL SHARE, BY DIAMETER	--	91.0%	9.0%	--	--	81.0%	17.0%	2.0%	79.3%	6.4%	14.3%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	--	5,269.6	490.6	.3	--	1,099.7	222.4	28.6	225.6	17.9	43.2	60.4	48.1

TABLE 39

FIXED DISK DRIVES, 200 - 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 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	23,196.1	99.5	162.7	88.0
WORKSTATIONS Engineering and office, single user	69.9	.3	13.0	7.0
CONSUMER, GAME AND HOBBY COMPUTERS	46.6	.2	3.7	2.0
OTHER APPLICATIONS	--	--	5.6	3.0
Total	23,312.6	100.0	185.0	100.0

TABLE 40

FIXED DISK DRIVES, 200 - 300 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	1.39	1.35	1.50	--	--
2.5"	2.40	1.67	1.79	--	--
1.8"	--	--	--	--	--
Captive Average	1.53	1.47	1.54	--	--
PCM/Reseller					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.57	.50	.46	--	--
2.5"	.88	.72	--	--	--
1.8"	--	--	.79	.62	.49
PCM/Reseller Average	.57	.51	.54	.62	.49
OEM/Integrator					
8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.54	.48	.46	--	--
2.5"	.91	.68	.63	--	--
1.8"	1.00	.92	.75	.59	.47
OEM/Integrator Average	.58	.52	.51	.59	.47

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

1994 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	
Quantum	--	3463.0	227.0	3690.0	33.9	--	6490.0	420.0	6910.0	31.0
Conner Peripherals	--	2460.0	75.0	2535.0	23.3	--	4830.0	165.0	4995.0	22.4
Seagate Technology	--	1662.0	301.0	1963.0	18.1	--	3938.0	762.0	4700.0	21.1
Western Digital	--	1615.0	--	1615.0	14.9	--	2991.0	--	2991.0	13.4
Maxtor	--	400.0	--	400.0	3.7	--	850.0	--	850.0	3.8
Samsung Electronics	--	265.0	--	265.0	2.4	--	570.0	--	570.0	2.6
Toshiba	--	--	175.0	175.0	1.6	--	--	440.0	440.0	2.0
Other U.S.	.1	139.0	11.0	150.1	1.4	.2	275.0	21.0	296.2	1.3
Other Non-U.S.	--	16.2	62.6	78.8	.7	--	371.5	156.7	528.2	2.4
TOTAL	.1	10020.2	851.6	10871.9	100.0	.2	20315.5	1964.7	22280.4	100.0

FIXED DISK DRIVES, 300 - 500 MEGABYTES

1995 DISK/TREND REPORT

FIXED DISK DRIVES, 300 - 500 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	M2249, M2262
Sequel	XT-4380E/S

3.5" disk diameter

Conner Peripherals	CFS-425A**
Fujitsu	M2622S/T*, MK2682S/T**
Hitachi	DK314C-41*
Maxtor	7345A/S**, 7420AV**
NEC	D3772*, D3724**
Quantum	365A/S**, 420A LPS**
Raymond Engineering	84300
Seagate Technology	ST3491A**
Western Digital	WDAC1425**

2.5" disk diameter

Conner Peripherals	CFL-420A****
Fujitsu	M2705S***
IBM	DHAA/S-2405***, DBOA-2360****
NEC	D2713****
Quantum	341A/S Daytona***
Seagate Technology	ST9385AG***, ST9420AG****
Toshiba	MK-2326***, MK-1824****

1.8" disk diameter

Integral Peripherals	8340PA*****

*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).

The original disk drives in this capacity range 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 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 were followed with half high 5.25" models from 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 four disk 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. Steadily increasing areal densities made it possible for several other disk drive manufacturers to follow the Western Digital initiative with single disk 3.5" drives in 1994. With the start of 2.5" drive shipments in the 300-500 megabyte range in 1993, there has been an active race among drive manufacturers to establish a presence in the notebook computer market, and several have introduced drives only 12.7 millimeters high, or slightly less, with some models using only one disk. In late 1994, Integral Peripherals introduced a 1.8" drive with 340 megabytes capacity, using two disks, in the PCMCIA Type III PC Card format.

Market status

As expected, disk drive shipments in the 300-500 megabyte capacity group underwent a major increase in 1994, reaching 19.2 million units, an increase of 322.1%. However, the 1995 total for the product group is estimated at slightly less than 16 million drives, down 17.0%. The personal computer industry's appetite for increased disk capacity is so ravenous that leadership in disk drive shipments has jumped in one year from the 200-300 megabyte product group to the 500 megabyte-1 gigabyte range, skipping over this product group.

Rapidly declining prices held down the percentage increase in sales revenues for 1994. Revenues grew only 142.7% in 1994, for a total of $4.2 billion, and they are projected to drop to $2.7 billion in 1995, down 35.0%. Underlying the product group's weak revenue performance, the OEM/Integrator average price per megabyte for 3.5" drives, currently the group's dominant product, declined from $1.69 in 1992 to 79 cents in 1993, to 46 cents in 1994, and to an estimated 35 cents in 1995. Even a strong movement to higher average drive capacities within the product group, from 340 megabyte to 425 megabyte models, was not adequate to stabilize the product group's average unit price.

In 1994, 97.6% of the disk drives in the 300-500 megabyte capacity range were 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 created a movement to new product lines from most drive manufacturers, with low cost and reduced parts count becoming prime objectives. By 1998, the continuing movement to higher capacities for 3.5" and 2.5" drives used for desktop personal computer and notebook computer applications will leave 1.8" drives with most of the remaining shipments for the product group. In 1998, personal computers will decline to 89% of overall 300-500 megabyte drive shipments, with the rest in a variety of workstation, consumer and specialized industrial applications.

Because the market for 300-500 megabyte drives is dominated by desktop personal computer applications, shipments of 3.5" models reached 16.8 million units in 1994, 87.5% of the worldwide total. However, leadership of 3.5" drives in this capacity range is already starting to decline, as typical capacities for personal computers move higher. 1995 3.5" drive shipments are projected at 12.9 million units, down 23.3%, and providing only 80.9% of the worldwide total for the product group. Shipments of 3.5" drives in this product group are primarily through noncaptive channels, with captive drives providing only 6.4% of the 1994 total, dropping to an estimated 3.1% in 1995.

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 rose to 2.4 million in 1994, with about one third captive drives, also mostly from IBM and Toshiba. 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 average capacities for 2.5" disk drives, a trend which will move the typical 2.5" drive capacity to even higher levels in future years.

Conner Peripherals jumped into noncaptive 1994 shipment leadership in this product group, on the strength of its single disk 425 megabyte 3.5" drive, with 4.1

million drives, 23.5% of the worldwide unit total. Western Digital dropped to second place with 20.5%, and Seagate Technology was third with 19.8%.

Marketing trends

In recent years, a pattern of rapid decline has materialized for each disk drive product group as soon as it is practical to efficiently manufacture 3.5" drives at higher capacity levels with a minimum parts count. This pattern is expected to be repeated for the 300-500 megabyte product group, now that single disk 540 megabyte drives are in quantity production from all major drive manufacturers. 1996 total shipments for the product group are forecasted at 6.1 million drives, down 61.5%, and 1998 shipments are projected at only 580,000 drives, mostly 1.8" models. Sales revenues are expected to decline an average of 74.4% per year in the 1996-98 period, ending with 1998 revenues of $91.7 million.

As overall shipments for the 300-500 megabyte group decline, the product mix within the group will see major changes:

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
8"	.4	.2	--	--	--
	--	--	--	--	--
5.25"	16.6	3.6	.5	--	--
	.1%	--	--	--	--
3.5" 1.625" high	186.6	80.7	--	--	--
	1.0%	.5%	--	--	--
3.5" 1" high	16,623.6	12,825.0	3,385.0	565.0	--
	86.4%	80.3%	55.0%	30.2%	--
2.5" more than .5" high	2,198.4	2,339.5	2,050.0	600.0	10.0
	11.4%	14.6%	33.3%	32.1%	1.7%
2.5" .5" high or less	215.5	687.9	345.0	185.0	5.0
	1.1%	4.3%	5.6%	9.9%	.9%
1.8" PCMCIA Type III	--	40.0	370.0	520.0	565.0
	--	.3%	6.0%	27.8%	97.4%
Total	19,241.2	15,976.9	6,150.5	1,870.0	580.0

The same increases in disk areal density which are having such a noticeable effect on typical capacities of 3.5" drives will also affect 2.5" and 1.8" drives. In the case of 2.5" drives, system manufacturers are also moving up to capacities higher than those in this product group, with only slightly less urgency than with 3.5" drives. 1.8" drive shipments, on the other hand, are being driven to a somewhat lesser degree by notebook computer requirements for basic system drive capacity, and are expected to continue growing through 1998 in this capacity range. It is clear that 2.5" drives will be available at lower prices at each of the capacity points in this product group through 1998, but 1.8" drives with 300-500 megabyte capacities will be deemed appropriate for a continually broadening range of applications.

Technical trends

Advanced product development activities for 3.5" and 2.5" drives have already moved on to drives in higher capacity ranges. The remaining development programs involve only 1.8" drives, and will be aimed at two related objectives. Initially, cost reduction targets will stimulate efforts to utilize a single 1.8" disk to achieve 300-500 megabyte capacities, and this will probably become practical in the 1996/97 period. When single 1.8" disks can achieve this capacity, drive manufacturers might decide to introduce 5 millimeter thick Type II PC Card drives, which will be limited to a single disk. The packaging challenges for Type II drives will be difficult, but much of the work has already been done by drive manufacturers which deferred product introductions until the format could offer enough disk capacity to enjoy a broad market.

Forecasting assumptions

1. Shipments of 5.25" drives will end in 1996, and 3.5" drives will be shipped for the last time in 1997, as desktop personal computers move to higher capacities.
2. 2.5" drive shipments will shrink to negligible levels by 1998, as the notebook computer market also transitions to higher capacities.
3. Shipments of 1.8" drives will continue to grow through 1998, with modest penetration of notebook computer markets, plus a variety of workstation and industrial applications.

TABLE 42

FIXED DISK DRIVES, 300 - 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	529.2	779.1	250.8	376.2	97.5	152.9	28.8	43.2	--	--
Other U.S. Captive	5.9	8.1	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	535.1	787.2	250.8	376.2	97.5	152.9	28.8	43.2	--	--
PCM/Reseller	412.9	801.9	245.0	506.0	83.1	164.3	19.2	30.9	14.8	21.4
OEM/Integrator	1,068.5	1,990.2	946.2	1,540.8	330.0	554.2	107.9	175.4	36.6	56.8
TOTAL U.S. NONCAPTIVE	1,481.4	2,792.1	1,191.2	2,046.8	413.1	718.5	127.1	206.3	51.4	78.2
TOTAL U.S. REVENUES	2,016.5	3,579.3	1,442.0	2,423.0	510.6	871.4	155.9	249.5	51.4	78.2
Non-U.S. Manufacturers										
Captive	25.6	258.4	7.2	164.9	6.7	64.8	2.0	26.2	--	--
PCM/Reseller	37.5	106.6	7.9	35.9	4.2	12.1	3.2	6.1	3.3	5.8
OEM/Integrator	85.5	265.2	20.4	110.8	20.9	62.4	13.5	36.1	3.9	7.7
TOTAL NON-U.S. REVENUES	148.6	630.2	35.5	311.6	31.8	139.3	18.7	68.4	7.2	13.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,165.1	4,209.5	1,477.5	2,734.6	542.4	1,010.7	174.6	317.9	58.6	91.7
OEM Average Price ($000)		.184		.148		.146		.148		.155

TABLE 43

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994 Shipments		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,030.4	1,515.7	570.0	855.0	255.0	400.0	80.0	120.0	--	--
Other U.S. Captive	3.8	5.1	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,034.2	1,520.8	570.0	855.0	255.0	400.0	80.0	120.0	--	--
PCM/Reseller	2,330.8	4,505.3	1,722.0	3,525.0	630.0	1,280.0	120.0	210.0	90.0	130.0
OEM/Integrator	5,990.2	11,090.0	6,506.4	10,502.0	2,275.3	3,805.5	720.0	1,180.0	235.0	365.0
TOTAL U.S. NONCAPTIVE	8,321.0	15,595.3	8,228.4	14,027.0	2,905.3	5,085.5	840.0	1,390.0	325.0	495.0
TOTAL U.S. SHIPMENTS	9,355.2	17,116.1	8,798.4	14,882.0	3,160.3	5,485.5	920.0	1,510.0	325.0	495.0
Non-U.S. Manufacturers										
Captive	35.0	318.7	15.0	226.5	15.0	175.0	5.0	80.0	--	--
PCM/Reseller	235.0	676.0	52.0	245.0	26.0	85.0	17.0	35.0	20.0	35.0
OEM/Integrator	399.2	1,130.4	122.0	623.4	125.0	405.0	85.0	245.0	25.0	50.0
TOTAL NON-U.S. SHIPMENTS	669.2	2,125.1	189.0	1,094.9	166.0	665.0	107.0	360.0	45.0	85.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	10,024.4	19,241.2	8,987.4	15,976.9	3,326.3	6,150.5	1,027.0	1,870.0	370.0	580.0
Total Capacity (Terabytes)	3,693.5	7,092.2	3,425.8	6,101.5	1,298.8	2,404.4	389.5	712.1	147.8	231.4
Cumulative Shipments (Units in millions)										
IBM	2.3	3.3	2.9	4.1	3.1	4.5	3.2	4.7	3.2	4.7
Non-IBM	14.4	27.0	22.8	42.1	25.9	47.9	26.9	49.6	27.2	50.2
WORLDWIDE TOTAL	16.8	30.3	25.8	46.3	29.1	52.5	30.1	54.3	30.5	54.9

TABLE 44

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues				Forecast 1995					1996				1997			1998	
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	4.0	1.1	405.0	369.0	--	--	84.0	292.2	--	--	20.3	132.6	--	--	43.2	--	--	--
Other U.S. Captive	--	--	8.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	2.0	787.0	12.9	--	--	480.0	26.0	--	--	143.4	6.7	14.2	13.8	--	17.1	--	21.4
OEM/Integrator	--	10.5	1,720.9	258.8	--	2.0	1,177.6	349.2	12.0	.5	213.4	270.5	69.8	34.7	69.6	71.1	1.4	55.4
TOTAL U.S. REVENUES	4.0	13.6	2,921.0	640.7	--	2.0	1,741.6	667.4	12.0	.5	377.1	409.8	84.0	48.5	112.8	88.2	1.4	76.8
NON-U.S. MANUFACTURERS																		
Captive	--	2.6	152.4	103.4	1.9	.6	127.2	35.2	--	--	40.2	24.6	--	20.2	6.0	--	--	--
PCM/Reseller	--	--	94.6	12.0	--	--	31.3	4.6	--	--	7.9	1.6	2.6	1.1	--	5.0	--	5.8
OEM/Integrator	--	3.9	127.8	133.5	--	2.1	52.5	56.2	--	--	12.7	44.8	4.9	3.9	24.4	7.8	.7	7.0
TOTAL NON-U.S. REVENUES	--	6.5	374.8	248.9	1.9	2.7	211.0	96.0	--	--	60.8	71.0	7.5	25.2	30.4	12.8	.7	12.8
WORLDWIDE RECAP																		
Captive	4.0	3.7	565.5	472.4	1.9	.6	211.2	327.4	--	--	60.5	157.2	--	20.2	49.2	--	--	--
	-83.2%	-86.4%	+102.7%	+169.9%	-52.5%	-83.8%	-62.7%	-30.7%	--	--	-71.4%	-52.0%	--	-66.6%	-68.7%	--	--	--
PCM/Reseller	--	2.0	881.6	24.9	--	--	511.3	30.6	--	--	151.3	8.3	16.8	14.9	--	22.1	--	27.2
	--	-66.7%	+124.8%	+38.3%	--	--	-42.0%	+22.9%	--	--	-70.4%	-72.9%	--	-90.2%	--	+31.5%	--	+23.1%
OEM/Integrator	--	14.4	1,848.7	392.3	--	4.1	1,230.1	405.4	12.0	.5	226.1	315.3	74.7	38.6	94.0	78.9	2.1	62.4
	--	-67.9%	+156.4%	+727.6%	--	-71.5%	-33.5%	+3.3%	--	-87.8%	-81.6%	-22.2%	+522.5%	-82.9%	-70.2%	+5.6%	-97.8%	-20.9%
Total Revenues	4.0	20.1	3,295.8	889.6	1.9	4.7	1,952.6	763.4	12.0	.5	437.9	480.8	91.5	73.7	143.2	101.0	2.1	89.6
	-83.2%	-74.3%	+136.7%	+270.0%	-52.5%	-76.6%	-40.8%	-14.2%	--	-89.4%	-77.6%	-37.0%	+662.5%	-83.2%	-70.2%	+10.4%	-98.5%	-11.3%
ANNUAL SHARE, BY DIAMETER	.1%	.5%	78.4%	21.0%	.1%	.2%	71.5%	27.9%	.3%	--	43.4%	47.6%	9.0%	23.3%	45.0%	31.7%	2.3%	97.7%

TABLE 45

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments				Forecast 1995					1996				1997			1998	
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	.4	.3	900.0	615.0	--	--	240.0	615.0	--	--	70.0	330.0	--	--	120.0	--	--	--
Other U.S. Captive	--	--	5.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	2.1	4,453.2	50.0	--	--	3,390.0	135.0	--	--	1,185.0	40.0	55.0	125.0	--	85.0	--	130.0
OEM/Integrator	--	10.1	10,037.9	1,042.0	--	2.0	8,600.0	1,860.0	40.0	.5	1,840.0	1,680.0	285.0	330.0	480.0	370.0	10.0	355.0
TOTAL U.S. SHIPMENTS	.4	12.5	15,396.2	1,707.0	--	2.0	12,230.0	2,610.0	40.0	.5	3,095.0	2,050.0	340.0	455.0	600.0	455.0	10.0	485.0
NON-U.S. MANUFACTURERS																		
Captive	--	.8	174.9	143.0	.2	.2	155.2	70.9	--	--	120.0	55.0	--	65.0	15.0	--	--	--
PCM/Reseller	--	--	630.0	46.0	--	--	220.0	25.0	--	--	65.0	10.0	10.0	10.0	--	25.0	--	35.0
OEM/Integrator	--	3.4	609.1	517.9	--	1.4	300.5	321.5	--	--	105.0	280.0	20.0	35.0	170.0	40.0	5.0	45.0
TOTAL NON-U.S. SHIPMENTS	--	4.2	1,414.0	706.9	.2	1.6	675.7	417.4	--	--	290.0	345.0	30.0	110.0	185.0	65.0	5.0	80.0
WORLDWIDE RECAP																		
Captive	.4	1.1	1,080.0	758.0	.2	.2	395.2	685.9	--	--	190.0	385.0	--	65.0	135.0	--	--	--
	-90.9%	-86.1%	+309.2%	+218.5%	-50.0%	-81.8%	-63.4%	-9.5%	--	--	-51.9%	-43.9%	--	-65.8%	-64.9%	--	--	--
PCM/Reseller	--	2.1	5,083.2	96.0	--	--	3,610.0	160.0	--	--	1,250.0	50.0	65.0	135.0	--	110.0	--	165.0
	--	-64.4%	+264.6%	+92.0%	--	--	-29.0%	+66.7%	--	--	-65.4%	-68.7%	--	-89.2%	--	+69.2%	--	+50.0%
OEM/Integrator	--	13.5	10,647.0	1,559.9	--	3.4	8,900.5	2,181.5	40.0	.5	1,945.0	1,960.0	305.0	365.0	650.0	410.0	15.0	400.0
	--	-69.5%	+340.8%	--	--	-74.8%	-16.4%	+39.8%	--	-85.3%	-78.1%	-10.2%	+662.5%	-81.2%	-66.8%	+34.4%	-97.7%	-2.4%
Total Shipments	.4	16.7	16,810.2	2,413.9	.2	3.6	12,905.7	3,027.4	40.0	.5	3,385.0	2,395.0	370.0	565.0	785.0	520.0	15.0	565.0
	-90.9%	-71.3%	+312.7%	+470.3%	-50.0%	-78.4%	-23.2%	+25.4%	--	-86.1%	-73.8%	-20.9%	+825.0%	-83.3%	-67.2%	+40.5%	-98.1%	+8.7%
ANNUAL SHARE, BY DIAMETER	--	.1%	87.5%	12.4%	--	--	80.9%	18.9%	.2%	--	55.1%	38.9%	6.0%	30.3%	42.0%	27.7%	2.6%	97.4%
TOTAL CAPACITY (Terabytes)	.2	5.8	6,228.0	858.2	.1	1.2	4,996.3	1,090.3	13.6	.2	1,416.8	861.6	125.8	237.3	282.4	192.4	5.4	226.0

TABLE 46

FIXED DISK DRIVES, 300 - 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	--	--	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	153.9	.8	--	--
PERSONAL COMPUTERS Business and professional, single user	18,779.5	97.6	516.2	89.0
WORKSTATIONS Engineering and office, single user	288.6	1.5	46.4	8.0
CONSUMER, GAME AND HOBBY COMPUTERS	19.2	.1	5.8	1.0
OTHER APPLICATIONS	--	--	11.6	2.0
Total	19,241.2	100.0	580.0	100.0

TABLE 47

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	Forecast 1996	Forecast 1997	Forecast 1998
Captive					
8"	20.00	18.76	--	--	--
5.25"	9.02	6.20	--	--	--
3.5"	1.47	1.49	.80	.73	--
2.5"	1.74	1.33	1.13	1.01	--
1.8"	--	--	--	--	--
Captive Average	1.59	1.39	1.02	.91	--
PCM/Reseller					
8"	--	--	--	--	--
5.25"	2.47	--	--	--	--
3.5"	.46	.35	.28	.26	--
2.5"	.73	.52	.46	--	--
1.8"	--	--	.75	.54	.41
PCM/Reseller Average	.47	.36	.31	.38	.41
OEM/Integrator					
8"	--	--	--	--	--
5.25"	3.14	3.76	2.85	--	--
3.5"	.46	.35	.27	.25	--
2.5"	.70	.51	.44	.40	.37
1.8"	--	.88	.72	.51	.39
OEM/Integrator Average	.49	.39	.37	.39	.39

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

	1994 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	
Conner Peripherals	--	2045.0	52.0	2097.0	23.4	--	3910.0	185.0	4095.0	23.5
Western Digital	--	1930.0	--	1930.0	21.6	--	3575.0	--	3575.0	20.5
Seagate Technology	--	1715.0	161.0	1876.0	20.9	1.0	3143.0	302.0	3446.0	19.8
Quantum	--	962.0	65.0	1027.0	11.5	--	1846.0	120.0	1966.0	11.3
Maxtor	--	910.0	--	910.0	10.2	--	1560.0	--	1560.0	9.0
IBM	--	275.0	195.0	470.0	5.2	--	450.0	485.0	935.0	5.4
Samsung Electronics	--	360.0	--	360.0	4.0	--	895.0	--	895.0	5.1
Toshiba	--	--	155.0	155.0	1.7	--	--	476.0	476.0	2.7
Other U.S.	5.5	5.5	--	11.0	.1	11.2	7.1	--	18.3	.1
Other Non-U.S.	.1	78.0	41.1	119.2	1.4	3.4	344.1	87.9	435.4	2.6
TOTAL	5.6	8280.5	669.1	8955.2	100.0	15.6	15730.2	1655.9	17401.7	100.0

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

1995 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

8"-10.5" disk diameter

Fujitsu	M2382K/P, M2361A
Hitachi	DKU-87I

5.25" disk diameter

Fujitsu	M2263
Hitachi	DK711S-60D
Sequel	XT-8760SH

3.5" disk diameter

Conner Peripherals	CFS-635A**, CFS-850A**
Fujitsu	M2624S/T*, M2684S/T**
Hitachi	DK325C-57**
IBM	DPEA-30540**, DALA-3540**
JTS	P3540****
Maxtor	7850AV**, 7540AV**
NEC	D3743**, D3725**
Quantum	540A/S Maverick**, 730A/S Lightning**
Samsung Electronics	PLS-3085A/S**
Seagate Technology	ST3780A**, ST5660A/N***
Western Digital	WDAC2635**, WDHC2635**

2.5"-3" disk diameter

Fujitsu	M2706S***, M2713TAM****
Hitachi	DK211A***, DK222A-54****
IBM	DPRS-20810***, DSOA-20810****
JTS	N2840AR*****
Maxtor	250837P****
Quantum	514A/S Daytona***
Seagate Technology	ST9655AG***
Toshiba	MK-2628***, MK-1926****

*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.
*****Maximum 10.5 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 disk 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 products from many of the same companies already competing in lower capacity 5.25" drive markets, but most of these drives were pushed out of the market in the early 1990's by a wave of 3.5" drive introductions.

In 1990, Maxtor was also the first company to offer a 3.5" drive in this product group, but the firm was quickly followed by numerous competitors. During 1993-94, most 3.5" drive manufacturers added 1" high models, and in 1995 most of the surviving participants have added drives using a single 3.5" disk.

Toshiba, which provided much of the product leadership in 2.5" drives during the early 1990's, announced 520 megabyte 2.5" models in 1993, the first 2.5" drives in this capacity range. In 1994, IBM's Bolero series achieved up to 720 megabytes using two disks in a 12.5 millimeter high drive. A new type of disk drive competitor for the notebook computer market has appeared in 1995, with the JTS introduction of the 3" Nordic drive, a model which is intended to offer lower prices than 2.5" drives of the same capacity.

Market status

Shipments of drives in this capacity range didn't reach a million drives until 1992, but things change quickly in the disk drive industry, and in 1995 worldwide shipments for the product group are expected to top 42.1 million units. Total shipments at this level will make the group the industry's largest, with 48% of the year's entire shipments for drives of all capacities. Sales revenues for disk drives in the 500 megabyte - 1 gigabyte range are forecasted to reach $9.1 billion in 1995, up 128.8% over the previous year.

The rapid rise of disk drive shipments in this capacity range was triggered by the jump in typical disk capacities demanded for desktop personal computers, plus enhanced sales stimulated by the sharp fall in average drive prices. Faster PC processors, improved operating systems and application programs, data downloaded from the Internet and wider personal computer usage are all contributing to 1995's notable increase in drive shipments in the 500 megabyte - 1 gigabyte range. Just in time to exploit the new demand, the industry's incessant increases in areal density made possible 3.5" drives in this capacity range with only one or two disks, for which production could be quickly ramped to high levels, at low unit cost. The average OEM/Integrator price per megabyte for 3.5" drives dropped from 92 cents in 1993 to 52 cents in 1994, and the average for 1995 is projected at only 25 cents. The result has been one of the industry's most prolific marriages of supply and demand.

Shipments of 3.5" drives for desktop personal computer markets have been the dominant contributor to the product group's 1995 sales success. 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 have become the standard for 3.5" drives in 1994-95. The 1993 shipment total for 1" high drives was 1.6 million, 1994 shipments grew to more than 9.5 million units, and 36.3 million drives are forecasted for 1995. The same phenomenon is starting to occur with 2.5" drives, as drives with 12.5 or 12.7 millimeter heights appear in the product lines of most 2.5" drive manufacturers. 1995 shipments of 2.5" drives in this capacity range are forecasted to top 5.8 million units, with the majority now 12.7 millimeters or less in height.

The evolution of applications for drives in this product group has been rapid. In 1993 business and professional personal computers utilized only 63.2% of the unit shipments, but in 1994 the PC share was up to 84.7, and it is projected to hold 96.0% of 1998 shipments. Engineering and office workstation applications held 17.7% of 1993 shipments, dropping to 7.1% in 1994, and are expected to decline to 2.5% of the 1997 market. Networks/minicomputers/multiuser applications led this product group before 1993, but down to 8.1% of 1993 shipments, with a further decline to 1% projected for 1998, as the capacity requirements for these applications migrate to levels above this product group.

Quantum moved up to lead the industry in noncaptive drive shipments in this capacity range in 1994, with 28% of the worldwide total, mostly 3.5" drives. Western Digital held second place with 17.4%, and Conner Peripherals was third with 13.2%.

Marketing trends

Shipments of 500 megabyte - 1 gigabyte are forecasted to decline only 5.9% in 1996, and the product group is expected to retain shipment leadership for a second year, despite a reduction of worldwide shipments to 39.7 million drives. After 1996, key personal computer applications are expected to transition to higher typical capacities, and shipments in 1997 will be less than half the previous, dropping even faster in 1998, to only 4.6 million drives. Total sales revenues for 1998 are projected to dip below $1 billion.

The older large diameter drives which dominated shipments in this product group until the last few years are at end of life, and the full size 3.5" drives are ending production this year.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
8"-10.5"	5.2	6.4	2.0	--	--
	--	--	--	--	--
5.25"	38.2	8.3	3.5	--	--
	.3%	--	--	--	--
3.5" 1.625" high	36.3	3.5	--	--	--
	.3%	--	--	--	--
3.5" 1" high	9,573.3	36,307.2	32,785.0	13,085.0	1,760.0
	87.6%	86.1%	82.6%	71.8%	37.9%
2.5" more than .5" high	592.1	2,143.0	1,070.0	260.0	50.0
	5.4%	5.1%	2.7%	1.4%	1.1%
2.5" .5" high or less	680.0	3,710.0	5,840.0	4,855.0	2,590.0
	6.2%	8.8%	14.7%	26.6%	55.8%
1.8" PCMCIA Type III	--	--	--	30.0	240.0
	--	--	--	.2%	5.2%
Total	10,925.1	42,178.4	39,700.5	18,230.0	4,640.0

The DISK/TREND Report forecast for 1996-98 assumes that demand in 1996 for 3.5" drives in the 500 megabyte - 1 gigabyte range for personal computer applications will be sufficient to maintain overall shipment leadership for the product group, despite a rapid increase in shipments of 1-2 gigabyte drives which will reach a total almost as large. The inevitable improvements in recording density will affect drive prices in each product group in a similar manner -- the disks to be produced in 1996 at low cost with an individual capacity of 850 megabytes will be used in drives sold in each of the two product groups, and the decline in average price per unit should follow similar patterns in each product group. The expected result is that 850 megabyte single disk 3.5" drives should have an excellent sales year in 1996, until displaced in following years by the predictable movement to even higher capacities for personal computers.

Growing demand is expected for 2.5" drives for notebook computers, with most of the market moving to drives with heights of 12.7 millimeters or less by 1998, representing 55.8% of the product group's shipments in that year. By 1997, the first 1.8" PC Card drives with over 500 megabytes capacity are expected, also targeted mostly at notebook computer applications.

Technical trends

This product group has benefited greatly from development work under way in other capacity ranges. The 3.5" drives currently available at low cost have been the result of development of "product families" originally initiated for lower capacity ranges, which have evolved into drives with capacities in this product group and higher. The product family concept makes it possible to quickly move to new higher capacity models as new critical components, such as heads, disks and semiconductors, become available. Usually, only a small percentage of the drive's components are changed for a new model, achieving a fast manufacturing start, and reducing costs to a minimum level.

Most major drive manufacturers will undoubtedly introduce single platter 3.5" drives with about 850 megabytes in 1996, and many of the same components will be utilized in 2.5" drives. IBM is starting 1995 shipments of an 810 megabyte 2.5" drive using two disks, and next year's areal densities will further reduce the disk count.

Forecasting assumptions

1. 5.25" and 8" drives will be produced for the last time in 1996.
2. Shipments of 3.5" drives for personal computer markets and other applications will decline only slightly in 1996, but will drop rapidly in following years, displaced by higher capacity drives.
3. Shipments of 2.5" drives will peak in 1996, and initial shipments of 1.8" drives in this product group will start no later than 1996.

TABLE 49

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	488.6	720.4	913.5	1,368.8	831.0	1,272.5	570.6	890.0	252.5	395.5
Other U.S. Captive	13.2	18.0	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	501.8	738.4	913.5	1,368.8	831.0	1,272.5	570.6	890.0	252.5	395.5
PCM/Reseller	477.2	867.6	925.2	1,707.3	619.1	1,126.8	233.9	423.4	32.4	58.4
OEM/Integrator	990.2	1,946.6	2,735.8	4,662.9	1,812.2	3,245.7	703.7	1,294.6	160.7	282.0
TOTAL U.S. NONCAPTIVE	1,467.4	2,814.2	3,661.0	6,370.2	2,431.3	4,372.5	937.6	1,718.0	193.1	340.4
TOTAL U.S. REVENUES	1,969.2	3,552.6	4,574.5	7,739.0	3,262.3	5,645.0	1,508.2	2,608.0	445.6	735.9
Non-U.S. Manufacturers										
Captive	37.3	207.6	108.5	550.7	89.2	383.9	64.4	224.8	33.3	106.9
PCM/Reseller	6.0	14.8	57.6	135.8	45.8	107.9	24.3	56.7	8.0	17.4
OEM/Integrator	72.1	226.0	270.0	727.4	230.3	633.9	118.1	331.3	46.0	139.0
TOTAL NON-U.S. REVENUES	115.4	448.4	436.1	1,413.9	365.3	1,125.7	206.8	612.8	87.3	263.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,084.6	4,001.0	5,010.6	9,152.9	3,627.6	6,770.7	1,715.0	3,220.8	532.9	999.2
OEM Average Price ($000)		.306		.186		.151		.138		.154

TABLE 50

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	620.4	914.7	1,593.2	2,400.3	1,835.0	2,820.0	1,470.0	2,300.0	700.0	1,100.0
Other U.S. Captive	10.2	13.4	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	630.6	928.1	1,593.2	2,400.3	1,835.0	2,820.0	1,470.0	2,300.0	700.0	1,100.0
PCM/Reseller	1,526.2	2,760.2	5,273.1	9,692.2	4,365.0	7,940.0	1,845.0	3,345.0	262.0	475.0
OEM/Integrator	3,241.3	6,405.7	15,182.7	25,888.8	12,451.5	22,282.0	5,305.0	9,780.0	1,055.0	1,885.0
TOTAL U.S. NONCAPTIVE	4,767.5	9,165.9	20,455.8	35,581.0	16,816.5	30,222.0	7,150.0	13,125.0	1,317.0	2,360.0
TOTAL U.S. SHIPMENTS	5,398.1	10,094.0	22,049.0	37,981.3	18,651.5	33,042.0	8,620.0	15,425.0	2,017.0	3,460.0
Non-U.S. Manufacturers										
Captive	30.1	120.9	125.0	518.4	145.0	613.0	125.0	445.0	70.0	225.0
PCM/Reseller	15.0	37.0	290.0	670.0	275.0	640.0	160.0	370.0	50.0	110.0
OEM/Integrator	232.0	673.2	1,196.0	3,008.7	1,325.0	3,405.5	748.0	1,990.0	285.0	845.0
TOTAL NON-U.S. SHIPMENTS	277.1	831.1	1,611.0	4,197.1	1,745.0	4,658.5	1,033.0	2,805.0	405.0	1,180.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	5,675.2	10,925.1	23,660.0	42,178.4	20,396.5	37,700.5	9,653.0	18,230.0	2,422.0	4,640.0
Total Capacity (Terabytes)	3,234.9	6,223.0	15,496.4	27,563.7	13,588.2	25,196.7	7,440.9	14,115.2	2,075.9	4,015.7
Cumulative Shipments (Units in millions)										
IBM	1.0	1.6	2.6	4.0	4.4	6.8	5.9	9.1	6.6	10.2
Non-IBM	8.4	15.3	30.5	55.0	49.0	89.9	57.2	105.9	58.9	109.4
WORLDWIDE TOTAL	9.4	16.9	33.1	59.1	53.5	96.8	63.2	115.0	65.6	119.6

TABLE 51

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues				Forecast 1995				1996				1997			1998		
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	8.6	411.8	300.0	--	3.6	493.7	871.5	--	--	438.6	833.9	315.0	575.0	--	132.0	263.5	--
Other U.S. Captive	--	8.4	9.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	5.0	859.6	3.0	--	.2	1,692.3	14.8	--	--	1,106.8	20.0	408.8	13.3	1.3	48.4	7.9	2.1
OEM/Integrator	--	21.3	1,790.5	134.8	--	4.5	4,028.0	630.4	--	2.4	2,676.5	566.8	952.2	337.6	4.8	81.5	159.9	40.6
TOTAL U.S. REVENUES	--	43.3	3,071.5	437.8	--	8.3	6,214.0	1,516.7	--	2.4	4,221.9	1,420.7	1,676.0	925.9	6.1	261.9	431.3	42.7
NON-U.S. MANUFACTURERS																		
Captive	58.1	18.9	15.2	115.4	120.7	8.4	57.6	364.0	30.0	3.9	48.6	301.4	11.0	213.8	--	--	106.9	--
PCM/Reseller	--	--	--	14.8	--	--	84.0	51.8	--	--	68.0	39.9	26.7	30.0	--	3.4	12.8	1.2
OEM/Integrator	7.2	8.4	70.4	140.0	5.5	1.9	193.7	526.3	2.5	--	187.0	444.4	72.0	258.1	1.2	10.0	125.0	4.0
TOTAL NON-U.S. REVENUES	65.3	27.3	85.6	270.2	126.2	10.3	335.3	942.1	32.5	3.9	303.6	785.7	109.7	501.9	1.2	13.4	244.7	5.2
WORLDWIDE RECAP																		
Captive	58.1	35.9	436.6	415.4	120.7	12.0	551.3	1,235.5	30.0	3.9	487.2	1,135.3	326.0	788.8	--	132.0	370.4	--
	-44.3%	-58.5%	+225.1%	--	+107.7%	-66.6%	+26.3%	+197.4%	-75.1%	-67.5%	-11.6%	-8.1%	-33.1%	-30.5%	--	-59.5%	-53.0%	--
PCM/Reseller	--	5.0	859.6	17.8	--	.2	1,776.3	66.6	--	--	1,174.8	59.9	435.5	43.3	1.3	51.8	20.7	3.3
	--	-86.7%	+398.0%	--	--	-96.0%	+106.6%	+274.2%	--	--	-33.9%	-10.1%	-62.9%	-27.7%	--	-88.1%	-52.2%	+153.8%
OEM/Integrator	7.2	29.7	1,860.9	274.8	5.5	6.4	4,221.7	1,156.7	2.5	2.4	2,863.5	1,011.2	1,024.2	595.7	6.0	91.5	284.9	44.6
	-76.1%	-51.2%	+112.8%	--	-23.6%	-78.5%	+126.9%	+320.9%	-54.5%	-62.5%	-32.2%	-12.6%	-64.2%	-41.1%	--	-91.1%	-52.2%	+643.3%
Total Revenues	65.3	70.6	3,157.1	708.0	126.2	18.6	6,549.3	2,458.8	32.5	6.3	4,525.5	2,206.4	1,785.7	1,427.8	7.3	275.3	676.0	47.9
	-51.4%	-61.8%	+167.3%	--	+93.3%	-73.7%	+107.4%	+247.3%	-74.2%	-66.1%	-30.9%	-10.3%	-60.5%	-35.3%	--	-84.6%	-52.7%	+556.2%
ANNUAL SHARE, BY DIAMETER	1.6%	1.8%	79.0%	17.6%	1.4%	.2%	71.7%	26.7%	.5%	.1%	66.9%	32.5%	55.5%	44.3%	.2%	27.7%	67.7%	4.6%

Note: 8 inch totals include 6.5 inch - 9.5 inch drives.
2.5 inch totals include 3 inch drives.

TABLE 52

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments				Forecast 1995			
	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS								
IBM Captive	--	.7	539.0	375.0	--	.3	1,155.0	1,245.0
Other U.S. Captive	--	7.0	6.4	--	--	--	--	--
PCM/Reseller	--	3.7	2,748.5	8.0	--	.2	9,642.0	50.0
OEM/Integrator	--	15.5	5,984.2	406.0	--	3.8	23,650.0	2,235.0
TOTAL U.S. SHIPMENTS	--	26.9	9,278.1	789.0	--	4.3	34,447.0	3,530.0
NON-U.S. MANUFACTURERS								
Captive	3.7	5.9	15.1	96.2	5.4	3.0	90.0	420.0
PCM/Reseller	--	--	--	37.0	--	--	500.0	170.0
OEM/Integrator	1.5	5.4	316.4	349.9	1.0	1.0	1,273.7	1,733.0
TOTAL NON-U.S. SHIPMENTS	5.2	11.3	331.5	483.1	6.4	4.0	1,863.7	2,323.0
WORLDWIDE RECAP								
Captive	3.7	13.6	560.5	471.2	5.4	3.3	1,245.0	1,665.0
	-43.9%	-32.3%	+758.3%	--	+45.9%	-75.7%	+122.1%	+253.4%
PCM/Reseller	--	3.7	2,748.5	45.0	--	.2	10,142.0	220.0
	--	-89.8%	+788.0%	--	--	-94.6%	+269.0%	+388.9%
OEM/Integrator	1.5	20.9	6,300.6	755.9	1.0	4.8	24,923.7	3,968.0
	-55.9%	-67.8%	+273.8%	--	-33.3%	-77.0%	+295.6%	+424.9%
Total Shipments	5.2	38.2	9,609.6	1,272.1	6.4	8.3	36,310.7	5,853.0
	-48.0%	-68.6%	+366.4%	--	+23.1%	-78.3%	+277.9%	+360.1%
ANNUAL SHARE, BY DIAMETER	--	.3%	88.1%	11.6%	--	--	86.2%	13.8%
TOTAL CAPACITY (Terabytes)	3.6	25.9	5,441.6	751.9	4.7	5.5	23,800.0	3,753.5

	Forecast 1996				1997			1998		
	8"	5.25"	3.5"	2.5"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS										
IBM Captive	--	--	1,290.0	1,530.0	1,050.0	1,250.0	--	480.0	620.0	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	7,850.0	90.0	3,270.0	70.0	5.0	420.0	45.0	10.0
OEM/Integrator	--	2.0	19,680.0	2,600.0	7,935.0	1,825.0	20.0	740.0	940.0	205.0
TOTAL U.S. SHIPMENTS	--	2.0	28,820.0	4,220.0	12,255.0	3,145.0	25.0	1,640.0	1,605.0	215.0
NON-U.S. MANUFACTURERS										
Captive	1.5	1.5	120.0	490.0	30.0	415.0	--	--	225.0	--
PCM/Reseller	--	--	460.0	180.0	210.0	160.0	--	30.0	75.0	5.0
OEM/Integrator	.5	--	1,385.0	2,020.0	590.0	1,395.0	5.0	90.0	735.0	20.0
TOTAL NON-U.S. SHIPMENTS	2.0	1.5	1,965.0	2,690.0	830.0	1,970.0	5.0	120.0	1,035.0	25.0
WORLDWIDE RECAP										
Captive	1.5	1.5	1,410.0	2,020.0	1,080.0	1,665.0	--	480.0	845.0	--
	-72.2%	-54.5%	+13.3%	+21.3%	-23.4%	-17.6%	--	-55.6%	-49.2%	--
PCM/Reseller	--	--	8,310.0	270.0	3,480.0	230.0	5.0	450.0	120.0	15.0
	--	--	-18.1%	+22.7%	-58.1%	-14.8%	--	-87.1%	-47.8%	+200.0%
OEM/Integrator	.5	2.0	21,065.0	4,620.0	8,525.0	3,220.0	25.0	830.0	1,675.0	225.0
	-50.0%	-58.3%	-15.5%	+16.4%	-59.5%	-30.3%	--	-90.3%	-48.0%	+800.0%
Total Shipments	2.0	3.5	30,785.0	6,910.0	13,085.0	5,115.0	30.0	1,760.0	2,640.0	240.0
	-68.7%	-57.8%	-15.2%	+18.1%	-57.5%	-26.0%	--	-86.5%	-48.4%	+700.0%
ANNUAL SHARE, BY DIAMETER	--	--	81.8%	18.2%	71.9%	28.1%	--	38.0%	56.9%	5.1%
TOTAL CAPACITY (Terabytes)	1.5	2.4	20,010.3	5,182.5	9,813.8	4,285.3	16.2	1,496.0	2,376.0	143.7

Note: 8 inch totals include 6.5 inch - 9.5 inch drives.
2.5 inch totals include 3 inch drives.

TABLE 53

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	10.9	.1	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	884.9	8.1	46.4	1.0
PERSONAL COMPUTERS Business and professional, single user	9,253.6	84.7	4,454.4	96.0
WORKSTATIONS Engineering and office, single user	775.7	7.1	116.0	2.5
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	23.2	.5
OTHER APPLICATIONS	--	--	--	--
Total	10,925.1	100.0	4,640.0	100.0

TABLE 54

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
8"	22.31	30.17	25.00	--	--
5.25"	3.98	5.71	3.71	--	--
3.5"	1.32	.67	.53	.40	.32
2.5"	1.41	1.05	.74	.58	.48
1.8"	--	--	--	--	--
Captive Average	1.49	.96	.68	.51	.43
PCM/Reseller					
8"	--	--	--	--	--
5.25"	1.90	1.20	--	--	--
3.5"	.55	.26	.21	.16	.13
2.5"	.76	.54	.29	.22	.19
1.8"	--	--	--	.47	.37
PCM/Reseller Average	.56	.27	.22	.17	.15
OEM/Integrator					
8"	7.20	7.78	7.14	--	--
5.25"	2.07	2.01	1.77	--	--
3.5"	.52	.25	.20	.16	.13
2.5"	.63	.47	.29	.21	.18
1.8"	--	--	--	.45	.33
OEM/Integrator Average	.54	.28	.22	.17	.17

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.

8 inch totals include 6.5 inch - 9.5 inch drives.

2.5 inch totals include 3 inch drives.

TABLE 55

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	8"	5.25"	3.5"	2.5"	Total		8"	5.25"	3.5"	2.5"	Total	
Quantum	--	--	1045.0	44.0	1089.0	21.7	--	--	2689.0	74.0	2763.0	28.0
Western Digital	--	--	930.0	--	930.0	18.5	--	--	1720.0	--	1720.0	17.4
Conner Peripherals	--	--	880.0	--	880.0	17.5	--	--	1300.0	--	1300.0	13.2
Seagate Technology	--	--	622.0	20.0	642.0	12.8	--	1.0	1225.0	35.0	1261.0	12.8
Maxtor	--	--	600.0	--	600.0	12.0	--	--	1040.0	--	1040.0	10.5
IBM	--	--	345.0	155.0	500.0	10.0	--	--	575.0	305.0	880.0	8.9
Toshiba	--	--	--	115.0	115.0	2.3	--	--	--	377.0	377.0	3.8
Fujitsu	--	--	91.4	--	91.4	1.8	--	.3	234.6	--	234.9	2.4
Digital Equipment	--	--	94.2	--	94.2	1.9	--	--	156.7	--	156.7	1.6
Other U.S.	--	12.6	19.7	--	32.3	.6	--	18.2	27.0	--	45.2	.5
Other Non-U.S.	--	1.0	33.5	6.1	40.6	.9	1.5	5.1	81.8	9.9	98.3	.9
TOTAL	--	13.6	4660.8	340.1	5014.5	100.0	1.5	24.6	9049.1	800.9	9876.1	100.0

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

FIXED DISK DRIVES, 1 - 2 GIGABYTES

1995 DISK/TREND REPORT

FIXED DISK DRIVES, 1 - 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

9.5" disk diameter

Hitachi	DKU-86I, H-6556-I

8" disk diameter

Fujitsu	M2392K

5.25" disk diameter

Fujitsu	M2266, M2652
Gigastorage International	B5110A**
Hitachi	DK516C-16
Seagate Technology	ST41800K

3.5" disk diameter

Conner Peripherals	CFS-1275A**, CFS-1621**
Fujitsu	M2694*, M2927**
Hewlett-Packard	C3724A/S**, C3323A**
Hitachi	DK315C-14*, DK326C-10**
IBM	DJAA-31700**, DORS-31080**
Maxtor	71626AP**,71260A/S**
Micropolis	2217AV*, 4110A/S**
NEC	D3845**, D3847**
Quantum	1280A/S Fireball**, 1400S Empire**
Samsung	TBR-31081A**, PLS-31609A**
Seagate Technology	ST51080A/N***, ST31640A**
Western Digital	WDAC31000**, WDAC31600**

2.5" disk diameter

Fujitsu	M2714TAM****
Hitachi	DK212A-10***
IBM	DPRA-21215***, DSOA-21080****
Integral Peripherals	Platinum/1010****
Maxtor	251340****
Quantum	1080AT Europa***
Toshiba	MK-2720FC***

*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.

There are still drives in this product group that were designed for mainframe computer applications, but their shipments are now negligible. IBM's 3380 was the core of this product group during the first half of the 1980's, after painful delays in the product's introduction. However, IBM's 3380 series moved to higher capacities in 1985, and the product group has seen little application in mainframe computer markets in the last decade. During this period, the industry has seen successive generations of 8"-10.5" drives, then 5.25" drives, and current dominance by 3.5" drives.

Although 1" high 3.5" drives will provide more than 95% of 1995 shipments for this product group, significant new drive programs are under way in both smaller and larger diameter drives. The first 2.5" drives with more than 1 gigabyte capacity have appeared in the product lines of 7 manufacturers in 1995, with capacities ranging up to 1.3 gigabytes, and several drives with heights less than 12.7 millimeters. The industry is also seeing the reincarnation of the 5.25" form factor, with a new drive from Gigastorage International, designed to provide very low cost disk storage for high-end personal computers. At least one of the major disk drive manufacturers is also planning a comparable 5.25" drive for introduction in mid-1996.

Market status

Shipments of 1-2 gigabyte drives are going through a period of rapid growth, but prices are falling faster than shipments are rising. 1994 total unit shipments for the product group in 1994 rose to 4.8 million drives and sales revenues grew to $3.9 billion, a boost in shipments of 103.8%, but an increase in revenues of only 19.9%. In 1995, shipments are projected to jump 233.6% to over 16 million units, while revenues increase to $4.8 billion, up only 23.4%.

Average unit prices are falling quickly as high volume personal computer applications, for which low cost drives with average performance are in demand, overtake the product group's traditional workstation, midrange and mainframe computer markets, for which smaller quantities of high performance drives are required. Although the first 3.5" drives with more than 1 gigabyte capacity did not ship until 1991, by 1994 3.5" drives provided 97.3% of total unit shipments for this product group. The average OEM/Integrator price per megabyte for 3.5" drives in this capacity class was 74 cents in 1993, but the price declined to 50 cents in 1994, and in 1995 it is estimated at only 19 cents.

Until the last few years, 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 dropped to 2.4% in 1994 and are now disappearing completely. Even the 54% of 1994 shipments which were used in networks/minicomputer/multiuser applications will shrink to an estimated 4% in 1998, and 1994's 27.9% for workstation applications will drop to 3% in 1998. Personal computer applications consumed only 2.5% of the 1993 shipment total but had already grown to 15.4% in 1994, and are destined to take an estimated 93% of 1998 shipments, as the desktop personal computer market continues to absorb continually higher disk drive capacities.

Seagate Technology continued to lead in noncaptive unit shipments for the product group in 1994 with 30.9% of the worldwide total, including both 5.25" and 3.5" drives. IBM moved up to second place with 13.3% and Quantum was third with 10.0%, with both firms shipping only 3.5" disk drives.

Marketing trends

In 1996, worldwide shipments of 1-2 gigabyte drives are forecasted to jump to more than 36.3 million units, rivaling the 500 megabyte - 1 gigabyte product group for industry leadership. In 1997, the 1-2 gigabyte group is expected to assume clear leadership in total shipments with 49.4 million drives. In 1997, the product group is projected to drop to 29.3 million drives, down 40.7%, as the computer industry concentrates on disk drives with even higher capacities for personal computers and most other applications. Sales revenues for the product group are expected to peak in 1997 at $8.6 billion, before dropping to less than $5 billion in 1998.

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 out of production after 1995. 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 in the next year or two. 2.5" drives are also shrinking in physical size, with four manufacturers already offering drives with heights of 12.7 millimeters or less. By 1998, drives of that height will provide an estimated 80% of 2.5" drive shipments, and overall shipments of 2.5" drives will provide a quarter of all of the product group's shipments.

The emergence of new 5.25" drives, designed for very low cost per megabyte, is a development that competitive disk drive manufacturers will be watching closely. Current DISK/TREND Report forecasts assume that 1-2 gigabyte 5.25" drive shipments will climb to 1.3 million units in 1997, then decline. If a significant number of personal computer manufacturers endorse the concept by placing orders, expect more drive manufacturers to join the game, and shipment levels might move higher.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
10"-14"	1.5	.5	--	--	--
	--	--	--	--	--
8"-9.5"	18.8	3.9	--	--	--
	.4%	--	--	--	--
5.25"	109.9	30.0	456.0	1,900.0	1,780.0
	2.3%	.2%	1.3%	3.8%	6.1%
3.5" 1.625" high	1,124.1	175.3	--	--	--
	23.3%	1.1%	--	--	--
3.5" 1" high or less	3,561.0	15,381.6	32,535.0	41,060.0	20,290.0
	74.0%	95.8%	89.5%	83.1%	69.2%
2.5" more than .5" high	--	441.0	1,125.0	1,310.0	1,170.0
	--	2.7%	3.1%	2.7%	4.0%
2.5" .5" high or less	--	30.0	2,235.0	5,160.0	6,050.0
	--	.2%	6.1%	10.4%	20.7%
Total	4,815.3	16,062.3	36,351.0	49,430.0	29,300.0

Technical trends

Developing disk drives for the 1-2 gigabyte range has become a sophisticated exercise in applied engineering, in which nothing new has to be invented, but many leading edge components must be made available in large quantities, assembled with great precision, and delivered in a low-cost mechanism which rarely fails. Even though the industry's landmark new drives are now typically designed for much higher capacity levels, some of the highest areal densities are now utilized in high volume 2.5" drives in this product group.

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 continuing major challenge for most of the drive manufacturers is to design new 3.5" and 2.5" 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. Shipments of high performance 1-2 gigabyte 3.5" drives for midrange computer applications will end in 1996 as the result of a migration to higher capacities. Newer 1" high 3.5" drives with lower parts count, intended for low-cost personal computer applications will dominate the product group's shipments, which will peak in 1997.
2. The final production of 8"-14" drives will be in 1995.
3. New low-cost 5.25" drives will start volume production by early 1996, peaking in shipments in 1997.
4. 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 desktop personal computers.
5. 2.5" drives will attain continuous growth during the forecast period, with shipments after 1995 dominated by drives with heights of 12.7 millimeters or less.

TABLE 56

FIXED DISK DRIVES, 1 - 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	612.0	911.0	576.6	839.0	980.9	1,428.8	1,080.3	1,610.9	626.3	957.9
Other U.S. Captive	268.6	395.7	18.0	22.5	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	880.6	1,306.7	594.6	861.5	980.9	1,428.8	1,080.3	1,610.9	626.3	957.9
PCM/Reseller	312.4	514.4	537.2	1,076.1	797.3	1,537.2	752.4	1,452.6	317.5	616.1
OEM/Integrator	1,078.1	1,494.5	1,212.9	2,038.1	1,926.5	3,338.7	2,102.3	3,785.4	1,137.7	2,136.2
TOTAL U.S. NONCAPTIVE	1,390.5	2,008.9	1,750.1	3,114.2	2,723.8	4,875.9	2,854.7	5,238.0	1,455.2	2,752.3
TOTAL U.S. REVENUES	2,271.1	3,315.6	2,344.7	3,975.7	3,704.7	6,304.7	3,935.0	6,848.9	2,081.5	3,710.2
Non-U.S. Manufacturers										
Captive	--	408.3	6.5	361.6	40.6	376.1	77.3	604.3	85.8	446.5
PCM/Reseller	--	--	72.8	161.3	115.3	255.0	116.9	259.3	57.8	131.5
OEM/Integrator	148.2	195.7	182.8	339.5	349.8	683.4	446.1	915.2	295.1	663.4
TOTAL NON-U.S. REVENUES	148.2	604.0	262.1	862.4	505.7	1,314.5	640.3	1,778.8	438.7	1,241.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,419.3	3,919.6	2,606.8	4,838.1	4,210.4	7,619.2	4,575.3	8,627.7	2,520.2	4,951.6
OEM Average Price ($000)		.576		.243		.175		.146		.139

TABLE 57

FIXED DISK DRIVES, 1 - 2 GIGABYTES

UNIT SHIPMENT SUMMARY

DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)

	1994 Shipments		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	443.0	655.0	780.0	1,130.0	1,780.0	2,585.0	2,605.0	3,870.0	1,605.0	2,450.0
Other U.S. Captive	153.4	274.0	20.0	25.0	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	596.4	929.0	800.0	1,155.0	1,780.0	2,585.0	2,605.0	3,870.0	1,605.0	2,450.0
PCM/Reseller	542.6	902.3	2,141.1	4,320.3	4,590.0	8,840.0	5,380.0	10,370.0	2,485.0	4,805.0
OEM/Integrator	1,824.5	2,549.7	4,994.3	8,416.1	11,310.0	19,495.0	15,060.0	26,780.0	8,820.0	16,130.0
TOTAL U.S. NONCAPTIVE	2,367.1	3,452.0	7,135.4	12,736.4	15,900.0	28,335.0	20,440.0	37,150.0	11,305.0	20,935.0
TOTAL U.S. SHIPMENTS	2,963.5	4,381.0	7,935.4	13,891.4	17,680.0	30,920.0	23,045.0	41,020.0	12,910.0	23,385.0
Non-U.S. Manufacturers										
Captive	--	53.8	5.0	106.1	55.0	519.0	130.0	1,270.0	155.0	955.0
PCM/Reseller	--	--	320.0	710.0	660.0	1,465.0	815.0	1,810.0	425.0	960.0
OEM/Integrator	297.5	380.5	744.3	1,354.8	1,810.0	3,447.0	2,685.0	5,330.0	1,845.0	4,000.0
TOTAL NON-U.S. SHIPMENTS	297.5	434.3	1,069.3	2,170.9	2,525.0	5,431.0	3,630.0	8,410.0	2,425.0	5,915.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,261.0	4,815.3	9,004.7	16,062.3	20,205.0	36,351.0	26,675.0	49,430.0	15,335.0	29,300.0
Total Capacity (Terabytes)	3,656.2	5,390.9	11,033.1	19,801.6	24,241.5	43,577.4	35,095.0	65,286.0	24,696.0	47,236.0
Cumulative Shipments (Units in millions)										
IBM	1.0	1.6	1.8	2.8	3.6	5.3	6.2	9.2	7.8	11.7
Non-IBM	5.4	8.1	13.6	23.0	32.1	56.8	56.1	102.4	69.9	129.2
WORLDWIDE TOTAL	6.5	9.8	15.5	25.8	35.7	62.2	62.4	111.6	77.7	140.9

TABLE 58

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues				Forecast 1995					1996			1997			1998		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																		
IBM Captive	--	--	50.0	861.0	--	--	--	744.0	95.0	--	613.2	815.6	--	857.6	753.3	--	390.4	567.5
Other U.S. Captive	--	--	150.2	245.5	--	--	--	22.5	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	8.4	506.0	--	--	--	1,074.1	2.0	--	1,518.9	18.3	--	1,426.2	26.4	--	588.4	27.7
OEM/Integrator	--	--	47.4	1,447.1	--	--	3.7	1,954.4	80.0	59.4	2,961.8	317.5	228.0	2,968.6	588.8	192.2	1,366.8	577.2
TOTAL U.S. REVENUES	--	--	256.0	3,059.6	--	--	3.7	3,795.0	177.0	59.4	5,093.9	1,151.4	228.0	5,252.4	1,368.5	192.2	2,345.6	1,172.4
NON-U.S. MANUFACTURERS																		
Captive	55.2	183.0	127.8	42.3	18.4	30.4	220.2	66.6	26.0	68.0	190.0	118.1	--	388.8	215.5	--	189.8	256.7
PCM/Reseller	--	--	--	--	--	--	--	157.5	3.8	--	234.4	20.6	--	228.5	30.8	--	97.2	34.3
OEM/Integrator	--	2.0	11.9	181.8	--	2.3	4.8	278.7	53.7	2.2	426.6	254.6	--	439.6	475.6	--	198.4	465.0
TOTAL NON-U.S. REVENUES	55.2	185.0	139.7	224.1	18.4	32.7	225.0	502.8	83.5	70.2	851.0	393.3	--	1,056.9	721.9	--	485.4	756.0
WORLDWIDE RECAP																		
Captive	55.2	183.0	328.0	1,148.8	18.4	30.4	220.2	833.1	121.0	68.0	803.2	933.7	--	1,246.4	968.8	--	580.2	824.2
	+60.9%	+89.2%	-32.0%	+16.3%	-66.7%	-83.4%	-32.9%	-27.5%	--	-69.1%	-3.6%	+671.7%	--	+55.2%	+3.8%	--	-53.4%	-14.9%
PCM/Reseller	--	--	8.4	506.0	--	--	--	1,231.6	5.8	--	1,753.3	38.9	--	1,654.7	57.2	--	685.6	62.0
	--	--	-91.4%	+44.9%	--	--	--	+143.4%	--	--	+42.4%	+570.7%	--	-5.6%	+47.0%	--	-58.6%	+8.4%
OEM/Integrator	--	2.0	59.3	1,628.9	--	2.3	8.5	2,233.1	133.7	61.6	3,388.4	572.1	228.0	3,408.2	1,064.4	192.2	1,565.2	1,042.2
	--	-93.3%	-75.3%	+71.1%	--	+15.0%	-85.7%	+37.1%	--	+624.7%	+51.7%	+327.9%	+270.1%	+.6%	+86.1%	-15.7%	-54.1%	-2.1%
Total Revenues	55.2	185.0	395.7	3,283.7	18.4	32.7	228.7	4,297.8	260.5	129.6	5,944.9	1,544.7	228.0	6,309.3	2,090.4	192.2	2,831.0	1,928.4
	+60.9%	+46.0%	-51.7%	+43.4%	-66.7%	-82.3%	-42.2%	+30.9%	--	-43.3%	+38.3%	+493.0%	+75.9%	+6.1%	+35.3%	-15.7%	-55.1%	-7.7%
ANNUAL SHARE, BY DIAMETER	1.4%	4.7%	10.1%	83.8%	.4%	.7%	4.7%	88.9%	5.3%	1.7%	78.1%	20.2%	2.6%	73.2%	24.2%	3.9%	57.3%	38.8%

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

TABLE 59

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994				Forecast														
	Shipments				1995					1996			1997			1998		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																		
IBM Captive	--	--	5.0	650.0	--	--	--	1,035.0	95.0	--	1,460.0	1,125.0	--	2,560.0	1,310.0	--	1,280.0	1,170.0
Other U.S. Captive	--	--	46.5	227.5	--	--	--	25.0	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	6.0	896.3	--	--	--	4,315.3	5.0	--	8,780.0	60.0	--	10,260.0	110.0	--	4,670.0	135.0
OEM/Integrator	--	--	36.1	2,513.6	--	--	13.0	8,203.1	200.0	450.0	17,950.0	1,095.0	1,900.0	22,320.0	2,560.0	1,780.0	11,390.0	2,960.0
TOTAL U.S. SHIPMENTS	--	--	93.6	4,287.4	--	--	13.0	13,578.4	300.0	450.0	28,190.0	2,280.0	1,900.0	35,140.0	3,980.0	1,780.0	17,340.0	4,265.0
NON-U.S. MANUFACTURERS																		
Captive	1.5	18.3	9.0	25.0	.5	3.1	13.0	69.5	20.0	4.0	380.0	135.0	--	960.0	310.0	--	520.0	435.0
PCM/Reseller	--	--	--	--	--	--	--	700.0	10.0	--	1,395.0	70.0	--	1,680.0	130.0	--	790.0	170.0
OEM/Integrator	--	.5	7.3	372.7	--	.8	4.0	1,209.0	141.0	2.0	2,570.0	875.0	--	3,280.0	2,050.0	--	1,640.0	2,360.0
TOTAL NON-U.S. SHIPMENTS	1.5	18.8	16.3	397.7	.5	3.9	17.0	1,978.5	171.0	6.0	4,345.0	1,080.0	--	5,920.0	2,490.0	--	2,950.0	2,965.0
WORLDWIDE RECAP																		
Captive	1.5	18.3	60.5	902.5	.5	3.1	13.0	1,129.5	115.0	4.0	1,840.0	1,260.0	--	3,520.0	1,620.0	--	1,800.0	1,605.0
	+66.7%	+96.8%	-33.1%	+89.4%	-66.7%	-83.1%	-78.5%	+25.2%	--	-69.2%	+62.9%	+995.7%	--	+91.3%	+28.6%	--	-48.9%	-.9%
PCM/Reseller	--	--	6.0	896.3	--	--	--	5,015.3	15.0	--	10,175.0	130.0	--	11,940.0	240.0	--	5,460.0	305.0
	--	--	-92.1%	+129.6%	--	--	--	+459.6%	--	--	+102.9%	+766.7%	--	+17.3%	+84.6%	--	-54.3%	+27.1%
OEM/Integrator	--	.5	43.4	2,886.3	--	.8	17.0	9,412.1	341.0	452.0	20,520.0	1,970.0	1,900.0	25,600.0	4,610.0	1,780.0	13,030.0	5,320.0
	--	-93.2%	-75.9%	+155.0%	--	+60.0%	-60.8%	+226.1%	--	--	+118.0%	+477.7%	+320.4%	+24.8%	+134.0%	-6.3%	-49.1%	+15.4%
Total Shipments	1.5	18.8	109.9	4,685.1	.5	3.9	30.0	15,556.9	471.0	456.0	32,535.0	3,360.0	1,900.0	41,060.0	6,470.0	1,780.0	20,290.0	7,230.0
	+66.7%	+13.3%	-68.3%	+134.4%	-66.7%	-79.3%	-72.7%	+232.1%	--	--	+109.1%	+613.4%	+316.7%	+26.2%	+92.6%	-6.3%	-50.6%	+11.7%
ANNUAL SHARE, BY DIAMETER	--	.4%	2.3%	97.3%	--	--	.2%	97.0%	2.8%	1.3%	89.6%	9.1%	3.8%	83.2%	13.0%	6.1%	69.3%	24.6%
TOTAL CAPACITY (Terabytes)	2.4	35.4	153.3	5,199.8	.8	7.2	39.6	19,176.9	577.1	503.4	39,042.0	4,032.0	2,850.0	53,378.0	9,058.0	3,204.0	32,464.0	11,568.0

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

TABLE 60

FIXED DISK DRIVES, 1 - 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	13.5	.3	--	--
MAINFRAME SYSTEMS				
General purpose	116.5	2.4	--	--
NETWORKS/MINI/MULTIUSER				
Midrange systems and network servers	2,599.3	54.0	1,172.0	4.0
PERSONAL COMPUTERS				
Business and professional, single user	743.5	15.4	27,249.0	93.0
WORKSTATIONS				
Engineering and office, single user	1,342.5	27.9	879.0	3.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	4,815.3	100.0	29,300.0	100.0

TABLE 61

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
14"	23.00	23.00	--	--	--
8"	5.30	5.42	--	--	--
5.25"	4.00	12.09	12.14	--	--
3.5"	1.19	.68	.36	.27	.20
2.5"	--	.84	.61	.42	.32
Captive Average	1.58	.88	.48	.32	.25
PCM/Reseller					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	.95	--	--	--	--
3.5"	.50	.19	.14	.10	.07
2.5"	--	.30	.25	.17	.12
PCM/Reseller Average	.50	.19	.14	.10	.08
OEM/Integrator					
14"	--	--	--	--	--
8"	2.16	1.48	--	--	--
5.25"	.95	.39	.12	.08	.06
3.5"	.50	.19	.13	.10	.07
2.5"	--	.32	.24	.16	.12
OEM/Integrator Average	.51	.19	.14	.11	.08

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 6.5 - 9.5 inch drives.

TABLE 62

FIXED DISK DRIVES, 1 - 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 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	--	18.0	928.0	946.0	35.5	--	27.0	1158.0	1185.0	30.9
IBM	--	--	302.0	302.0	11.3	--	--	510.0	510.0	13.3
Quantum	--	--	231.0	231.0	8.7	--	--	383.0	383.0	10.0
Western Digital	--	--	202.8	202.8	7.6	--	--	375.8	375.8	9.8
Fujitsu	--	.4	285.0	285.4	10.7	--	2.5	333.0	335.5	8.8
Conner Peripherals	--	--	215.0	215.0	8.1	--	--	300.0	300.0	7.8
Hewlett-Packard	--	9.5	204.0	213.5	8.0	--	12.0	272.0	284.0	7.4
Micropolis	--	1.4	164.9	166.3	6.2	--	3.1	260.2	263.3	6.9
Other U.S.	--	--	90.5	90.5	3.4	--	--	150.9	150.9	3.9
Other Non-U.S.	--	2.0	10.1	12.1	.5	.5	4.8	39.7	45.0	1.2
TOTAL	--	31.3	2633.3	2664.6	100.0	.5	49.4	3782.6	3832.5	100.0

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

FIXED DISK DRIVES, 2 - 3 GIGABYTES

1995 DISK/TREND REPORT

FIXED DISK DRIVES, 2 - 3 GIGABYTES

Coverage

Examples of disk drives in this group include:

9.5" disk diameter

Hitachi	H-6587-314

8" disk diameter

Fujitsu	F6427K

6.5" disk diameter

Hitachi	H-6588-314, DKU-88I

5.25" disk diameter

Fujitsu	M2654SI
Hitachi	DK517C-37
Seagate Technology	ST42400N, ST43401N

3.5" disk diameter

Conner Peripherals	CFP-2105E/S**, CFP-2107E/S**
Fujitsu	M2903*, M2952**
Hewlett-Packard	C2490A*, C3725S**
Hitachi	DK328-21**
IBM	DORS-32160**, DFHS-32160**
Micropolis	4221**
NEC	D3896**
Quantum	VP32181 Empire II**, XP32181 Atlas II**
Seagate Technology	ST-32430N/W**, ST32171N/W/FC**

*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. Most of the 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 three. 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 -- but is destined to be replaced by the 4.5 gigabyte 3.5" Starfire drive in late 1995, following an embarrassing false start in mid-1995. A total of nine manufacturers have now entered the market with 3.5" drives, with most now emphasizing 1" high models.

Market status

Total shipments of 2-3 gigabyte drives tripled in 1994, boosted by rapid growth in mainframe computers, network file servers, workstations and a variety of midrange applications. Shipments are expected to climb another 91% in 1995, reaching 4.3 million drives, due to continued growth in the same markets, plus early usage with desktop personal computers. Sales revenues for 1994 were $3.4 billion, up 48.6%, with 1995 revenues forecasted to top $4.4 billion, an increase of 32.4%.

The transitional nature of the current applications for drives in this product group is reflected in the changing product mix. Shipments of 5.25", 6.5", 8", and 9.5" drives for mainframe systems are fading, with final production expected next year, as some system requirements transition to higher capacities and as existing applications with the same capacity requirements move to drives which are physically smaller and lower in price. The first significant shipments of 2-3 gigabyte 3.5" drives did not occur until 1993, but 3.5" drives are projected to provide 99.1% of 1995 unit shipments.

15.4% of 1994 shipments of 2-3 gigabyte drives were used for mainframe applications, but mainframe usage will disappear well before the end of the 1998 forecast period, as disk capacities used for that application grow beyond this product group. Networks/minicomputer/multiuser applications were 64.3% of 1994 shipments and are forecasted to decline to only 3.0% of 1998 shipments, although the unit shipment total will increase slightly. 2-3 gigabyte disk drive shipments for personal computer applications in 1994 were less than 1% of the total, but PC's are expected to constitute 95% of the market in 1998, as the nature of the software and applications for desktop personal computers continues to undergo fundamental changes.

Noncaptive unit shipments continued to be dominated by Seagate Technology in 1994, with 43.4% of the worldwide total, consisting of 8", 5.25" and 3.5" drives. IBM moved up to second place with 17.4%, and Hewlett-Packard dropped to third place.

Marketing trends

The 2-3 gigabyte product group is destined to be overwhelmed during the next few years with explosive growth for desktop personal computer applications. Annual growth in unit shipments is expected to average 139.4% in the 1996-98 period, with 1998 unit shipments projected at 58.4 million drives, making this the leading product group in unit shipments.

Despite slumping average unit prices, sales revenues for 1998 are forecasted at more than double the 1995 level, but following a somewhat erratic growth pattern during the 1996-98 period. The product group's 1996 total sales revenues are expected to decline 11.9% in 1996, before reestablishing a growth pattern in the following years. The 1996 revenue drop can be traced to an 80.7% reduction in U.S. captive revenues for 3.5" drives, as major system manufacturers drop usage of high performance drives in the 2-3 gigabyte range to transition to drives with higher capacities. Renewed revenue growth in 1997 and 1998 will result from the dynamic expansion in the personal computer market for drives in this capacity range.

Shipments of 1" high 3.5" drives started in 1994, with 1" high models now available from all manufacturers of 3.5" drives, and all 3.5" drive shipments after 1995 are expected to be 1" models. The first 2.5" drives with capacities in the 2-3 gigabyte range are expected in 1996, with rapid growth in shipments during the following years. By 1998, 2.5" drives are projected to hold 13.5% of all 2-3 gigabyte drive shipments, with the balance all 3.5" drives.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
6.5"-9.5"	17.7	7.0	2.0	--	--
	.8%	.2%	--	--	--
5.25"	184.7	31.6	8.0	--	--
	8.1%	.7%	.1%	--	--
3.5" 1.625" high	1,887.5	1,352.5	--	--	--
	82.9%	31.1%	--	--	--
3.5" 1" high or less	186.4	2,956.2	11,390.0	25,440.0	50,500.0
	8.2%	68.05	96.9%	88.5%	86.5%
2.5"	--	--	350.0	3,310.0	7,900.0
	--	--	3.0%	11.5%	13.5%
Total	2,276.3	4,347.3	11,750.0	28,750.0	58,400.0

Technical trends

With 95% of 1998 unit shipments of 2-3 gigabyte drives expected to be used in the intensely competitive personal computer market, low manufacturing cost will be a design objective at least as important as performance and reliability. The major product development emphasis will be placed on development of 3.5" and 2.5" drives which can be manufactured efficiently at high production rates, utilizing designs with a low parts count.

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 future drives in the 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 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 drives designed for personal computer applications, and will introduce a 2.5" drive in this capacity range in 1996.
2. 1995 will be the last production year for all drives in the 5.25" to 9.5" range.
3. Starting in 1996, shipments in this product group will be dominated by sales of 1" high 3.5" drives for network file servers, workstations and desktop personal computers.
4. Multiple vendors will initiate shipments of 2.5" drives in the 2-3 gigabyte capacity range starting in 1996.

TABLE 63

FIXED DISK DRIVES, 2 - 3 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	591.0	866.8	1,120.5	1,716.5	278.1	406.1	600.3	894.5	983.3	1,501.1
Other U.S. Captive	376.4	615.9	473.0	586.5	47.3	60.8	39.6	52.8	35.1	50.4
TOTAL U.S. CAPTIVE	967.4	1,482.7	1,593.5	2,303.0	325.4	466.9	639.9	947.3	1,018.4	1,551.5
PCM/Reseller	243.7	354.1	341.2	516.4	619.1	981.5	785.5	1,285.0	949.4	1,636.2
OEM/Integrator	977.2	1,233.6	1,114.8	1,414.3	1,542.3	2,010.9	2,401.9	3,314.1	3,157.0	4,660.3
TOTAL U.S. NONCAPTIVE	1,220.9	1,587.7	1,456.0	1,930.7	2,161.4	2,992.4	3,187.4	4,599.1	4,106.4	6,296.5
TOTAL U.S. REVENUES	2,188.3	3,070.4	3,049.5	4,233.7	2,486.8	3,459.3	3,827.3	5,546.4	5,124.8	7,848.0
Non-U.S. Manufacturers										
Captive	--	274.9	--	119.9	--	204.3	33.3	330.8	108.4	727.9
PCM/Reseller	--	--	2.4	2.4	34.6	67.7	70.6	157.8	116.0	288.7
OEM/Integrator	18.7	36.1	48.5	122.4	125.1	215.2	205.6	482.2	394.9	975.6
TOTAL NON-U.S. REVENUES	18.7	311.0	50.9	244.7	159.7	487.2	309.5	970.8	619.3	1,992.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	2,207.0	3,381.4	3,100.4	4,478.4	2,646.5	3,946.5	4,136.8	6,517.2	5,744.1	9,840.2
OEM Average Price ($000)		.930		.573		.295		.197		.143

TABLE 64

FIXED DISK DRIVES, 2 - 3 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	195.0	286.0	330.0	505.0	325.0	475.0	1,065.0	1,590.0	2,360.0	3,610.0
Other U.S. Captive	135.4	232.9	230.0	285.0	70.0	90.0	90.0	120.0	115.0	165.0
TOTAL U.S. CAPTIVE	330.4	518.9	560.0	790.0	395.0	565.0	1,155.0	1,710.0	2,475.0	3,775.0
PCM/Reseller	258.2	377.7	570.0	859.0	2,050.0	3,250.0	3,990.0	6,530.0	6,835.0	11,780.0
OEM/Integrator	1,052.9	1,344.9	1,981.0	2,512.0	5,239.0	6,825.0	12,355.0	16,965.0	22,730.0	33,210.0
TOTAL U.S. NONCAPTIVE	1,311.1	1,722.6	2,551.0	3,371.0	7,289.0	10,075.0	16,345.0	23,495.0	29,565.0	44,990.0
TOTAL U.S. SHIPMENTS	1,641.5	2,241.5	3,111.0	4,161.0	7,684.0	10,640.0	17,500.0	25,205.0	32,040.0	48,765.0
Non-U.S. Manufacturers										
Captive	--	14.8	--	14.3	--	174.0	50.0	540.0	220.0	1,620.0
PCM/Reseller	--	--	3.5	3.5	115.0	225.0	350.0	780.0	810.0	2,020.0
OEM/Integrator	13.8	20.0	70.5	168.5	416.0	711.0	995.0	2,225.0	2,555.0	5,995.0
TOTAL NON-U.S. SHIPMENTS	13.8	34.8	74.0	186.3	531.0	1,110.0	1,395.0	3,545.0	3,585.0	9,635.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,655.3	2,276.3	3,185.0	4,347.3	8,215.0	11,750.0	18,895.0	28,750.0	35,625.0	58,400.0
Total Capacity (Terabytes)	3,466.8	4,761.1	6,653.7	9,060.5	18,851.5	26,957.1	46,888.5	71,213.0	95,418.5	156,100.0
Cumulative Shipments (Units in millions)										
IBM	.4	.5	.7	1.1	1.0	1.5	2.1	3.1	4.4	6.7
Non-IBM	2.1	2.9	5.0	6.8	12.8	18.1	30.7	45.2	63.9	100.0
WORLDWIDE TOTAL	2.5	3.5	5.7	7.9	13.9	19.6	32.8	48.4	68.4	106.8

TABLE 65

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues			Forecast 1995			Forecast 1996				Forecast 1997		Forecast 1998	
	8"	5.25"	3.5"	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	--	--	866.8	--	--	1,716.5	--	--	236.0	170.1	342.0	552.5	666.7	834.4
Other U.S. Captive	--	169.6	446.3	--	--	586.5	--	--	60.8	--	52.8	--	50.4	--
PCM/Reseller	--	37.9	316.2	--	--	516.4	--	--	981.5	--	1,265.1	19.9	1,605.6	30.6
OEM/Integrator	14.8	173.4	1,045.4	--	33.6	1,380.7	--	7.5	1,950.5	52.9	2,949.8	364.3	3,967.4	692.9
TOTAL U.S. REVENUES	14.8	380.9	2,674.7	--	33.6	4,200.1	--	7.5	3,228.8	223.0	4,609.7	936.7	6,290.1	1,557.9
NON-U.S. MANUFACTURERS														
Captive	254.8	20.1	--	82.5	24.4	13.0	42.8	10.2	151.3	--	251.6	79.2	490.1	237.8
PCM/Reseller	--	--	--	--	--	2.4	--	--	67.7	--	144.5	13.3	260.8	27.9
OEM/Integrator	16.6	18.7	.8	9.5	6.1	106.8	--	1.0	202.7	11.5	283.3	198.9	510.4	465.2
TOTAL NON-U.S. REVENUES	271.4	38.8	.8	92.0	30.5	122.2	42.8	11.2	421.7	11.5	679.4	291.4	1,261.3	730.9
WORLDWIDE RECAP														
Captive	254.8	189.7	1,313.1	82.5	24.4	2,316.0	42.8	10.2	448.1	170.1	646.4	631.7	1,207.2	1,072.2
	-19.2%	-38.6%	+39.7%	-67.6%	-87.1%	+76.4%	-48.1%	-58.2%	-80.7%	--	+44.3%	+271.4%	+86.8%	+69.7%
PCM/Reseller	--	37.9	316.2	--	--	518.8	--	--	1,049.2	--	1,409.6	33.2	1,866.4	58.5
	--	-78.4%	+300.8%	--	--	+64.1%	--	--	+102.2%	--	+34.3%	--	+32.4%	+76.2%
OEM/Integrator	31.4	192.1	1,046.2	9.5	39.7	1,487.5	--	8.5	2,153.2	64.4	3,233.1	563.2	4,477.8	1,158.1
	-34.7%	-33.8%	+776.9%	-69.7%	-79.3%	+42.2%	--	-78.6%	+44.8%	--	+50.2%	+774.5%	+38.5%	+105.6%
Total Revenues	286.2	419.7	2,675.5	92.0	64.1	4,322.3	42.8	18.7	3,650.5	234.5	5,289.1	1,228.1	7,551.4	2,288.8
	-21.3%	-45.8%	+135.1%	-67.9%	-84.7%	+61.6%	-53.5%	-70.8%	-15.5%	--	+44.9%	+423.7%	+42.8%	+86.4%
ANNUAL SHARE, BY DIAMETER	8.5%	12.4%	79.1%	2.1%	1.4%	96.5%	1.1%	.5%	92.6%	5.8%	81.3%	18.7%	76.8%	23.2%

Note: 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

	1994 Shipments			Forecast 1995			1996				1997		1998	
	8"	5.25"	3.5"	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	--	--	286.0	--	--	505.0	--	--	295.0	180.0	720.0	870.0	1,990.0	1,620.0
Other U.S. Captive	--	43.0	189.9	--	--	285.0	--	--	90.0	--	120.0	--	165.0	--
PCM/Reseller	--	23.6	354.1	--	--	859.0	--	--	3,250.0	--	6,455.0	75.0	11,635.0	145.0
OEM/Integrator	2.5	99.4	1,243.0	--	21.0	2,491.0	--	5.0	6,680.0	140.0	15,525.0	1,440.0	29,830.0	3,380.0
TOTAL U.S. SHIPMENTS	2.5	166.0	2,073.0	--	21.0	4,140.0	--	5.0	10,315.0	320.0	22,820.0	2,385.0	43,620.0	5,145.0
NON-U.S. MANUFACTURERS														
Captive	11.0	3.8	--	4.5	4.6	5.2	2.0	2.0	170.0	--	430.0	110.0	1,210.0	410.0
PCM/Reseller	--	--	--	--	--	3.5	--	--	225.0	--	730.0	50.0	1,890.0	130.0
OEM/Integrator	4.2	14.9	.9	2.5	6.0	160.0	--	1.0	680.0	30.0	1,460.0	765.0	3,780.0	2,215.0
TOTAL NON-U.S. SHIPMENTS	15.2	18.7	.9	7.0	10.6	168.7	2.0	3.0	1,075.0	30.0	2,620.0	925.0	6,880.0	2,755.0
WORLDWIDE RECAP														
Captive	11.0	46.8	475.9	4.5	4.6	795.2	2.0	2.0	555.0	180.0	1,270.0	980.0	3,365.0	2,030.0
	-38.2%	-25.6%	+145.8%	-59.1%	-90.2%	+67.1%	-55.6%	-56.5%	-30.2%	--	+128.8%	+444.4%	+165.0%	+107.1%
PCM/Reseller	--	23.6	354.1	--	--	862.5	--	--	3,475.0	--	7,185.0	125.0	13,525.0	275.0
	--	-75.3%	+508.4%	--	--	+143.6%	--	--	+302.9%	--	+106.8%	--	+88.2%	+120.0%
OEM/Integrator	6.7	114.3	1,243.9	2.5	27.0	2,651.0	--	6.0	7,360.0	170.0	16,985.0	2,205.0	33,610.0	5,595.0
	-34.3%	-36.1%	--	-62.7%	-76.4%	+113.1%	--	-77.8%	+177.6%	--	+130.8%	--	+97.9%	+153.7%
Total Shipments	17.7	184.7	2,073.9	7.0	31.6	4,308.7	2.0	8.0	11,390.0	350.0	25,440.0	3,310.0	50,500.0	7,900.0
	-36.8%	-45.3%	+498.4%	-60.5%	-82.9%	+107.8%	-71.4%	-74.7%	+164.3%	--	+123.4%	+845.7%	+98.5%	+138.7%
ANNUAL SHARE, BY DIAMETER	.8%	8.1%	91.1%	.2%	.7%	99.1%	--	.1%	97.0%	2.9%	88.6%	11.4%	86.6%	13.4%
TOTAL CAPACITY (Terabytes)	49.9	430.9	4,280.3	20.3	76.7	8,963.5	5.8	19.3	26,197.0	735.0	63,600.0	7,613.0	136,350.0	19,750.0

Note: 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	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS General purpose	349.6	15.4	--	--
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	1,464.6	64.3	1,752.0	3.0
PERSONAL COMPUTERS Business and professional, single user	13.7	.6	55,480.0	95.0
WORKSTATIONS Engineering and office, single user	448.4	19.7	1,168.0	2.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	2,276.3	100.0	58,400.0	100.0

TABLE 68

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
8"	8.08	6.34	7.37	--	--
5.25"	2.01	2.54	2.42	--	--
3.5"	1.40	1.62	.35	.20	.13
2.5"	--	--	.45	.28	.21
Captive Average	1.65	1.67	.40	.23	.16
PCM/Reseller					
8"	--	--	--	--	--
5.25"	.67	--	--	--	--
3.5"	.42	.28	.13	.07	.05
2.5"	--	--	--	.11	.08
PCM/Reseller Average	.44	.28	.13	.07	.05
OEM/Integrator					
8"	1.70	1.30	--	--	--
5.25"	.68	.59	.56	--	--
3.5"	.40	.26	.12	.07	.04
2.5"	--	--	.18	.11	.08
OEM/Integrator Average	.43	.26	.12	.08	.05

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.

8 inch totals include 6.5 - 9.5 inch drives.

TABLE 69

FIXED DISK DRIVES, 2 - 3 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 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	1.5	90.0	546.0	637.5	48.1	2.5	97.0	656.0	755.5	43.4
IBM	--	--	211.0	211.0	15.9	--	--	304.0	304.0	17.4
Hewlett-Packard	--	10.0	188.0	198.0	14.9	--	13.0	243.0	256.0	14.7
Quantum	--	--	85.0	85.0	6.4	--	--	147.0	147.0	8.4
Micropolis	--	6.9	95.6	102.5	7.7	--	9.0	125.4	134.4	7.7
Other U.S.	--	2.0	75.1	77.1	5.9	--	4.0	121.7	125.7	7.2
Other Non-U.S.	.7	13.0	.1	13.8	1.1	4.2	14.9	.9	20.0	1.2
TOTAL	2.2	121.9	1200.8	1324.9	100.0	6.7	137.9	1598.0	1742.6	100.0

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

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

1995 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	DKU-88I-10

5.25" disk diameter

Micropolis	1936AV, 1991
Seagate Technology	ST410800N/W
Sequel	5350, 5400

3.5" disk diameter

Conner Peripherals	CFP-4207E/S*
Fujitsu	M2948*, M2954**
Hewlett-Packard	C3331A**
Hitachi	DK328C-43**
IBM	DCHS-39100*, DCHS-34550**
Micropolis	3243*
Quantum	VP34360 Empire II**, XP39100 Atlas II*
Seagate Technology	ST34371W/FC**, ST-18771N/FC*

*Maximum 41.3 mm height, or less.
**Maximum 25.4 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, initially introduced in 1989. The 5,676 megabyte 3390-3 and the 17 gigabyte 3390-9 are still being shipped in limited quantities in 1995.

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 the early 1990's, Fujitsu

8" and Hitachi 9.5" drives were included in plug compatible subsystems for mainframe applications equivalent to IBM 3380 and 3390 drives, and more recent PCM models have used Fujitsu 5.25" and Hitachi 6.5" disks.

5.25" drives above 3 gigabytes appeared for the first time in 1992, and are still available from three manufacturers. The 9 gigabyte 5.25" drives available from Seagate Technology and Micropolis starting in 1994 have offered the lowest OEM price per megabyte of any drives currently available, and have been widely used in a variety of applications, including mainframe computers, network file servers and video-on-demand systems.

IBM utilized magnetoresistive heads and PRML encoding with the firm's Starfire 4.5 and 5.3 gigabyte drives announced in late 1993, the first 3.5" drives to pioneer the over 3 gigabyte range. After a difficult production start for these drives during 1994-95, IBM announced new 9.1 gigabyte (1.625" high) and 4.5 gigabyte (1" high) 3.5" drives for delivery in late 1995. During 1995, IBM has been joined by all of the other disk drive manufacturers active in the high capacity disk drive field in offering 3.5" drives with more than 3 gigabyte capacities, several of which have announced both 1" 4.5 gigabyte and 8-9 gigabyte full size 3.5" drives.

Market status

With 1994 shipments of only 432,500 drives, the product group for drives with more than 3 gigabyte capacities continued to provide the smallest unit shipment total of any DISK/TREND product group, but that is changing in 1995, as unit shipments grow an estimated 393%, to 2.1 million drives. The sharp increase in unit shipments is attributable to growth in network file server and workstation markets, but larger shipments for these applications has also paralleled the transition to physically smaller, lower cost drives. For these reasons, total sales revenue for the product group has been declining during the last few years, dropping another 37.7% in 1994. The revenue total for 1995 is expected to be up 22.5%, however, as 3.5" drive usage with networks, workstations and mainframe computers increases rapidly.

Shipments of both 5.25" and 3.5" drives have grown rapidly in 1994 and 1995. The 9 gigabyte 5.25" drives from Seagate and Micropolis found market acceptance in EMC's mainframe disk systems, and in network file servers, specialized video systems and other applications from numerous system and storage subsystem manufacturers, by offering very high capacities in a limited space and by providing the best price per megabyte for any disk drives currently available. 4.5 gigabyte 3.5" drives are still in limited supply from several drive manufacturers, but are being used in all of the same applications. 3.5" drives with capacities more than 3 gigabytes will provide an estimated 85.7% of all unit shipments in the product group, and 5.25" drives will provide an additional 13.1%, leaving slightly over 1% for drives with larger disks.

Networks/minicomputer/multiuser applications consumed only 14.6% of 1993 shipments, but their share increased to 57.6% of the 1994 total. By 1998, the networks/minicomputer/multiuser unit shipment total will triple, but this application's percentage of overall shipments for the product group will be only 2%. 78.2% of the group's units shipments were used with mainframe computers in 1993, and the share held by mainframe applications in 1994 was down to 31.3%. Despite 1998 unit shipments projected to be almost three times larger, the mainframe share of 1998 total shipments will be only 1%. A similar pattern will prevail for workstation usage, with the 1994 share dropping to .9% in 1998. The major 1998 difference for disk drives over 3 gigabytes will be the emergence of desktop personal computers as the product group's major customer, with 96% of the group's projected unit shipments.

Seagate Technology jumped into first place in 1994 noncaptive shipments with 46.4% of the worldwide total, a combination of 5.25" and 3.5" drives. IBM advanced to second place with 20.4% and Micropolis dropped to third with 18.4%.

Marketing trends

It is clear that the fundamental changes which personal computer data storage requirements have brought to most of the disk drive industry will also affect the capacity range above 3 gigabytes before the end of this forecast period. The current DISK/TREND Report forecast is for a total of 37.3 million drives with capacities over 3 gigabytes in 1998, an average annual increase of 163.3% during the 1996-98 period. Sales revenues for the product group are projected to reach $10.3 billion in 1998, an average annual increase during 1996-98 of a more modest 47.4%. As the group's major emphasis shifts to drives for the personal computer market, the overall OEM/Integrator average unit price will fall from $1,554 in 1994 to $214 in 1998, and the OEM/Integrator average price per megabyte in 1998 will be only 3 cents.

In 1998, 3.5" drive shipments are expected to total 36.7 million units, 98.6% of all drives shipped that year with capacities more than 3 gigabytes. 1" high 3.5" drives are expected to establish an aggressive growth pattern, but 1998 shipments are projected at only 25.7% of the product group total, as greater emphasis during the next few years will be placed on increases in drive capacity than in reduction in physical size.

Although still currently growing, shipments of 5.25" drives are forecasted to peak in 1997, as capacities of 3.5" drives continue to increase and ever-higher shipments keep the average price per megabyte of 3.5" drives close to that of 5.25" drives. 1998 is projected as the first year of shipments for 2.5" drives over 3 gigabytes, although this development could occur earlier if any drive manufacturer decides to develop 2.5" drives with more disks than currently utilized.

Worldwide total unit shipments (000)	1994	1995	1996	1997	1998
10"-14"	44.0	5.0	--	--	--
	10.2%	.2%	--	--	--
6.5"-9.5"	33.6	21.4	5.6	--	--
	7.8%	1.0%	.1%	--	--
5.25"	134.0	280.0	310.4	385.0	155.0
	31.1%	13.1%	4.5%	2.2%	.4%
3.5" 1.625" high	220.6	1,757.0	5,315.0	13,830.0	27,125.0
	51.0%	82.4%	77.7%	78.6%	72.7%
3.5" 1" high	--	69.0	1,210.0	3,385.0	9,600.0
	--	3.2%	17.7%	19.2%	25.7%
2.5" more than .5" high	--	--	--	--	420.0
	--	--	--	--	1.1%
Total	432.5	2,132.4	6,841.0	17,600.0	37,300.0

The last shipments of IBM's 3390 mainframe drive series are expected in 1995, replaced by the disk drive array series with the recycled "RAMAC" name it used on the first disk drive 39 years ago. IBM has used 2 gigabyte 3.5" drives on RAMAC arrays since the September, 1994, introduction, but hopes to ship RAMAC 2 with 4 gigabyte drives by the end of October, 1995. However, this product line may have a short life, as the firm plans a 1996 introduction of its new "Seascape" controller architecture for enterprise system storage requirements, which will probably trigger a procession of capacity upgrades using higher density 3.5" drives.

Technical trends

The disk drive industry's leading edge development efforts to improve areal density and performance will continue to be concentrated mostly on the high-end drives in this product group, even though some of IBM's 2.5" drives in lower capacity groups have also utilized industry leading recording densities. Among drives with more than 3 gigabytes capacity, IBM's 3.5" Scorpion series leads in 1995 areal density with 828 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 1998 with areal densities of more than 3.5 gigabits per square inch. At that recording density it will require only one 3.5" disk for each 4 gigabytes -- or even higher capacities depending on the encoding method and zoning technique, without compression. 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 21 gigabyte models, which will stimulate continued shipment growth for 5.25" drives for a few more years, 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. Other head manufacturers will establish quantity production capability for magnetoresistive heads, and some other disk drive manufacturers are already using 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 success with the 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 9,600-10,000 RPM range.

Forecasting assumptions

1. IBM and other drive manufacturers will be successful in improving areal density utilized in high-end drives by an average of 60% per year.

2. IBM will start shipments of RAMAC 2 mainframe disk drive arrays with 4 gigabyte 3.5" drives by the end of October, 1995, and new mainframe arrays using the Seascape controller family and higher capacity drives will be introduced in 1996.

3. PCM vendors will continue to match IBM's mainframe storage subsystem products with a variety of competitive subsystems using 5.25" and 3.5" drives.

4. Shipments of 3.5" drives with capacities over 3 gigabytes will continue to grow through 1998, but 5.25" drives will peak in 1997.

5. The first 2.5" drives in this product group will be shipped in 1998.

TABLE 70

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1994 Revenues		Forecast 1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	958.0	1,438.0	582.1	874.0	912.9	1,366.1	792.3	1,224.5	1,219.1	1,786.1
Other U.S. Captive	12.4	24.8	2.5	2.5	101.7	129.9	77.1	100.6	61.1	87.0
TOTAL U.S. CAPTIVE	970.4	1,462.8	584.6	876.5	1,014.6	1,496.0	869.4	1,325.1	1,280.2	1,873.1
PCM/Reseller	213.2	247.4	455.6	583.0	886.3	1,229.2	1,236.4	1,793.1	1,667.4	2,499.2
OEM/Integrator	179.7	219.7	1,120.4	1,301.0	1,590.8	1,952.0	2,418.1	3,167.7	3,333.8	4,656.2
TOTAL U.S. NONCAPTIVE	392.9	467.1	1,576.0	1,884.0	2,477.1	3,181.2	3,654.5	4,960.8	5,001.2	7,155.4
TOTAL U.S. REVENUES	1,363.3	1,929.9	2,160.6	2,760.5	3,491.7	4,677.2	4,523.9	6,285.9	6,281.4	9,028.5
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	167.2	13.9	198.9	19.7	314.8
PCM/Reseller	429.3	717.0	259.3	415.8	70.5	151.8	110.7	248.1	198.5	397.0
OEM/Integrator	.1	.1	41.9	67.1	99.8	166.4	191.0	318.8	342.9	577.0
TOTAL NON-U.S. REVENUES	429.4	717.1	301.2	482.9	170.3	485.4	315.6	765.8	561.1	1,288.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,792.7	2,647.0	2,461.8	3,243.4	3,662.0	5,162.6	4,839.5	7,051.7	6,842.5	10,317.3
OEM Average Price ($000)		1.554		.974		.527		.306		.214

TABLE 71

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1994		Forecast							
	Shipments		1995		1996		1997		1998	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	69.0	104.0	113.3	170.0	343.0	515.0	413.5	635.0	1,275.0	1,850.0
Other U.S. Captive	4.6	9.2	1.0	1.0	90.0	115.0	115.0	150.0	130.0	185.0
TOTAL U.S. CAPTIVE	73.6	113.2	114.3	171.0	433.0	630.0	528.5	785.0	1,405.0	2,035.0
PCM/Reseller	118.1	142.3	403.7	533.7	1,400.0	1,950.0	3,185.0	4,625.0	5,945.0	8,875.0
OEM/Integrator	109.5	141.3	1,129.3	1,324.3	3,000.0	3,690.0	7,880.0	10,335.0	15,600.0	21,800.0
TOTAL U.S. NONCAPTIVE	227.6	283.6	1,533.0	1,858.0	4,400.0	5,640.0	11,065.0	14,960.0	21,545.0	30,675.0
TOTAL U.S. SHIPMENTS	301.2	396.8	1,647.3	2,029.0	4,833.0	6,270.0	11,593.5	15,745.0	22,950.0	32,710.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	110.0	15.0	215.0	30.0	480.0
PCM/Reseller	21.1	35.6	14.4	23.4	53.7	136.0	270.0	605.0	735.0	1,470.0
OEM/Integrator	.1	.1	50.0	80.0	195.0	325.0	620.0	1,035.0	1,570.0	2,640.0
TOTAL NON-U.S. SHIPMENTS	21.2	35.7	64.4	103.4	248.7	571.0	905.0	1,855.0	2,335.0	4,590.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	322.4	432.5	1,711.7	2,132.4	5,081.7	6,841.0	12,498.5	17,600.0	25,285.0	37,300.0
Total Capacity (Terabytes)	1,836.5	2,406.5	8,423.7	10,316.0	26,542.7	35,439.7	77,081.8	107,883.1	173,615.2	256,120.0
Cumulative Shipments (Units in millions)										
IBM	.4	.6	.5	.8	.8	1.3	1.2	1.9	2.5	3.8
Non-IBM	.3	.4	1.9	2.4	6.6	8.7	18.7	25.6	42.7	61.1
WORLDWIDE TOTAL	.7	1.0	2.4	3.2	7.5	10.0	20.0	27.6	45.3	64.9

TABLE 72

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1994 Revenues				Forecast 1995				1996			1997		1998		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	1,222.0	--	--	216.0	113.5	--	--	760.5	--	--	1,366.1	--	1,224.5	--	1,668.1	118.0
Other U.S. Captive	--	--	24.8	--	--	--	--	2.5	--	--	129.9	--	100.6	--	87.0	--
PCM/Reseller	--	--	161.5	85.9	--	--	202.4	380.6	--	121.3	1,107.9	80.6	1,712.5	30.6	2,468.6	--
OEM/Integrator	--	--	117.7	102.0	--	--	296.1	1,004.9	--	177.6	1,774.4	117.4	3,050.3	47.5	4,578.2	30.5
TOTAL U.S. REVENUES	1,222.0	--	304.0	403.9	113.5	--	498.5	2,148.5	--	298.9	4,378.3	198.0	6,087.9	78.1	8,801.9	148.5
NON-U.S. MANUFACTURERS																
Captive	--	--	--	--	--	--	--	--	--	--	167.2	--	198.9	--	301.4	13.4
PCM/Reseller	--	647.0	70.0	--	--	355.8	60.0	--	59.2	.3	92.3	--	248.1	--	397.0	--
OEM/Integrator	--	--	--	.1	--	--	--	67.1	--	--	166.4	--	318.8	--	560.2	16.8
TOTAL NON-U.S. REVENUES	--	647.0	70.0	.1	--	355.8	60.0	67.1	59.2	.3	425.9	--	765.8	--	1,258.6	30.2
WORLDWIDE RECAP																
Captive	1,222.0	--	24.8	216.0	113.5	--	--	763.0	--	--	1,663.2	--	1,524.0	--	2,056.5	131.4
	-61.8%	--	+7.8%	--	-90.7%	--	--	+253.2%	--	--	+118.0%	--	-8.4%	--	+34.9%	--
PCM/Reseller	--	647.0	231.5	85.9	--	355.8	262.4	380.6	59.2	121.6	1,200.2	80.6	1,960.6	30.6	2,865.6	--
	--	-22.6%	+563.3%	--	--	-45.0%	+13.3%	+343.1%	-83.4%	-53.7%	+215.3%	-33.7%	+63.4%	-62.0%	+46.2%	--
OEM/Integrator	--	--	117.7	102.1	--	--	296.1	1,072.0	--	177.6	1,940.8	117.4	3,369.1	47.5	5,138.4	47.3
	--	--	+191.3%	--	--	--	+151.6%	+950.0%	--	-40.0%	+81.0%	-33.9%	+73.6%	-59.5%	+52.5%	--
Total Revenues	1,222.0	647.0	374.0	404.0	113.5	355.8	558.5	2,215.6	59.2	299.2	4,804.2	198.0	6,853.7	78.1	10,060.5	178.7
	-63.0%	-23.7%	+280.5%	--	-90.7%	-45.0%	+49.3%	+448.4%	-83.4%	-46.4%	+116.8%	-33.8%	+42.7%	-60.6%	+46.8%	--
ANNUAL SHARE, BY DIAMETER	46.3%	24.4%	14.1%	15.2%	3.5%	11.0%	17.2%	68.3%	1.1%	5.8%	93.1%	2.8%	97.2%	.8%	97.6%	1.6%

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

TABLE 73

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1994 Shipments				Forecast 1995				1996			1997		1998		
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																
IBM Captive	44.0	--	--	60.0	5.0	--	--	165.0	--	--	515.0	--	635.0	--	1,650.0	200.0
Other U.S. Captive	--	--	9.2	--	--	--	--	1.0	--	--	115.0	--	150.0	--	185.0	--
PCM/Reseller	--	--	71.6	70.7	--	--	112.7	421.0	--	125.0	1,825.0	155.0	4,470.0	60.0	8,815.0	--
OEM/Integrator	--	--	51.5	89.8	--	--	165.3	1,159.0	--	185.0	3,505.0	230.0	10,105.0	95.0	21,575.0	130.0
TOTAL U.S. SHIPMENTS	44.0	--	132.3	220.5	5.0	--	278.0	1,746.0	--	310.0	5,960.0	385.0	15,360.0	155.0	32,225.0	330.0
NON-U.S. MANUFACTURERS																
Captive	--	--	--	--	--	--	--	--	--	--	110.0	--	215.0	--	460.0	20.0
PCM/Reseller	--	33.6	2.0	--	--	21.4	2.0	--	5.6	.4	130.0	--	605.0	--	1,470.0	--
OEM/Integrator	--	--	--	.1	--	--	--	80.0	--	--	325.0	--	1,035.0	--	2,570.0	70.0
TOTAL NON-U.S. SHIPMENTS	--	33.6	2.0	.1	--	21.4	2.0	80.0	5.6	.4	565.0	--	1,855.0	--	4,500.0	90.0
WORLDWIDE RECAP																
Captive	44.0	--	9.2	60.0	5.0	--	--	166.0	--	--	740.0	--	1,000.0	--	2,295.0	220.0
	-40.5%	--	+91.7%	--	-88.6%	--	--	+176.7%	--	--	+345.8%	--	+35.1%	--	+129.5%	--
PCM/Reseller	--	33.6	73.6	70.7	--	21.4	114.7	421.0	5.6	125.4	1,955.0	155.0	5,075.0	60.0	10,285.0	--
	--	-15.8%	+327.9%	--	--	-36.3%	+55.8%	+495.5%	-73.8%	+9.3%	+364.4%	+23.6%	+159.6%	-61.3%	+102.7%	--
OEM/Integrator	--	--	51.5	89.9	--	--	165.3	1,239.0	--	185.0	3,830.0	230.0	11,140.0	95.0	24,145.0	200.0
	--	--	+172.5%	--	--	--	+221.0%	--	--	+11.9%	+209.1%	+24.3%	+190.9%	-58.7%	+116.7%	--
Total Shipments	44.0	33.6	134.3	220.6	5.0	21.4	280.0	1,826.0	5.6	310.4	6,525.0	385.0	17,215.0	155.0	36,725.0	420.0
	-43.0%	-19.8%	+228.4%	--	-88.6%	-36.3%	+108.5%	+727.7%	-73.8%	+10.9%	+257.3%	+24.0%	+163.8%	-59.7%	+113.3%	--
ANNUAL SHARE, BY DIAMETER	10.2%	7.8%	31.2%	50.8%	.2%	1.0%	13.1%	85.7%	.1%	4.5%	95.4%	2.2%	97.8%	.4%	98.6%	1.0%
TOTAL CAPACITY (Terabytes)	363.3	198.4	908.1	936.7	45.4	155.7	2,456.8	7,658.1	38.6	3,726.8	31,674.3	6,545.0	101,338.1	3,875.0	250,943.0	1,302.0

Note: 14 inch totals include 10 inch - 14 inch drives.
8 inch totals include 6.5 inch - 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)									
	1994 Shipments		FORECAST							
			1995		1996		1997		1998	
	US	WW	US	WW	US	WW	US	WW	US	WW
3390-2 type (3784 MB)										
PCM	.4	1.3	--	--	--	--	--	--	--	--
3390-3 type (5676 MB)										
IBM	22.0	34.0	2.2	3.5	--	--	--	--	--	--
PCM	18.8	31.4	11.1	18.4	3.0	5.0	--	--	--	--
3390-9 type (17028 MB)										
IBM	7.0	10.0	1.0	1.5	--	--	--	--	--	--
PCM	1.9	2.9	3.3	5.0	.7	1.0	--	--	--	--
9345 type (1500 MB)										
IBM	2.0	3.0	--	--	--	--	--	--	--	--
Disk subsystems with array capability (Average available capacity per drive)										
IBM (1419 MB)	43.5	66.0	234.0	360.0	13.0	20.0	--	--	--	--
IBM (2838 MB)	--	--	59.0	90.0	115.0	180.0	19.0	30.0	--	--
PCM (2838 MB)	50.1	77.0	68.0	105.0	58.0	90.0	20.0	30.0	--	--
IBM (5676 MB)	--	--	--	--	50.0	75.0	96.0	148.0	9.0	15.0
PCM (5676 MB)	--	--	--	--	44.0	66.0	39.0	80.0	55.0	85.0
IBM (8514 MB)	--	--	--	--	--	--	17.0	25.0	99.0	150.0
PCM (8514 MB)	17.0	25.0	44.0	66.0	31.0	47.0	46.0	70.0	45.0	70.0
PCM (17028 MB)	--	--	--	--	8.5	12.0	15.0	22.0	20.0	30.0
TOTAL SPINDLES	162.7	250.6	422.6	649.4	323.2	496.0	252.0	405.0	228.0	350.0
TOTAL FORMATTED CAPACITY (Terabytes)		1,125.3		1,861.2		2,244.9		2,647.9		2,951.5
		+25.3%		+65.4%		+20.6%		+18.0%		+11.5%

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	1994 Estimate Units (000)	1994 Estimate %	1998 Projection Units (000)	1998 Projection %
VERY HIGH PERFORMANCE Supercomputers and high end imaging	--	--	37.3	.1
MAINFRAME SYSTEMS General purpose	135.3	31.3	373.0	1.0
NETWORKS/MINI/MULTIUSER Midrange systems and network servers	249.5	57.6	746.0	2.0
PERSONAL COMPUTERS Business and professional, single user	.3	.1	35,808.0	96.0
WORKSTATIONS Engineering and office, single user	47.4	11.0	335.7	.9
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	432.5	100.0	37,300.0	100.0

TABLE 76

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1994	Forecast 1995	1996	1997	1998
Captive					
14"	3.36	2.50	--	--	--
8"	--	--	--	--	--
5.25"	.67	--	--	--	--
3.5"	.83	1.30	.50	.27	.15
2.5"	--	--	--	--	.19
Captive Average	2.21	1.39	.50	.27	.15
PCM/Reseller					
14"	--	--	--	--	--
8"	3.26	2.28	1.53	--	--
5.25"	.45	.26	.08	.03	.02
3.5"	.29	.21	.12	.06	.04
2.5"	--	--	--	--	--
PCM/Reseller Average	.95	.34	.12	.06	.04
OEM/Integrator					
14"	--	--	--	--	--
8"	--	--	--	--	--
5.25"	.32	.20	.08	.03	.02
3.5"	.26	.20	.10	.05	.03
2.5"	--	--	--	--	.07
OEM/Integrator Average	.29	.20	.10	.05	.03

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 inch - 9.5 inch drives.

TABLE 77

FIXED DISK DRIVES, MORE THAN 3 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1994 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	--	64.0	68.0	132.0	53.1	--	68.0	80.0	148.0	46.4
IBM	--	--	40.0	40.0	16.1	--	--	65.0	65.0	20.4
Micropolis	--	38.0	8.8	46.8	18.8	--	46.3	12.5	58.8	18.4
Other U.S.	--	5.8	3.0	8.8	3.5	--	8.8	3.0	11.8	3.7
Other Non-U.S.	19.8	1.3	.1	21.2	8.5	33.6	2.0	.1	35.7	11.1
TOTAL	19.8	109.1	119.9	248.8	100.0	33.6	125.1	160.6	319.3	100.0

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

RIGID DISK DRIVE SPECIFICATIONS

1995 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 defines the appropriate DISK/TREND product group for each disk drive. Prior to 1992, drives were grouped by unformatted capacity, but the industry movement to embedded controllers eventually made that practice obsolete, since most rigid disk 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 and IDE (PC AT), or the new serial interfaces, SSA and FC AL. Capacities per track are listed, except for drives with zoned recording, in which each band of tracks has a different capacity.

Linear density, recording code, areal density

When specified by the drive manufacturer, both BPI (bits per inch) and FCI (flux changes per inch) are listed. The ratio between BPI and FCI varies, depending upon the recording code used. For example, with 1,7 RLL (run length limited) encoding, the value for BPI is 133% of the value for FCI. With PRML (partial response maximum likelihood), several variations are used and some manufacturers have not specified FCI. Areal density (BPI multiplied by TPI) is useful in comparing the recording density used in various disk drives.

Average access time

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. DISK/TREND specifications show separately 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.

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.

1995 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	AMDAHL	AMDAHL	AVATAR	AVATAR	CALLUNA TECHNOLOGY
DRIVE	6390-A/B34 6390-A/B38 6390-A/B3C 6390-A/B3F	6395-A 6395-A9C 6395-A9X	AR-2170NI AR-2170NS	AR-3170FI AR-3170FS	CT-80MC Callunacard
DISK/TREND GROUP	9	9	1	1	2
MARKET	PCM	PCM	OEM	OEM	OEM
MEDIA: Disk diameter	210 mm	130 mm	65 mm	65 mm	48 mm
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	SCSI-2, PC AT	SCSI-2, PC AT	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,838/3,390	F: 4,255	--	--	--
REMOVABLE	--	--	F: 170	F: 170	F: 85
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	4
Tracks per surface	3339/3987	3339	2404	2404	1084
Track density (TPI)			4300	4300	2490
Maximum linear density (BPI) (FCI)			80000 60000	80000 60000	50411 37808
Areal density (Mb/square inch)			344.0	344.0	125.5
Recording code	1,7 RLL		1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4348	4340	3804	3804	4800
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	12	12	18
Average rotational delay (msec)	6.9	6.9	8	8	6.25
Average access time (msec)	18.4/19.9	21.4	20	20	24.25
Data transfer rate (MBytes/sec) Internal, min/max External	 4.5	 4.5	 1.5/2.8 10.0	 1.5/2.8 10.0	 1.3/2.3 4.0
SIZE: (mm) H x W x D	--	--	17.5 x 72.4 x 107.9	25.4 x 101.6 x 146	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	9/92	3Q94	6/95	6/95	5/93
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	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk. Includes 3.5" 1.44 MB floppy drive.	PCMCIA Type III *Glass disk.

MANUFACTURER	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY
DRIVE	CT-105MC Callunacard	CT-130MC Callunacard	CT-170FD Callunacard	CT-170MC Callunacard	CT-260MC Callunacard
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	48 mm	48 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film*	Thin Film*
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PCMCIA-ATA	PCMCIA-ATA	IDE	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 170	--	--
REMOVABLE	F: 105	F: 130	--	F: 170	F: 260
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	1099	1256	1467	1467	1801
Track density (TPI)	2490	2840	3300	3300	4000
Maximum linear density (BPI) (FCI)	62244 46683	67580 50685	73570 55178	73570 55178	84777 63583
Areal density (Mb/square inch)	155.0	191.9	242.8	242.8	339.1
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4800	4800	4800	4800	4800
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	6.25	6.25	6.25	6.25	6.25
Average access time (msec)	22.25	22.25	22.25	22.25	22.25
Data transfer rate (MBytes/sec) Internal, min/max External	1.7/3.0 4.0	1.6/3.1 11.1 PIO Mode 3	2.0/4.0 11.1 PIO Mode 3	2.0/4.0 11.1 PIO Mode 3	2.2/4.7 11.1 PIO Mode 3
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 81.5	10.5 x 54 x 85.6	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	12/93	5/94	12/94	9/94	3/95
COMMENTS	PCMCIA Type III *Glass disk.	PCMCIA Type III *Glass disk.	*Glass disk. 50 pin IDE version.	PCMCIA Type III *Glass disk.	PCMCIA Type III *Glass disk.

MANUFACTURER	COMPAREX	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	6490-A34 6490-A38 6490-B34 6490-B38 6490-B3C	CFL-420A Filepro Notebook Kiwi	CFS-425A Filepro Cabo	CFS-541A Filepro Cabo	CFS-635A Filepro Cabo
DISK/TREND GROUP	8	5	5	6	6
MARKET	PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	9.5"	65 mm	95 mm	95 mm	95 mm
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film, MIG	Thin Film, MIG		
Interface	IBM	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,838	F: 422	F: 425	F: 540	F: 635
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	4	2	2	3
Tracks per surface	3339	2393	3687	3924	3640
Track density (TPI)	*	4200	3840	4100	3849
Maximum linear density (BPI) (FCI)	*	80000 60000	75000 57000	93000 70000	77000 58000
Areal density (Mb/square inch)		336.0	288.0	381.3	296.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, 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)	12.5	12	15	14	15
Average rotational delay (msec)	7.1	8.3	8.3	8.3	8.3
Average access time (msec)	19.6	20.3	23.3	22.3	23.3
Data transfer rate (MBytes/sec) Internal, min/max External	4.2	2.4/4.1 11.1 PIO Mode 3	11.1 PIO Mode 3 13.3 DMA Mode 1	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	--	12.7 x 69.8 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	2Q92	1Q95	11/94	6/95	4/95
COMMENTS	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-850A Filepro Cabo	CFP-1080E Filepro Performance Antiqua	CFP-1080S Filepro Performance Antiqua	CFS-1081A Filepro Cabo	CFS-1275A Filepro Cabo
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film, MIG	Thin Film, MIG	Thin Film, MIG		Thin Film, MIG
Interface	IDE	SCSI-2	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 850	F: 1,080	F: 1,080	F: 1,080	F: 1,278
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	4	6
Tracks per surface	3687	3658	3658	3930	3687
Track density (TPI)	3833	3849	3849	4100	3833
Maximum linear density (BPI) (FCI)	75000 57000	64000 48000	64000 48000	93000 70000	75000 57000
Areal density (Mb/square inch)	287.5	246.3	246.3	381.3	287.5
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	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	11 RD/11.5 WR	11 RD/11.5 WR	14	15
Average rotational delay (msec)	8.3	5.6	5.6	8.3	8.3
Average access time (msec)	23.3	16.6 RD/17.1 WR	16.6 RD/17.1 WR	22.3	23.3
Data transfer rate (MBytes/sec) Internal, min/max External	 11.1 PIO Mode 3 13.3 DMA Mode 1	3.9/7.0 20.0 synch.	3.9/7.0 10.0 synch.	 16.6 PIO Mode 4 16.6 DMA Mode 2	 11.1 PIO Mode 3 13.3 DMA Mode 1
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	11/94	6/95	11/94
COMMENTS					

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CFS-1621A Filepro Cabo	CFP-2105E CFP-2105W Filepro Performance Cayman	CFP-2105S Filepro Performance Cayman	CFP-2107E CFP-2107W Filepro Performance Cayman	CFP-2107S Filepro Performance Cayman
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,620	F: 2,147	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	10	10	10	10
Tracks per surface	3930	3948	3948	4016	4016
Track density (TPI)	4100	4030	4030	4090	4090
Maximum linear density (BPI) (FCI)	94000 70000	78000 58500	78000 58500	78000 58500	78000 58500
Areal density (Mb/square inch)	385.4	314.3	314.3	319.0	319.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	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)	14	8.5 RD/9.0 WR	8.5 RD/9.0 WR	8.5 RD/9.0 WR	8.5 RD/9.0 WR
Average rotational delay (msec)	8.3	5.6	5.6	4.17	4.17
Average access time (msec)	22.3	14.1 RD/14.6 WR	14.1 RD/14.6 WR	12.67/13.17	12.67/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	16.6 PIO Mode 4 16.6 DMA Mode 2	4.2/8.5 20.0 synch.	4.2/8.5 10.0 synch.	6.0/10.9 20.0 synch.	6.0/10.9 10.0 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	6/95	2Q95	2Q95	2Q95	2Q95
COMMENTS					

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	FUJITSU	FUJITSU
DRIVE	CFP-4207C SSAbre Cayman	CFP-4207E CFP-4207W Filepro Performance Cayman	CFP-4207S Filepro Performance Cayman	M2611S/SA/SB	M2611T
DISK/TREND GROUP	9	9	9	2	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SSA	SCSI-2	SCSI-2	SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,294	F: 4,294	F: 4,294	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	20	20	20	2	2
Tracks per surface	4016	4016	4016	1334	1334
Track density (TPI)	4090	4090	4090	1681	1681
Maximum linear density (BPI) (FCI)	78000 58500	78000 58500	78000 58500	29571 22178	29571 22178
Areal density (Mb/square inch)	319.0	319.0	319.0	49.7	49.7
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	7200	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)	9.0 RD/9.5 WR	9.0 RD/9.5 WR	9.0 RD/9.5 WR	25	25
Average rotational delay (msec)	4.17	4.17	4.17	8.6	8.6
Average access time (msec)	13.17/13.67	13.17/13.67	13.17/13.67	33.6	33.6
Data transfer rate (MBytes/sec) Internal, min/max External	6.0/10.9 10.0 synch.	6.0/10.9 20.0 synch.	6.0/10.9 10.0 synch.	2.5 synch. 1.5 asynch.	7.4 max.
SIZE: (mm) H x W x D	41.2 x 101.6 x 146.1	41.2 x 101.6 x 146.1	41.2 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	2Q95	2Q95	2Q95	4Q88	3Q89
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2612ES/ESA/ESB M2612S/SA/SB	M2612ET/T	M2613ES/ESA/ESB M2613S/SA/SB	M2613ET/T	M2614ES/ESA/ESB M2614S/SA/SB
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	IDE	SCSI	IDE	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 90.84	F: 90.15	F: 136.6	F: 135.23	F: 182.36
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 16,896	F: 17,408	F: 16,896	F: 17,408
Data surfaces per spindle	4	4	6	6	8
Tracks per surface	1334	1334	1334	1334	1334
Track density (TPI)	1681	1681	1681	1681	1681
Maximum linear density (BPI) (FCI)	29571 22178	29571 22178	29571 22178	29571 22178	29571 22178
Areal density (Mb/square inch)	49.7	49.7	49.7	49.7	49.7
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	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)	20/25*	20/25	20/25*	20/25	20/25*
Average rotational delay (msec)	8.6	8.6	8.6	8.6	8.6
Average access time (msec)	28.6/33.6*	28.6/33.6	28.6/33.6*	28.6/33.6	28.6/33.6*
Data transfer rate (MBytes/sec) Internal, min/max External	2.5 synch. 1.5 asynch.	7.4 max.	2.5 synch. 1.5 asynch.	7.4 max.	2.5 synch. 1.5 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	4Q88	3Q89	4Q88	3Q89	4Q88
COMMENTS	*ESA/S/SA/SB.		*ESA/S/SA/SB.		*ESA/S/SA/SB.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2614ET/T	M2616ES/ESA/ESB M2616SA	M2616ET/T	M2635S	M2635T
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	IDE	SCSI	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 180.31	F: 105	F: 105	F: 160	F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 17,408	F: 16,896	Varies by zone	Varies by zone
Data surfaces per spindle	8	4	4	4	4
Tracks per surface	1334	1542	1542	1574	1574
Track density (TPI)	1681	1681	1681	2600	2600
Maximum linear density (BPI) (FCI)	29571 22178	32069 24052	32069 24052	57000 42750	57000 42750
Areal density (Mb/square inch)	49.7	53.9	53.9	148.2	148.2
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)	20/25	20	20	14.5	14.5
Average rotational delay (msec)	8.6	8.6	8.6	6.7	6.7
Average access time (msec)	28.6/33.6	28.6	28.6	21.2	21.2
Data transfer rate (MBytes/sec) Internal, min/max External	7.4 max.	2.5 synch. 1.5 asynch.	7.4 max.	2.1/2.6 10.0 synch. 5.0 asynch.	2.1/2.6 8.0
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	17 x 69.9 x 100	17 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	3Q89	1Q90	1Q90	2Q93	2Q93
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2636S	M2636T	M2637S	M2637T	M2681S
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MIG
Interface	SCSI-2	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 200	F: 200	F: 240	F: 240	F: 264
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	6	6	3
Tracks per surface	1574	1574	1574	1574	2379
Track density (TPI)	2600	2600	2600	2600	2713
Maximum linear density (BPI) (FCI)	57000 42750	57000 42750	57000 42750	57000 42750	58000 43500
Areal density (Mb/square inch)	148.2	148.2	148.2	148.2	157.4
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)	14.5	14.5	14.5	14.5	13.8
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	21.2	21.2	21.2	21.2	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	 10.0 synch. 4.0 asynch.	 8.0	 2.1/2.6 10.0 synch. 4.0 asynch.	 2.1/2.6 8.0	 2.8/4.7 10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q93	1Q93	2Q93	1Q93	1Q94
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2681T	M2703S	M2249S/SA/SB	M2261H/HA/HB M2261S/SA/SB	M2262H/HA/HB M2262S/SA/SB
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	65 mm	130 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	MIG	MR Thin Film	Ferrite	MIG	MIG
Interface	IDE	SCSI-2	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 264	F: 260	F: 333.6	F: 357.1	F: 492
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 16,640	F: 27,136	F: 27,136
Data surfaces per spindle	3	3	15	8	11
Tracks per surface	2379		1243	1658	1658
Track density (TPI)	2713	4017	1267	1712	1712
Maximum linear density (BPI) (FCI)	58000 43500	84800	19295 14471	28816 21612	28816 21612
Areal density (Mb/square inch)	157.4	340.6	24.4	49.3	49.3
Recording code	1,7 RLL	PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13.8	12	18	16	16
Average rotational delay (msec)	6.7	5.6	8.3	8.3	8.3
Average access time (msec)	20.5	17.6	26.3	24.3	24.3
Data transfer rate (MBytes/sec) Internal, min/max External	2.8/4.7 11.1 PIO Mode 3	3.7/5.4 10.0 synch. 5.0 asynch.	1.25 2.5 synch. 1.5 asynch.	1.875 4.0 synch. 1.75 asynch.	1.875 4.0 synch. 1.75 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	17 x 69.9 x 100	82.6 x 146.1 x 218	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1Q94	4Q94	1Q88	2Q88	2Q88
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2622F/FA/FB M2622H/HA/HB	M2622S/SA/SB	M2622T	M2623F/FA/FB M2623H/HA/HB	M2623S/SA/SB
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI-1/2	SCSI-1/2	IDE	SCSI-1/2	SCSI-1/2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 330.17	F: 330.17	F: 326.7	F: 425.1	F: 425.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	7	7	7	9	9
Tracks per surface	1435	1435	1435	1435	1435
Track density (TPI)	1751	1751	1751	1751	1751
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	46383 34787	46383 34787	46383 34787
Areal density (Mb/square inch)	81.2	81.2	81.2	81.2	81.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	4400	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)	12	12	12	12	12
Average rotational delay (msec)	6.8	6.8	6.8	6.8	6.8
Average access time (msec)	18.8	18.8	18.8	18.8	18.8
Data transfer rate (MBytes/sec) Internal, min/max External	 10.0 synch. 4.0 asynch.	 2.4/3.0 5.0 synch. 3.0 asynch.	 2.4/3.0 7.4 max.	 2.4/3.0 10.0 synch. 4.0 asynch.	 2.4/3.0 5.0 synch. 3.0 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	4Q91	1Q91	3Q91	4Q91	1Q91
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2623T	M2682S	M2682T	M2704S	M2705S
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MR Thin Film	MR Thin Film
Interface	IDE	SCSI-2	IDE	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 420.1	F: 353	F: 352	F: 350	F: 350
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	4	4	4	4
Tracks per surface	1435	2379	2379		
Track density (TPI)	1751	2713	2713	4017	4300
Maximum linear density (BPI) (FCI)	46383 34787	58000 43500	58000 43500	84800	78000
Areal density (Mb/square inch)	81.2	157.4	157.4	340.6	335.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4400	4500	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.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	13.8	13.8	12	12
Average rotational delay (msec)	6.8	6.7	6.7	5.6	5.6
Average access time (msec)	18.8	20.5	20.5	17.6	17.6
Data transfer rate (MBytes/sec) Internal, min/max External	 2.4/3.0 7.4 max.	 2.8/4.7 10.0 synch. 5.0 asynch.	 2.8/4.7 11.1 PIO Mode 3	 3.7/5.4 10.0 synch. 5.0 asynch.	 3.3/6.0 10.0 synch. 5.0 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	17 x 69.9 x 100	17 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	3Q91	1Q94	1Q94	4Q94	4Q94
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M1603SAU Picobird-7'E	M1603TAU Picobird-7'E	M1612TAU Picobird-8'	M2263H/HA/HB M2263S/SA/SB	M2344K/KS
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 mm	210 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	MIG	MIG	Ferrite
Interface	SCSI-2	IDE	IDE	SCSI	Mod. SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 540	F: 540	F: 545	F: 671.9	U: 690.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 27,136	U: 40,960
Data surfaces per spindle	3	3	2	15	13.5
Tracks per surface	3457	3457	4133	1658	1248
Track density (TPI)	3676	3676	4394	1712	846
Maximum linear density (BPI) (FCI)	72700 54525	72700 54525	90853	28816 21612	20767 13844
Areal density (Mb/square inch)	267.2	267.2	399.2	49.3	17.6
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	1,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	4500	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	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	12	16	16
Average rotational delay (msec)	5.6	5.6	6.67	8.3	8.3
Average access time (msec)	15.6	15.6	18.67	24.3	24.3
Data transfer rate (MBytes/sec) Internal, min/max External	4.3/7.8 10.0 synch. 5.0 asynch.	4.3/7.8 16.6 PIO Mode 4 16.6 DMA Mode 2	4.4/8.0 16.6 PIO Mode 4 16.6 DMA Mode 2	1.875 4.0 synch. 1.75 asynch.	2.458
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	82.6 x 146.1 x 203.2	--
FIRST CUSTOMER SHIPMENT	3/95	2/95	9/95	4Q88	2Q87
COMMENTS					2 heads/surface except servo surface.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2360A	M2361A	M2372K/KS	M2380A	M2382K/P
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	10.5"	10.5"	210 mm	210 mm	210 mm
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Mod. SMD, SCSI	Modified SMD	Mod. SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 689.8	U: 689.8	U: 823.9	U: 1,000.2	U: 1,000.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 40,960	U: 49,728	U: 49,728
Data surfaces per spindle	10	10	13.5	13.5	13.5
Tracks per surface	1684	1682	1490	1490	1490
Track density (TPI)	880	880	1193	1193	1193
Maximum linear density (BPI) (FCI)	18620 12413	18610 12413	20766 13844	25211 18908	25211 18908
Areal density (Mb/square inch)	16.4	16.4	24.8	30.1	30.1
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3673	3600	3600	3709	3620
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)	18	18	16	16	16
Average rotational delay (msec)	8.17	8.3	8.3	8.1	8.3
Average access time (msec)	26.17	26.3	24.3	24.1	24.3
Data transfer rate (MBytes/sec) Internal, min/max External	12.54 max.	2.458	2.458	18.44 max.	3.0
SIZE: (mm) H x W x D	--	--	--	--	--
FIRST CUSTOMER SHIPMENT	3Q86	2Q85	9/87	1Q89	1Q88
COMMENTS	Parallel data transfer, 4 or 5 channels. 2 heads/surface	2 heads/surface	2 heads/surface except servo surface.	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	M2624F/FA/FB M2624H/HA/HB	M2624S/SA/SB	M2624T	M2684S	M2684T
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG	MIG	MIG
Interface	SCSI-1/2	SCSI-1/2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 520.1	F: 520.1	F: 513.5	F: 532	F: 528
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	11	6	6
Tracks per surface	1435	1435	1435	2379	2379
Track density (TPI)	1751	1751	1751	2700	2700
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	46383 34787	58000 43500	58000 43500
Areal density (Mb/square inch)	81.2	81.2	81.2	156.6	156.6
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 (MBytes/sec) Internal, min/max External	2.4/3.0 10.0 synch. 4.0 asynch.	2.4/3.0 5.0 synch. 3.0 asynch.	2.4/3.0 7.4 max.	2.8/4.7 10.0 synch. 5.0 asynch.	2.8/4.7 11.1 PIO Mode 3
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					

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: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	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
Areal density (Mb/square inch)	107.6	107.6	107.6	107.6	107.6
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 (MBytes/sec) Internal, min/max External	3.17/5.2 10.0 synch. 4.0 asynch.	3.17/5.2 10.0 synch. 4.0 asynch.	3.0/5.12 10.0 synch. 4.0 asynch.	2.54/4.17 10.0 synch. 4.0 asynch.	10.0 synch. 4.0 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	M2712TAM Hornet-6'	M2713TAM Hornet-6'	F6427H
DISK/TREND GROUP	6	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Disk diameter	95 mm	65 mm	65 mm	65 mm	210 mm
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film*	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IDE	IDE	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 938.7	F: 530	F: 540	F: 810	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 47,476
Data surfaces per spindle	13	6	2	3	15
Tracks per surface	1819		3916	3916	2655
Track density (TPI)	2208	4017	6606	6606	2080
Maximum linear density (BPI) (FCI)	48724 36543	84800	133000	133000	33310 24980
Areal density (Mb/square inch)	107.6	340.6	878.6	878.6	69.3
Recording code	1,7 RLL	PRML	8,9 PRML	8,9 PRML	1,7 RLL
Rotational speed (RPM)	4400	5400	3634	3634	4340
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	Dedicated Surf.
Average positioning time (msec)	10	12	12	12	12
Average rotational delay (msec)	6.8	5.6	8.26	8.26	6.9
Average access time (msec)	16.8	17.6	20.26	20.26	18.9
Data transfer rate (MBytes/sec) Internal, min/max External	 10.0 synch. 4.0 asynch.	 3.7/5.4 10.0 synch. 5.0 asynch.	 3.4/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2	 3.4/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2	 4.5
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	17 x 69.9 x 100	12.5 x 70 x 100	12.5 x 70 x 100	--
FIRST CUSTOMER SHIPMENT	5/92	4Q94	10/95	10/95	12/90
COMMENTS			*Glass disk.	*Glass disk.	Drive has maximum of 16 spindles.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6429G	F6429H	M1606SAU Picobird-7'E	M1606TAU Picobird-7'E	M1614TAU Picobird-8'
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	Captive	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	Thin Film	Thin Film	MIG
Interface	Fujitsu	Fujitsu	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 1,890	F: 1,080	F: 1,080	F: 1,090
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	15	15	6	6	4
Tracks per surface	1770	2655	3457	3457	4133
Track density (TPI)	3310	3310	3676	3676	4394
Maximum linear density (BPI) (FCI)	45423 34067	53084 39813	72700 54525	72700 54525	90853
Areal density (Mb/square inch)	150.4	175.7	267.2	267.2	399.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	8,9 PRML
Rotational speed (RPM)	4340	4340	5400	5400	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)	10.5	12	10	10	12
Average rotational delay (msec)	6.9	6.9	5.6	5.6	6.67
Average access time (msec)	17.4	18.9	15.6	15.6	18.67
Data transfer rate (MBytes/sec) Internal, min/max External	4.5	4.5	4.3/7.8 10.0 synch. 5.0 asynch.	4.3/7.8 16.6 PIO Mode 4 16.6 DMA Mode 2	4.4/8.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D			25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	6/94	6/94	3/95	2/95	9/95
COMMENTS	Drive has maximum of 32 spindles.	Drive has maximum of 32 spindles.			

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2266H/HA/HB M2266S/SA/SB	M2392K	M2651H/HA/HB M2651S/SA/SB	M2652H/HA/HB M2652HD/HDA/HDB M2652S/SA/SB	M2652P
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	210 mm	130 mm	130 mm	130 mm
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	Modified SMD	SCSI-2	SCSI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,079.1	U: 2,027	F: 1,396	F: 1,746	U: 2,001
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 43,520	U: 50,400	F: 45,056	F: 45,056	U: 52,864
Data surfaces per spindle	15	21	16	20	20
Tracks per surface	1658	1916	1944	1944	1893
Track density (TPI)	1634	1456	1840	1840	1840
Maximum linear density (BPI) (FCI)	46635 34976	25055 18791	50257 37692	50257 37692	50257 37692
Areal density (Mb/square inch)	76.2	36.5	92.5	92.5	92.5
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	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)	14.5	12	11	11	11
Average rotational delay (msec)	8.3	8.3	5.6	5.6	5.6
Average access time (msec)	22.8	20.3	16.6	16.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	3.05 4.8 synch. 2.0 asynch.	3.0	--/4.758 10.0 synch. 3.0 asynch.	--/4.758 10.0 synch. 3.0 asynch.	4.758
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	82.6 x 146.1 x 220
FIRST CUSTOMER SHIPMENT	2Q90	1Q90	2Q91	2Q91	2Q91
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2694EH/EHA/EHB M2694ES/ESA/ESB	M2694H/HA/HB M2694S/SA/SB	M2714TAM Hornet-6'	M2927 Allegro-1'E	M2932 Allegro-2
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	IDE	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,083.9	F: 1,083.9	F: 1,080	F: 1,080	F: 2,170
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	4	6	9
Tracks per surface	1819	1819	3916		3422
Track density (TPI)	2208	2208	6606	3550	3871
Maximum linear density (BPI) (FCI)	48724 36543	48724 36543	133000	75500	100946
Areal density (Mb/square inch)	107.6	107.6	878.6	268.0	390.8
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	PRML	8,9 RLL
Rotational speed (RPM)	5400	4400	3634	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.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10	10	12	10	10 RD/11.2 WR
Average rotational delay (msec)	5.6	6.8	8.26	5.6	4.17
Average access time (msec)	15.6	16.8	20.26	15.6	14.17/16.17
Data transfer rate (MBytes/sec) Internal, min/max External	3.2/5.2 10.0 synch. 4.0 asynch.	10.0 synch. 4.0 asynch.	3.4/6.8 16.6 PIO Mode 4 16.6 DMA Mode 2	4.7/6.8 20.0 synch. 10.0 asynch.	8.6/11.3 20.0 synch. 12.0 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	12.5 x 70 x 100	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	11/92	5/92	10/95	1Q94	3/95
COMMENTS			*Glass disk.		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6427K	F6429K	M2654H/HA/HB M2654S/SA/SB Hummingbird	M2654SI DynaCACHE Hummingbird	M2903 Allegro-1
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	Captive	OEM	OEM	OEM
MEDIA: Disk diameter	210 mm	130 mm	130 mm	130 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	Fujitsu	Fujitsu	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,835	F: 2,835	F: 2,055	F: 2,055	F: 2,118
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 45,056	F: 45,056	Varies by zone
Data surfaces per spindle	15	20	21	21	13
Tracks per surface	4007	2988	2179	2179	3150
Track density (TPI)	2820	3310	1953	1953	3553
Maximum linear density (BPI) (FCI)	33310 24982	56681 42510	50892 38153	50892 38153	75534
Areal density (Mb/square inch)	93.9	187.6	99.4	99.4	268.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	4340	4340	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)	12	12	12	11.5	10.3 RD/11.2 WR
Average rotational delay (msec)	6.9	6.9	5.6	5.6	5.6
Average access time (msec)	18.9	18.9	17.6	17.1	15.9 RD/16.8 WR
Data transfer rate (MBytes/sec) Internal, min/max External	4.758	4.5	10.0 synch. 3.0 asynch.	10.0 synch. 3.0 asynch.	4.7/6.8 20.0 synch. 6.0 asynch.
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
FIRST CUSTOMER SHIPMENT	7/92	6/94	7/92	1Q94	2/94
COMMENTS	Drive has maximum of 16 spindles.	Drive has maximum of 32 spindles.			

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2915 Allegro-1	M2932Q/R	M2932S/H	M2952 Allegro-3'	M2909 Allegro-1
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,170	F: 2,177	F: 2,177	F: 2,420	F: 3,087
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	9	9	5	19
Tracks per surface	3018	3429	3429	5565	3150
Track density (TPI)	3553	3871	3871	6500	3553
Maximum linear density (BPI) (FCI)	71627	100946	100946	118000	75534
Areal density (Mb/square inch)	254.5	390.8	390.8	767.0	268.4
Recording code	PRML	8,9 RLL	8,9 RLL	8,9 RLL	PRML
Rotational speed (RPM)	7200	7200	7200	7200	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.	Embedded	Dedicated Surf.
Average positioning time (msec)	10.1 RD/11 WR	10 RD/11.2 WR	10 RD/11.2 WR	8	10.3 RD/11.2 WR
Average rotational delay (msec)	4.17	4.17	4.17	4.17	5.6
Average access time (msec)	14.27/15.17	14.17/15.37	14.17/15.37	12.17	15.9 RD/16.8 WR
Data transfer rate (MBytes/sec) Internal, min/max External	6.2/8.0 20.0 synch. 6.0 asynch.	8.6/11.3 20.0 synch. 10.0 asynch.	8.6/11.3 12.0 synch. 6.0 asynch.	9.5/14.0 40.0 synch. 20.0 asynch.	4.7/6.8 20.0 synch. 6.0 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146	41.3 x 101.6 x 146	25.4 x 101.6 x 146	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	12/94	1/95	1/95	10/95	2/94
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2934 Allegro-2	M2934Q/R	M2934S/H	M2948 Allegro-3	M2954 Allegro-3'
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,350	F: 4,355	F: 4,355	F: 8,800	F: 4,350
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	18	18	9
Tracks per surface	3422	3429	3429	5751	5565
Track density (TPI)	3871	3871	3871	6500	6500
Maximum linear density (BPI) (FCI)	100946	100946	100946	118000	118000
Areal density (Mb/square inch)	390.8	390.8	390.8	767.0	767.0
Recording code	8,9 RLL	8,9 RLL	8,9 RLL	8,9 RLL	8,9 RLL
Rotational speed (RPM)	7200	7200	7200	7200	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.	Embedded	Embedded
Average positioning time (msec)	10 RD/11.2 WR	10 RD/11.2 WR	10 RD/11.2 WR	10	8
Average rotational delay (msec)	4.17	4.17	4.17	4.17	4.17
Average access time (msec)	14.17/16.17	14.17/15.37	14.17/15.37	14.17	12.17
Data transfer rate (MBytes/sec) Internal, min/max External	8.6/11.3 20.0 synch. 12.0 asynch.	8.6/11.3 20.0 synch. 10.0 asynch.	8.6/11.3 12.0 synch. 6.0 asynch.	9.5/14.0 40.0 synch. 20.0 asynch.	9.5/14.0 40.0 synch. 20.0 asynch.
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	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	3/95	1/95	1/95	10/95	10/95
COMMENTS					

MANUFACTURER	GIGASTORAGE INTERNATIONAL	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	B5110A Stealth	C3323A	C3323D C3323SE C3323W SureStore 1000S	C3324A	C3724S,SC C3724TC,D SureStore 1000+
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,100	F: 1,050	F: 1,050	F: 1,200	F: 1,200
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	7	7	5	5
Tracks per surface	5462	2898	2910	3610	3610
Track density (TPI)	4250	3223	3277	4000	4000
Maximum linear density (BPI) (FCI)	94000 70500	69200 51900	64490 48368	92000	92000
Areal density (Mb/square inch)	399.5	223.0	211.3	368.0	368.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	PRML
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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	9.5 RD/10.5 WR	9.5 RD/10.5 WR	9.5 RD/10.5 WR	9.5
Average rotational delay (msec)	8.3	5.6	5.6	5.6	5.6
Average access time (msec)	20.3	15.1 RD/16.1 WR	15.1 RD/16.1 WR	15.1 RD/16.1 WR	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	5.0/10.0 16.6 DMA Mode 2	4.2/6.0 20.0 synch. 5.0 asynch.	4.0/6.6 20.0 synch. 5.0 asynch.	5.7-8.0 20.0 synch. 5.0 asynch.	5.7-8.0 10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	25.4 x 146 x 210	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	4Q95	4Q93	10/94	4/95	4/95
COMMENTS					

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C3724W,WC SureStore 1000+	C2490A	C2490D C2490SE C2490W SureStore 2000S	C3325A	C3330A
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	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: 1,200	F: 2,100	F: 2,100	F: 2,170	F: 2,175
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	18	18	9	5
Tracks per surface	3610	2582	2582	3610	5301
Track density (TPI)	4000	2840	2840	4000	5660
Maximum linear density (BPI) (FCI)	92000	58500 43875	58500 43875	92000	135000
Areal density (Mb/square inch)	368.0	166.1	166.1	368.0	764.1
Recording code	PRML	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	5400	6400	6400	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.	Embedded
Average positioning time (msec)	9.5	8.9	8.9	9.5 RD/10.5 WR	9.2 RD/10.0 WR
Average rotational delay (msec)	5.6	4.69	4.69	5.6	4.17
Average access time (msec)	15.1	13.59	13.59	15.1 RD/16.1 WR	13.37/14.17
Data transfer rate (MBytes/sec) Internal, min/max External	5.7-8.0 20.0 synch. 10.0 asynch.	4.5/7.1 20.0 synch. 5.0 asynch.	4.5/7.1 20.0 synch. 5.0 asynch.	5.7/8 20.0 synch. 10.0 asynch.	11/15 20.0 synch. 7.5 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	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/95	2Q93	10/94	4Q94	4Q95
COMMENTS					

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
DRIVE	C3725S,SC C3725TC,D SureStre 2000LP	C3725W,WC SureStre 2000LP	C3331A	DK524-20	DK524C-20
DISK/TREND GROUP	8	8	9	3	3
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	Ferrite	Ferrite
Interface	SCSI-2	SCSI-2	SCSI-2	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,170	F: 2,170	F: 4,350	U: 200.5	F: 168.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	U:	F:
Data surfaces per spindle	9	9	10		
Tracks per surface	3610	3610	5301	1105	1105
Track density (TPI)	4000	4000	5660	1100	1100
Maximum linear density (BPI) (FCI)	92000	92000	135000	29800 19866	29800 19866
Areal density (Mb/square inch)	368.0	368.0	764.1	32.8	32.8
Recording code	PRML	PRML	PRML	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	7200	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.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9.5	9.5	9.2 RD/10.0 WR	25	25
Average rotational delay (msec)	5.6	5.6	4.17	8.3	8.3
Average access time (msec)	15.1	15.1	13.37/14.17	33.3	33.3
Data transfer rate (MBytes/sec) Internal, min/max External	5.7-8.0 10.0 synch. 5.0 asynch.	5.7-8.0 20.0 synch. 10.0 asynch.	11/15 20.0 synch. 7.5 asynch.	1.814	4.0
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	41.3 x
FIRST CUSTOMER SHIPMENT	4/95	4/95	4Q95	3Q88	4Q88
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK222A-27	DK312C-20	DK312C-25	DK324C-21A	DK221A-34
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		MIG	MIG	MIG	MIG
Interface	IDE	SCSI	SCSI	SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 270	F: 209	F: 251	F: 215.0	F: 340
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 19,456	F: 19,456	F: 26,624	Varies by zone
Data surfaces per spindle	2	10	12	6	4
Tracks per surface	2602	1076	1076	1346	1967
Track density (TPI)	4500	1660	1660	2117	3500
Maximum linear density (BPI) (FCI)	99000 74250	38800 25866	38800 25866	43000 32250	83000 62250
Areal density (Mb/square inch)	445.5	64.4	64.4	91.0	290.5
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4464	3600	3600	3600	4464
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	16.8*	16.8*	17	12 RD/15 WR
Average rotational delay (msec)	6.7	8.3	8.3	8.3	6.7
Average access time (msec)	18.7	25.1	25.1	25.3	18.7 RD/21.7 WR
Data transfer rate (MBytes/sec) Internal, min/max External	11.1 PIO Mode 3	4.0 synch. 1.5 asynch.	4.0 synch. 1.5 asynch.	4.0 synch. 1.5 asynch.	2.6/5.9 8.0
SIZE: (mm) H x W x D	12.5 x 69.9 x 101.9	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
FIRST CUSTOMER SHIPMENT	1Q95	3Q89	3Q89	8/91	8/94
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	DK314C-41	DK211A-51	DK211A-68	DK212A-81	DK222A-54
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	MIG		
Interface	SCSI	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 418.9	F: 510	F: 680	F: 810	F: 540
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,600	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	14	6	8	6	4
Tracks per surface	1169	1967	1969	2602	2602
Track density (TPI)	1803	3500	3500	4500	4500
Maximum linear density (BPI) (FCI)	44222 29466	83000 62250	83000 62250	99000 74250	99000 74250
Areal density (Mb/square inch)	79.7	290.5	290.5	445.5	445.5
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	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)	16.8	12 RD/15 WR	12 RD/15 WR	12	12
Average rotational delay (msec)	8.3	6.7	6.7	6.7	6.7
Average access time (msec)	25.1	18.7 RD/21.7 WR	18.7 RD/21.7 WR	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	 4.0 synch. 1.5 asynch.	 2.6/5.9 8.0	 3.0/4.8 8.0	 11.1 PIO Mode 3	 11.1 PIO Mode 3
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	19 x 69.9 x 101.6	19 x 69.9 x 101.6	19.05 x 69.9 x 101.9	12.5 x 69.9 x 101.9
FIRST CUSTOMER SHIPMENT	2Q91	5/94	7/94	1Q95	1Q95
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK325C-57	DK326C-6	DK326C-6WD	DK711S-60D DK711S-60S	DKU-861-J14 DKU-861-J24 H-6586-J14 H-6586-J24
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	Captive, OEM	Captive,OEM,PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 mm	9.5"
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SCSI-2	SCSI-2	SCSI-2	Modified SMD	IBM, Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 573	F: 601	F: 601	U: 600	F: 630
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	U: 30,240	F: 47,476
Data surfaces per spindle	6	4	4	22	15
Tracks per surface	2458	3202	3202	903	885
Track density (TPI)	2800	3600	3600	1033	
Maximum linear density (BPI) (FCI)	52200 39150	63500 47625	63500 47625	26000 17333	
Areal density (Mb/square inch)	146.2	228.6	228.6	26.9	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	
Rotational speed (RPM)	4500	6300	6300	4876	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, 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)	12.4	9.8	9.8	12	11
Average rotational delay (msec)	6.7	4.76	4.76	6.15	8.3
Average access time (msec)	19.1	14.56	14.56	18.15	19.3
Data transfer rate (MBytes/sec) Internal, min/max External	 5.0 synch. 2.5 asynch.	 4.5/7.0 10.0 synch. 2.5 asynch.	 4.5/7.0 20.0 synch. 5.0 asynch.	2.458	3.0
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	127 x 216 x 380	--
FIRST CUSTOMER SHIPMENT	3Q92	1/94	3/94	4Q87	3Q88
COMMENTS				Oversized packaging.	Drive has 8 spindles.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-871-114 DKU-871-124 H-6587-114 H-6587-124	DK212A-10	DK315C-10	DK315C-11	DK315C-14
DISK/TREND GROUP	6	7	7	7	7
MARKET	Captive,OEM,PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	9.5"	65 mm	95 mm	95 mm	95 mm
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film		Thin Film	Thin Film	Thin Film
Interface	IBM, Hitachi	IDE	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 946	F: 1,080	F: 1,054	F: 1,100	F: 1,400
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	Varies by zone	Varies by zone	F: 30,200	Varies by zone
Data surfaces per spindle	15	8	11	15	15
Tracks per surface	1113	2602	2469	2488	2464
Track density (TPI)		4500	2800	2800	2800
Maximum linear density (BPI) (FCI)		99000 74250	52300 39225	54000 40500	52300 39225
Areal density (Mb/square inch)		445.5	146.4	151.2	146.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	4464	4500	4500	4500
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.5	12	11.8	10.4	11.8
Average rotational delay (msec)	7.1	6.7	6.7	6.7	6.7
Average access time (msec)	15.6	18.7	18.5	17.1	18.5
Data transfer rate (MBytes/sec) Internal, min/max External	4.2	11.1 PIO Mode 3	2.7/4.5 10.0 synch. 2.5 asynch.	10.0 synch. 2.5 asynch.	2.7/4.5 10.0 synch. 2.5 asynch.
SIZE: (mm) H x W x D	--	19.05 x 69.9 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 146.1
FIRST CUSTOMER SHIPMENT	9/90	1Q95	3Q92	2Q92	3Q92
COMMENTS	-114: max. 8 HDAs. -124: max. 12 HDAs. Also compatible mode to H-6586J 2 heads/surface				

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK326C-10	DK326C-10WD	DK328C-10 DK328C-10WD DK328C-10WS	DK516-12	DK516-15
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,052	F: 1,052	F: 1,050	U: 1,229	U: 1,538
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	U: 45,880	U: 45,880
Data surfaces per spindle	7	7	3	15	15
Tracks per surface	3202	3202	5840	1787	2235
Track density (TPI)	3600	3600	5800	1512	2000
Maximum linear density (BPI) (FCI)	63500 47625	63500 47625	120000 90000	46375 34780	44060 33045
Areal density (Mb/square inch)	228.6	228.6	696.0	70.1	88.1
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	6300	6300	5400	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.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9.8	9.8	9.8	14	14
Average rotational delay (msec)	4.76	4.76	5.6	8.3	8.3
Average access time (msec)	14.56	14.56	15.4	22.3	22.3
Data transfer rate (MBytes/sec) Internal, min/max External	4.5/7.0 10.0 synch. 2.5 asynch.	4.5/7.0 20.0 synch. 5.0 asynch.	6.7/11.0 20.0 synch. 10.0 asynch.	2.75	2.753
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	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	1/94	3/94	4Q95	3Q90	1Q91
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	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	DKU-871-214 DKU-871-224	H-6556-1
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	Captive,OEM,PCM	Captive,OEM,PCM	OEM, PCM	Captive
MEDIA: Disk diameter	130 mm	9.5"	9.5"	9.5"	9.5"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Thin Film	Thin Film	Ferrite
Interface	SCSI	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi	Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,342	F: 1,260	F: 1,890	F: 1,892	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 41,472	F: 47,476	F: 47,476	F: 56,664	F: 47,476
Data surfaces per spindle	15	15	15	15	15
Tracks per surface	2172	1770 (Physical)	2655	2226	1770 (Physical)
Track density (TPI)	1954				
Maximum linear density (BPI) (FCI)	48525 36393				
Areal density (Mb/square inch)	94.8				
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4260	3600
PERFORMANCE					
Actuator type	Rotary, 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)	13.5	13	12.5	10.5	15
Average rotational delay (msec)	8.3	8.3	8.3	7.1	8.3
Average access time (msec)	21.8	21.3	20.8	17.6	23.3
Data transfer rate (MBytes/sec) Internal, min/max External	5.0 synch. 2.0 asynch.	3.0	3.0	4.2	3.0
SIZE: (mm) H x W x D	82.6 x 146.1 x 203.2	--	--	--	--
FIRST CUSTOMER SHIPMENT	3Q90	3Q88	3Q88	9/90	3/88
COMMENTS		Drive has 8 spindles.	Drive has 8 spindles. 2 heads/surface	-214: max. 8 HDAs. -224: max. 12 HDAs. 2 heads/surface	Drive has 4 spindles.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK328C-21 DK328C-21WD DK328C-21WS	DK517C-26	DK517C-37	DKU-881-310 DKU-F881-304	H-6587-314 H-6587-324
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM, PCM	Captive
MEDIA: Disk diameter	95 mm	130 mm	130 mm	6.5"	9.5"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	Hitachi, IBM	Hitachi, IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,100	U: 2,600 F: 2,050	U: 3,700 F: 2,870	F: 2,838	F: 2,920
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 41,984	F: 41,984	F: 56,664	F: 56,664
Data surfaces per spindle	5	15	21	15	15
Tracks per surface	5840	3307	3307	3339	3436
Track density (TPI)	5800	2800	2800	2520	1930
Maximum linear density (BPI) (FCI)	120000 90000	54000 40500	54000 40500	47300 35475	29100 21825
Areal density (Mb/square inch)	696.0	151.2	151.2	119.2	56.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	4260	4260
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9.8	12	12	13.5	12
Average rotational delay (msec)	5.6	5.6	5.6	7.1	7.1
Average access time (msec)	15.4	17.6	17.6	20.6	19.1
Data transfer rate (MBytes/sec) Internal, min/max External	6.7/11.0 20.0 synch. 10.0 asynch.	10.0 synch. 2.5 asynch.	10.0 synch. 2.5 asynch.	4.2	4.2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	--	--
FIRST CUSTOMER SHIPMENT	4Q95	2Q92	2Q92	5/93	9/90
COMMENTS				Available with 4 to 32 HDAs.	-314: max. 8 HDAs. -324: max. 12 HDAs. Also compatible mode to H-6586K 2 heads/surface

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS
DRIVE	H-6588-314	DK328C-43 DK328C-43WD DK328C-43WS	DKU-881-10 DKU-F881-904 H-6588-9	7693	7699
DISK/TREND GROUP	8	9	9	8	9
MARKET	Captive	OEM	Captive,OEM,PCM	PCM	PCM
MEDIA: Disk diameter	6.5"	95 mm	6.5"	6.5"	6.5"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MR Thin Film	MR Thin Film	Thin Film	MR Thin Film
Interface	Hitachi, IBM	SCSI-2	Hitachi, IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,920	F: 4,300	F: 8,514	F: 2,838	F: 8,514
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	Varies by zone	F: 113,328	F: 56,664	F: 113,328
Data surfaces per spindle	15	10	19	15	19
Tracks per surface	3436	5840	3955	3339	3955
Track density (TPI)	2520	5800	3500	2520	3500
Maximum linear density (BPI) (FCI)	47300 35475	120000 90000	81964 61473	47300 35475	81964 61473
Areal density (Mb/square inch)	119.2	696.0	286.9	119.2	286.9
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	5400	1980	4260	1980
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13.5	9.8	16.5	13.5	16.5
Average rotational delay (msec)	7.1	5.6	15.2	7.1	15.2
Average access time (msec)	20.6	15.4	31.7	20.6	31.7
Data transfer rate (MBytes/sec) Internal, min/max External	4.2	6.7/11.0 20.0 synch. 10.0 asynch.	3.9	4.2	3.9
SIZE: (mm) H x W x D	--	25.4 x 101.6 x 146	--	--	--
FIRST CUSTOMER SHIPMENT	6/93	4Q95	6/94	6/93	3Q94
COMMENTS	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	DHAA-2270 Travelstar (Shima-2)	DHAS-2270 Travelstar (Shima-2)	DBOA-2360 Travelstar LP (Bolero)	DHAA-2344 Travelstar (Shima-3)	DHAA-2405 Travelstar (Shima-3)
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
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	IDE	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 270	F: 270	F: 360	F: 344	F: 405
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	3	3
Tracks per surface	2788	2788	3478	2788	2788
Track density (TPI)	5300	5300	6350	5300	5300
Maximum linear density (BPI) (FCI)	93100 69825	93100 69825	101400 76050	93100 69825	93100 69825
Areal density (Mb/square inch)	493.4	493.4	643.9	493.4	493.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3800	3800	4000	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)	14	14	13	14	14
Average rotational delay (msec)	7.9	7.9	7.5	7.9	7.9
Average access time (msec)	21.9	21.9	20.5	21.9	21.9
Data transfer rate (MBytes/sec) Internal, min/max External	3.0/4.4 8.3	3.0/4.4 10.0 synch.	3.3/4.9 11.1 PIO Mode 3	 8.3	3.0/4.4 8.3
SIZE: (mm) H x W x D	17 x 70 x 100	17 x 70 x 100	12.5 x 70 x 100	17 x 70 x 100	17 x 70 x 100
FIRST CUSTOMER SHIPMENT	1Q94	2Q94	10/94	1Q94	1Q94
COMMENTS			*Glass disk.		

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DHAS-2344 Travelstar (Shima-3)	DHAS-2405 Travelstar (Shima-3)	DALA-3540 Deskstar (Aladdin)	DALS-3540 Deskstar (Aladdin)	DBOA-2540 Travelstar LP (Bolero)
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	65 mm	65 mm	95 mm	95 mm	65 mm
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	SCSI-2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 344	F: 405	F: 540	F: 540	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	3	3	2	2	3
Tracks per surface	2788	2788	4892	4892	3478
Track density (TPI)	5300	5300	5340	5340	6350
Maximum linear density (BPI) (FCI)	93100 69825	93100 69825	82600 61950	82600 61950	101400 76050
Areal density (Mb/square inch)	493.4	493.4	441.1	441.1	643.9
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3800	3800	4500	4500	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)	14	14	12	12	13
Average rotational delay (msec)	7.9	7.9	6.7	6.7	7.5
Average access time (msec)	21.9	21.9	18.7	18.7	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	2.5/4.0 10.0 synch.	3.0/4.4 10.0 synch.	4.0/6.1 11.1 PIO Mode 3	4.0/6.1 10 synch.	3.3/4.9 11.1 PIO Mode 3
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	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	12/94	7/95	10/94
COMMENTS					*Glass disk.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DBOA-2720 Travelstar LP (Bolero)	DHAA-2540 Travelstar (Shima-4)	DHAS-2540 Travelstar (Shima-4)	DPEA-30540 Deskstar XP (Pegasus)	DPES-30540 Deskstar XP (Pegasus)
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	95 mm	95 mm
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	IDE	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 720	F: 540	F: 540	F: 540	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	4	4	4	2	2
Tracks per surface	3478	2788	2788	4896	4896
Track density (TPI)	6350	5300	5300	5340	5340
Maximum linear density (BPI) (FCI)	101400 76050	93100 69825	93100 69825	85600 64200	85600 64200
Areal density (Mb/square inch)	643.9	493.4	493.4	457.1	457.1
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	3800	3800	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	14	14	10.5 RD/12.5 WR	10.5 RD/12.5 WR
Average rotational delay (msec)	7.5	7.9	7.9	5.6	5.6
Average access time (msec)	20.5	21.9	21.9	16.1 RD/18.1 WR	16.1 RD/18.1 WR
Data transfer rate (MBytes/sec) Internal, min/max External	3.3/4.9 11.1 PIO Mode 3	3.0/4.4 8.3	 10.0 synch.	4.9/6.8 11.1 PIO Mode 3	4.9/6.8 10.0 synch.
SIZE: (mm) H x W x D	12.5 x 70 x 100	17 x 70 x 100	17 x 70 x 100	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	10/94	1Q94	2Q94	8/94	8/94
COMMENTS	*Glass disk.				

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DPRA-20810 Travelstar XP (Presto)	DPRS-20810 Travelstar XP (Presto)	DSOA-20540 Travelstar 2LP (Sonata)	DSOA-20810 Travelstar 2LP (Sonata)	DVAA-2810 Travelstar (Shiva-V)
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
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	IDE	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 810	F: 810	F: 540	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	4	2	3	6
Tracks per surface	3478	3478	4131	4131	2788
Track density (TPI)	6350	6350	7257	7257	5300
Maximum linear density (BPI) (FCI)	110300 82725	110300 82725	127200 95400	127200 95400	93100 69825
Areal density (Mb/square inch)	700.4	700.4	923.1	923.1	493.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4900	4900	4000	4000	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	13 RD	13 RD	14
Average rotational delay (msec)	6.1	6.1	7.5	7.5	7.9
Average access time (msec)	18.1	18.1	20.5 RD	20.5 RD	21.9
Data transfer rate (MBytes/sec) Internal, min/max External	4.5/7.1 11.1 PIO Mode 3	4.5/7.1 10 synch.	4.2/6.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.2/6.7 16.6 PIO Mode 4 16.6 DMA Mode 2	8.3
SIZE: (mm) H x W x D	17 x 70 x 100	17 x 70 x 100	12.5 x 70 x 100	12.5 x 70 x 100	17 x 70 x 100
FIRST CUSTOMER SHIPMENT	6/95	7/95	10/95	10/95	5/94
COMMENTS			*Glass disk.	*Glass disk.	

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DVAS-2810 Travelstar (Shima-V)	0662-A10 (Spitfire)	0662-S12 0662-S1D (Spitfire)	0662-SW1 0662-SWD (Spitfire)	0664-P1S (Allicat P10)
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	95 mm
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	IDE	SCSI-2	SCSI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 810	F: 1,052	F: 1,052	F: 1,052	U: 2,000 F: 1,741
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	U: 58,024
Data surfaces per spindle	6	5	5	5	15
Tracks per surface	2788	4136	4136	4136	2304
Track density (TPI)	5300	4077	4077	4077	3168
Maximum linear density (BPI) (FCI)	93100 69825	86900 78200	86900 78200	86900 78200	68700
Areal density (Mb/square inch)	493.4	354.3	354.3	354.3	217.6
Recording code	1,7 RLL	PRML	PRML	PRML	PRDF
Rotational speed (RPM)	3800	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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	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)	7.9	5.6	5.6	5.6	5.6
Average access time (msec)	21.9	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 (MBytes/sec) Internal, min/max External	10.0 synch.	11.1 PIO* 13.3 DMA Mode 1	10.0 synch. 5.0 asynch.	20.0 synch. 10.0 asynch.	5.22
SIZE: (mm) H x W x D	17 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	41.3 x 101.6 x 159.3
FIRST CUSTOMER SHIPMENT	5/94	1Q94	2Q93	2Q93	12/92
COMMENTS		*PIO Mode 3 M2=8.3 MB/sec. M4=16.7 MB/sec			

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DFHC-31080 Ultrastar XP (Starfire HP)	DFHS-31080 Ultrastar XP (Starfire HP)	DFMS-31080 Ultrastar (Starfire HC)	DJAA-31270 Deskstar (Jafar)	DJAA-31700 Deskstar (Jafar)
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SSA	SCSI-2	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,126	F: 1,126	F: 1,327	F: 1,270	F: 1,700
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	3	4
Tracks per surface	4416	4416	4416	6119	6119
Track density (TPI)	4352	4352	4352	6684	6684
Maximum linear density (BPI) (FCI)	125000	125000	133000	99100 77325	99100 77325
Areal density (Mb/square inch)	544.0	544.0	578.8	662.4	662.4
Recording code	PRML	PRML	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	5400	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)	6.9 RD/9.0 WR	6.9 RD/9.0 WR	6.9 RD/8.5 WR	12 RD	12 RD
Average rotational delay (msec)	4.17	4.17	5.6	6.67	6.67
Average access time (msec)	11.07/13.17	11.07/13.17	12.5 RD/14.1 WR	18.67 RD	18.67 RD
Data transfer rate (MBytes/sec) Internal, min/max External	9.6/12.6 20.0	9.6/12.6 20.0 synch. 10.0 asynch.	7.7/12.6 20.0 synch. 10.0 asynch.	4.8/7.8 16.6 PIO Mode 4 16.6 DMA Mode 2	4.8/7.8 16.6 PIO Mode 4 16.6 DMA Mode 2
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	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q94	4Q95	4Q95
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DORS-31080 Ultrastar ES (Orion)	DPEA-31080 Deskstar XP (Pegasus)	DPES-31080 Deskstar XP (Pegasus)	DPRA-21215 Travelstar XP (Presto)	DPRS-21215 Travelstar XP (Presto)
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	65 mm
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-2/3	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,080	F: 1,080	F: 1,215	F: 1,215
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	6	6
Tracks per surface	6717	4896	4896	3478	3478
Track density (TPI)	7056	5340	5340	6350	6350
Maximum linear density (BPI) (FCI)	103600 77700	85600 64200	85600 64200	110300 82725	110300 82725
Areal density (Mb/square inch)	731.0	457.1	457.1	700.4	700.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	4900	4900
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	10.5 RD/12.5 WR	10.5 RD/12.5 WR	12	12
Average rotational delay (msec)	5.6	5.6	5.6	6.1	6.1
Average access time (msec)	14.1 RD	16.1 RD/18.1 WR	16.1 RD/18.1 WR	18.1	18.1
Data transfer rate (MBytes/sec) Internal, min/max External	5.9/9.0 40.0 synch. 20.0 asynch.	4.9/6.8 11.1 PIO Mode 3	4.9/6.8 10.0 synch.	4.5/7.1 11.1 PIO Mode 3	4.5/7.1 10.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	17 x 70 x 100	17 x 70 x 100
FIRST CUSTOMER SHIPMENT	1/96	8/94	8/94	6/95	7/95
COMMENTS					

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DSOA-21080 Travelstar 2LP (Sonata)	0664-M1H (Allicat S10)	0664-N1H (Allicat S10)	0664-S1H	9333-011 9333-501 (Allicat)
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	Captive
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	95 mm
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	IDE	SCSI-2	SCSI-2	SSA	IBM Serial-Link
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	U: 2,490 F: 2,013.7	U: 2,490 F: 2,013.7	U: 2,490 F: 2,013.7	F: 2,013.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 48,128	F: 48,128	F: 48,128	F: 48,128
Data surfaces per spindle	4	15	15	15	15
Tracks per surface	4131	2870	2870	2870	2870
Track density (TPI)	7257	3168	3168	3168	3168
Maximum linear density (BPI) (FCI)	127200 95400	81913	81913	81913	81913
Areal density (Mb/square inch)	923.1	259.5	259.5	259.5	259.5
Recording code	1,7 RLL	PRDF	PRDF	PRDF	PRDF
Rotational speed (RPM)	4000	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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13 RD	9.2 RD/10.7 WR	9.2 RD/10.7 WR	9.2 RD/10.7 WR	9.2 RD/10.7 WR
Average rotational delay (msec)	7.5	5.6	5.6	5.6	5.6
Average access time (msec)	20.5 RD	14.8 RD/16.3 WR	14.8 RD/16.3 WR	14.8 RD/16.3 WR	14.8 RD/16.3 WR
Data transfer rate (MBytes/sec) Internal, min/max External	4.2/6.7 16.6 PIO Mode 4 16.6 DMA Mode 2	10.0 synch. 5.0 asynch.	20.0 synch. 10.0 asynch.	20.0	8.0
SIZE: (mm) H x W x D	12.5 x 70 x 100	41.3 x 101.6 x 153.2	41.3 x 101.6 x 153.2	41.3 x 101.6 x 153.2	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/95	11/92	11/92		8/93
COMMENTS	*Glass disk.				RS/6000. Up to 4 HDAs.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DFHC-32160 Ultrastar XP (Starfire HP)	DFHS-32160 Ultrastar XP (Starfire HP)	DFMS-32160 Ultrastar (Starfire HC)	DFMS-32600 Ultrastar (Starfire HC)	DORS-32160 Ultrastar ES (Orion)
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SSA	SCSI-2	SCSI-2	SCSI-2	SCSI-2/3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,255	F: 2,255	F: 2,325	F: 2,657	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	8	8	8	5
Tracks per surface	4416	4416	4416	4416	6717
Track density (TPI)	4352	4352	4352	4352	7056
Maximum linear density (BPI) (FCI)	125000	125000	133000	133000	103600 77700
Areal density (Mb/square inch)	544.0	544.0	578.8	578.8	731.0
Recording code	PRML	PRML	PRML	PRML	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	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	7.5 RD/9.0 WR	7.5 RD/9.0 WR	7.5 RD/9.0 WR	7.5 RD/9.0 WR	8.5 RD
Average rotational delay (msec)	4.17	4.17	5.6	5.6	5.6
Average access time (msec)	11.67/13.17	11.67/13.17	13.1 RD/14.6 WR	13.1 RD/14.6 WR	14.1 RD
Data transfer rate (MBytes/sec) Internal, min/max External	9.6/12.6 20.0	9.6/12.6 20.0 synch. 10.0 asynch.	7.7/12.6 20.0 synch. 10.0 asynch.	7.7/12.6 20.0 synch. 10.0 asynch.	5.9/9.0 40.0 synch. 20.0 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
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q94	2Q94	1/96
COMMENTS					

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, PCM	OEM, PCM	Captive	Captive	Captive
MEDIA: Disk diameter	95 mm	95 mm	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	90000
Areal density (Mb/square inch)	259.5	259.5	62.6	89.5	268.6
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 (MBytes/sec) Internal, min/max External	10.0 synch. 5.0 asynch.	20.0 synch. 10.0 asynch.	4.2	4.2	3.9
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-34550 Ultrastar 2XP (Scorpion HP)	DCHC-39100 Ultrastar 2XP (Scorpion HP)	DCHS-34550 Ultrastar 2XP (Scorpion HP)	DCHS-39100 Ultrastar 2XP (Scorpion HP)	DCMC-310800 Ultrastar 2 (Scorpion HC)
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SSA	SSA	SCSI-2/3	SCSI-2	SSA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 9,100	F: 4,550	F: 9,100	F: 10,800
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	18	9	18	20
Tracks per surface	6077	6077	6077	6077	*
Track density (TPI)	6160	5966	6160	5966	5966
Maximum linear density (BPI) (FCI)	134500	134500	134500	134500	145000
Areal density (Mb/square inch)	828.5	802.4	828.5	802.4	865.1
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	7200	7200	7200	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)	7.5	8.5 RD	7.5	8.5 RD	8.9 RD
Average rotational delay (msec)	4.17	4.17	4.17	4.17	5.6
Average access time (msec)	11.67	12.67 RD	11.67	12.67 RD	14.5 RD
Data transfer rate (MBytes/sec) Internal, min/max External	10.2/15.4 40.0 synch. 20.0 asynch.	10.2/15.4 40.0	10.2/15.4 40.0 synch. 20.0 asynch.	10.2/15.4 40.0 synch. 20.0 asynch.	8.4/14.2 40.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	41.3 x 101.6 x 146	25.4 x 101.6 x 146	41.3 x 101.6 x 146	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q95	4Q95	4Q95	4Q95	2Q96
COMMENTS					*Not announced. Preliminary specification.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DCMS-310800 Ultrastar 2 (Scorpion HC)	DFHS-34320 Ultrastar XP (Starfire HP)	DFHC-34320 Ultrastar XP (Starfire HP)	DFMS-34320 Ultrastar (Starfire HC)	DFMS-351AV Ultrastar AV
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SSA	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 10,800	F: 4,512	F: 4,512	F: 4,320	F: 5,106
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	20	16	16	13	16
Tracks per surface	*	4416	4416	4416	
Track density (TPI)	5966	4352	4352	4352	4352
Maximum linear density (BPI) (FCI)	145000	125000	125000	133000	133000
Areal density (Mb/square inch)	865.1	544.0	544.0	578.8	578.8
Recording code	PRML	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	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8.9 RD	8.0 RD/9.5 WR	8.0 RD/9.5 WR	8.0 RD/9.5 WR	8.0 RD/9.5 WR
Average rotational delay (msec)	5.6	4.17	4.17	5.6	5.6
Average access time (msec)	14.5 RD	12.17/13.67	12.17/13.67	13.6 RD/15.1 WR	13.6 RD/15.1 WR
Data transfer rate (MBytes/sec) Internal, min/max External	8.4/14.2 20.0 synch. 10.0 asynch.	9.6/12.6 20.0 synch. 10.0 asynch.	9.6/12.6 20.0	7.7/12.6 20.0 synch. 10.0 asynch.	7.7/12.6 20.0 synch. 10.0 asynch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 146	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	2Q96	2Q94	2Q94	2Q94	5/95
COMMENTS	*Not announced. Preliminary specification.				

MANUFACTURER	IBM	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	DFMS-35250 Ultrastar (Starfire HC)	8105PA Viper	8170PA Viper	PocketFile 105	PocketFile 170
DISK/TREND GROUP	9	3	3	3	3
MARKET	OEM, PCM	OEM	OEM	PCM	PCM
MEDIA: Disk diameter	95 mm	48 mm	48 mm	48 mm	48 mm
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film	Thin Film*
DRIVE: Heads	MR Thin Film	MIG	Thin Film	MIG	Thin Film
Interface	SCSI-2	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 5,318	--	--	--	--
REMOVABLE	--	F: 105.4	F: 170.8	F: 105.4	F: 170.8
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	16	4	4	4	4
Tracks per surface	4416	1107	1370	1107	1370
Track density (TPI)	4352	2840	3800	2840	3800
Maximum linear density (BPI) (FCI)	133000	70000 52000	84000 63000	70000 52000	84000 63000
Areal density (Mb/square inch)	578.8	198.8	319.2	198.8	319.2
Recording code	PRML	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)	8.0 RD/9.5 WR	15	12	15	12
Average rotational delay (msec)	5.6	6.7	6.7	6.7	6.7
Average access time (msec)	13.6 RD/15.1 WR	21.7	18.7	21.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	7.7/12.6 20.0 synch. 10.0 asynch.	--/3.0 10.7	--/3.5 12.0	--/3.0 10.7	--/3.5 12.0
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	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	2Q94	11/93	3/94	1/94	3/94
COMMENTS		PCMCIA Type III Ramp loaded heads.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads.	PCMCIA Type III Ramp loaded heads. *Untextured disks.

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	IOMEGA
DRIVE	8260PA Viper	PocketFile 260	8340PA Viper	Platinum/1010	Jaz 1GB IDE
DISK/TREND GROUP	4	4	5	7	1
MARKET	OEM	PCM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	65 mm	95 mm
Recording medium	Thin Film*	Thin Film*	Thin Film*	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	F: 1,010	--
REMOVABLE	F: 260.4	F: 260.4	F: 340.6	--	F: 540/1,070
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	6	4
Tracks per surface	1650	1650	2000		4204
Track density (TPI)	4300	4200	5100	5100	4301
Maximum linear density (BPI) (FCI)	112350 84260	105000 78750	123600 92700	123000 92250	89200 66900
Areal density (Mb/square inch)	483.1	441.0	630.4	627.3	383.6
Recording code	1,7 PRML	1,7 PRML	1,7 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	4500	4200	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	10 RD/12 WR
Average rotational delay (msec)	6.7	6.7	6.7	7.14	5.6
Average access time (msec)	18.7	18.7	18.7	19.14	15.6 RD/17.6 WR
Data transfer rate (MBytes/sec) Internal, min/max External	--/5.7 16.0	--/5.7 16.0	--/6.0 16.0	--/8.0 16.0	3.5/6.7 13.3 PIO Mode 4
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 70.1 x 101.9	25.4 x 101.6 x 149.9
FIRST CUSTOMER SHIPMENT	3Q94	3Q94	4Q94	3Q95	1Q96
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.	Ramp loaded heads.	

MANUFACTURER	IOMEGA	JTS	JTS	MAXTOR	MAXTOR
DRIVE	Jaz 1GB SCSI	N2840AR Nordic	P3540	7270AV	7273A
DISK/TREND GROUP	1	6	6	4	4
MARKET	OEM, PCM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	84 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	MIG	Thin Film	
Interface	SCSI-2	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 641.7	--	F: 270	F: 273
REMOVABLE	F: 540/1,070	--	F: 540	--	--
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	4204	3303	1024	2666	2771
Track density (TPI)	4301	4280	3300	3100	3050
Maximum linear density (BPI) (FCI)	89200 66900	74246 55685	56830 42662	64100 48075	68500 51375
Areal density (Mb/square inch)	383.6	317.8	187.5	198.7	208.9
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4103	4200	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)	10 RD/12 WR	15 RD/16 WR	11/16.5	14	12
Average rotational delay (msec)	5.6	7.3	7.14	8.45	6.7
Average access time (msec)	15.6 RD/17.6 WR	22.3 RD/23.3 WR	18.14/23.64	22.45	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	3.5/6.7 10.0 synch. 5.0 asynch.	--/5.3 16.6 PIO Mode 4	 10.0	2.7/4.7 11.1 PIO Mode 3 13.3 DMA Mode 1	3.5/5.6 11.1 PIO Mode 3 13.3 DMA Mode 1
SIZE: (mm) H x W x D	25.4 x 101.6 x 149.9	10.5 x 90 x 120	12.7 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	4Q95	11/95	4Q93	8/94	4Q93
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7420AV	7425AV	250837P Laramie	7540AV	7541A Durango
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 422	F: 427	F: 837	F: 540	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	3	2	5	4	2
Tracks per surface	2666	3721	3196	2666	
Track density (TPI)	3100	3900	5080	3100	4232
Maximum linear density (BPI) (FCI)	64100 48075	73870 55400	92200 69150	64100 48075	92000 69000
Areal density (Mb/square inch)	198.7	288.1	468.4	198.7	389.3
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3551	3551	4464	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)	14	12	14	14	14
Average rotational delay (msec)	8.45	8.45	6.7	8.45	6.7
Average access time (msec)	22.45	20.45	20.7	22.45	20.7
Data transfer rate (MBytes/sec) Internal, min/max External	2.7/4.7 11.1 PIO Mode 3 13.3 DMA Mode 1	2.8/5.3 11.1 PIO Mode 3	--/.7 11.1 PIO Mode 3	2.7/4.7 11.1 PIO Mode 3 13.3 DMA Mode 1	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	12.5 x 70 x 100	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	8/94	4Q94	4Q95	8/94	6/95
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7546A	7850AV	251005 Laramie	251340 Laramie	71050A Excalibur
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 546	F: 854	F: 1,005	F: 1,340	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	4	4	6	8	5
Tracks per surface	2771	3721	3196	3196	3854
Track density (TPI)	3050	3900	5080	5080	4030
Maximum linear density (BPI) (FCI)	68500 51375	73870 55400	92200 69150	92200 69150	78400 58800
Areal density (Mb/square inch)	208.9	288.1	468.4	468.4	316.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3551	4464	4464	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	14	14	12
Average rotational delay (msec)	6.7	8.45	6.7	6.7	6.67
Average access time (msec)	18.7	20.45	20.7	20.7	18.67
Data transfer rate (MBytes/sec) Internal, min/max External	3.4/5.5 11.1 PIO Mode 3 13.3 DMA Mode 1	2.8/5.3 11.1 PIO Mode 3	--/.7 11.1 PIO Mode 3	--/.7 11.1 PIO Mode 3	3.9/6.1 11.1 PIO Mode 3 13.3 DMA Mode 1
SIZE: (mm) H x W x D	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	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	4Q94	4Q95	4Q95	11/94
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	71050S Excalibur	71084A Durango	71084AP Durango	71260A Excalibur	71260S Excalibur
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,050	F: 1,084	F: 1,084	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	5	4	4	6	6
Tracks per surface	3854			3854	3854
Track density (TPI)	4030	4232	4232	4030	4030
Maximum linear density (BPI) (FCI)	78400 58800	92000 69000	92000 69000	78400 58800	78400 58800
Areal density (Mb/square inch)	316.0	389.3	389.3	316.0	316.0
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	14	12	12	12
Average rotational delay (msec)	6.67	6.7	6.7	6.67	6.67
Average access time (msec)	18.67	20.7	18.7	18.67	18.67
Data transfer rate (MBytes/sec) Internal, min/max External	3.9/6.1 10.0 synch. 5.0 asynch.	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	3.9/6.1 11.1 PIO Mode 3 13.3 DMA Mode 1	3.9/6.1 10.0 synch. 5.0 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	2/95	6/95	6/95	11/94	2/95
COMMENTS					

MANUFACTURER	MAXTOR	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	71626AP Durango	2210AV	2217AV	4110A Taurus I	4110AV Taurus I
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,626	F: 1,056	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	6	9	15	9	9
Tracks per surface		2360	2360	2415	2415
Track density (TPI)	4232	2764	2764	2750	2750
Maximum linear density (BPI) (FCI)	92000 69000	63331 47498	63331 47498	60000 45000	60000 45000
Areal density (Mb/square inch)	389.3	175.0	175.0	165.0	165.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	10	10	8.5	8.5
Average rotational delay (msec)	6.7	5.6	5.6	5.6	5.6
Average access time (msec)	18.7	15.6	15.6	14.1	14.1
Data transfer rate (MBytes/sec) Internal, min/max External	16.6 PIO Mode 4 16.6 DMA Mode 2	4.0/5.0 10.0 synch. 5.0 asynch.	4.0/5.0 10.0 synch. 5.0 asynch.	3.7/5.8 10.0 synch. 5.0 asynch.	3.7/5.8 10.0 synch. 5.0 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	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	6/95	10/93	10/93	4Q93	
COMMENTS		Optimized for video applications.	Optimized for video applications.		Optimized for video applications.

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	4110S Taurus I	4221 Taurus 2	4221WAV Taurus 2	1936AV	1936S
DISK/TREND GROUP	7	8	8	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,052	F: 2,140	F: 2,100	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	9	9	21	21
Tracks per surface	2415			2759	2772
Track density (TPI)	2750			2280	2280
Maximum linear density (BPI) (FCI)	60000 45000			53860 40400	53860 40400
Areal density (Mb/square inch)	165.0			122.8	122.8
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
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.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.5	8.9	8.9	13	13
Average rotational delay (msec)	5.6	4.17	4.17	5.6	5.6
Average access time (msec)	14.1	13.07	13.07	18.6	18.6
Data transfer rate (MBytes/sec) Internal, min/max External	3.7/5.8 10.0 synch. 5.0 asynch.	6.1/10.1 20.0 synch. 5.0 asynch.	6.1/10.1 20.0 synch.* 10.0 asynch.	4.5/6.0 10.0 synch. 4.0 asynch.	4.5/6.0 10.0 synch. 4.0 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	82.6 x 101.6 x 146.1	82.6 x 146.1 x 203.2
FIRST CUSTOMER SHIPMENT	2Q93	2Q94	12/94		3Q92
COMMENTS			*Max. sustained transfer rate is 7.3 MB/sec. Optimized for video applications.		

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1991 Scorpio 9	1991WAV Scorpio 9	3243 Capricorn 4	3243S Capricorn 4	3243WAV Capricorn 4
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SSA	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 9,100	F: 9,100	F: 4,295	F: 4,300	F: 4,300
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	27	27	19	19	19
Tracks per surface	4356	4356	3840	4081	3840
Track density (TPI)			4200		4200
Maximum linear density (BPI) (FCI)			75000 56250		75000 56250
Areal density (Mb/square inch)			315.0		315.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	7200	7200	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)	12	12	8.9	8.9	8.9
Average rotational delay (msec)	5.6	5.6	4.17	4.17	4.17
Average access time (msec)	17.6	17.6	13.07	13.07	13.07
Data transfer rate (MBytes/sec) Internal, min/max External	5.9/9.6 20.0 synch. 5.0 asynch.	5.9/9.6 20.0 synch.* 10.0 asynch.	5.8/10.0 20.0 synch. 5.0 asynch.	5.8/10.0 80.0	5.8/10.0 20.0 synch.* 10.0 asynch.
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	2Q94	11/94	2Q94	1Q95	11/94
COMMENTS		*Max. sustained transfer rate is 6.9 MB/sec. Optimized for video applications.			*Max. sustained transfer rate is 7.2 MB/sec. Optimized for video applications.

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3746	D3755 D3756	D3765	D3855 D3856	D3766
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	MIG	Thin Film	MIG	Thin Film
Interface	IDE	IDE	IDE	SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 128	F: 105	F: 176.5	F: 105	F: 245.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	F: 20,992	F: 29,690	F: 20,992	Varies by zone
Data surfaces per spindle	2	4	4	4	4
Tracks per surface	1673	1251	1486	1251	1673
Track density (TPI)	2200	1800	2036	1800	2200
Maximum linear density (BPI) (FCI)	51000 38250	32000 24000	49403 37052	32000 24000	51000 38250
Areal density (Mb/square inch)	112.2	57.6	100.6	57.6	112.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3456	3600	3456	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	19	16.5	25	14
Average rotational delay (msec)	6.67	8.7	8.3	8.7	6.67
Average access time (msec)	20.67	27.7	24.8	33.7	20.67
Data transfer rate (MBytes/sec) Internal, min/max External	5.0	1.5	2.365	1.5 asynch.	5.0
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	3Q93	6/90	2Q91	12/89	3Q93
COMMENTS				D3856 has 19 msec. average positioning time.	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3866	D2713	D3724	D3772	D3781
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Disk diameter	95 mm	65 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	IDE	PC AT	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 245.1	F: 352	F: 426	F: 331.46	F: 426.16
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 32,200	F: 32,200
Data surfaces per spindle	4	4	2	7	9
Tracks per surface	1673	2178	3493	1468	1468
Track density (TPI)	2200	3600	3800	2000	2000
Maximum linear density (BPI) (FCI)	51000 38250	74700 56025	89500 100688	49000 36750	49000 36750
Areal density (Mb/square inch)	112.2	268.9	340.1	98.0	98.0
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4000	4090	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	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14 RD/15 WR	14	14	14
Average rotational delay (msec)	6.67	7.5	7.3	8.3	8.3
Average access time (msec)	20.67	21.5 RD/22.5 WR	21.3	22.3	22.3
Data transfer rate (MBytes/sec) Internal, min/max External		10.6	11.1 PIO Mode 3 13.3 DMA Mode 1	5.0 synch. 2.37 asynch.	5.0 synch. 2.37 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	12.5 x 70 x 100	25.4 x 101.6 x 146	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT		4Q94	2Q95	2Q91	2Q91
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3717	D3725	D3726	D3743	D3817
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	PC AT	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 540	F: 730	F: 853	F: 560	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	4	4	4	2	4
Tracks per surface	2930	3493	3493	3682	2930
Track density (TPI)	3100	3800	3800	4000	3100
Maximum linear density (BPI) (FCI)	64000 48000	71000 53250	89500 100688	100000 112500	64000 48000
Areal density (Mb/square inch)	198.4	269.8	340.1	400.0	198.4
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	8.9 PRML	1,7 RLL
Rotational speed (RPM)	4500	4090	4090	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	11	14	11	12
Average rotational delay (msec)	6.67	7.3	7.3	6.67	6.67
Average access time (msec)	18.67	18.3	21.3	17.67	18.67
Data transfer rate (MBytes/sec) Internal, min/max External	11.1	13.3 DMA Mode 1	11.1 PIO Mode 3 13.3 DMA Mode 1	13.3 DMA Mode 1 16.6 PIO Mode 4	10.0 synch.
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	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	11/94	5/95	2Q95	7/95	11/94
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3825	D3843	D3727	D3745	D3747
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film		Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 730	F: 540	F: 1,083	F: 1,080	F: 1,620
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	6	4	6
Tracks per surface	3493	3682	3493	3682	3682
Track density (TPI)	3800	4000	3800	4000	4000
Maximum linear density (BPI) (FCI)	71000 53250	100000 112500	71000 53250	100000 112500	100000 112500
Areal density (Mb/square inch)	269.8	400.0	269.8	400.0	400.0
Recording code	1,7 RLL	8,9 PRML	1,7 RLL	8,9 PRML	8,9 PRML
Rotational speed (RPM)	4090	4500	4090	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
Average positioning time (msec)	11	11	11	11	11
Average rotational delay (msec)	7.3	6.67	7.3	6.67	6.67
Average access time (msec)	18.3	17.67	18.3	17.67	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	10.0 synch.	10.0 synch.	11.1 PIO Mode 3 13.3 DMA Mode 1	16.6 PIO Mode 4 13.3 DMA Mode 1	16.6 PIO Mode 4 13.3 DMA Mode 1
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT			6/95	10/95	10/95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3827	D3845	D3847	DSE1340A	DSE1340S
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,083	F: 1,120	F: 1,620	F: 1,340	F: 1,340
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	4	6	4	4
Tracks per surface	3493	3682	3682		
Track density (TPI)	3800	4000	4000	4700	4700
Maximum linear density (BPI) (FCI)	71000 53250	100000 112500	100000 112500	107000 120375	107000 120375
Areal density (Mb/square inch)	269.8	400.0	400.0	502.9	502.9
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	8,9 PRML	8,9 PRML
Rotational speed (RPM)	4090	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)	11	11	10	11	11
Average rotational delay (msec)	7.3	6.67	6.67	6.67	6.67
Average access time (msec)	18.3	17.67	16.67	17.67	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	 10.0 synch.	 10.0 synch.	 10.0 synch.	5.0/10.0 16.6 PIO Mode 4 13.3 DMA Mode 1	5.0/10.0 10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT				9/95	9/95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NOMAI	NOMAI
DRIVE	D3896	DSE2010A	DSE2010S	MCD-I	MCD-M
DISK/TREND GROUP	8	8	8	1	1
MARKET	Captive, OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	IDE	SCSI-2	SCSI-2, IDE	SCSI-2, IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,160	F: 2,010	F: 2,010	--	--
REMOVABLE	--	--	--	F: 540	F: 680
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	9	6	6	2	2
Tracks per surface	3928				
Track density (TPI)	4070	4700	4700	5000	5000
Maximum linear density (BPI) (FCI)	78000 58500	107000 120375	107000 120375	100000	
Areal density (Mb/square inch)	317.5	502.9	502.9	500.0	
Recording code	1,7 RLL	8,9 PRML	8,9 PRML	PRML	PRML
Rotational speed (RPM)	7200	4500	4500	4500	4500
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	11	11	10	10
Average rotational delay (msec)	4.17	6.67	6.67	6.6	6.6
Average access time (msec)	13.17	17.67	17.67	16.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	6.23/10.19 20.0 synch.	5.0/10.0 16.6 PIO Mode 4 13.3 DMA Mode 1	5.0/10.0 10.0 synch. 5.0 asynch.	4.5/8.3 10.0	4.5/8.3 10.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 102 x 150	25.4 x 102 x 150
FIRST CUSTOMER SHIPMENT	6/95	9/95	9/95	2H95	1996
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	127A Daytona	127S Daytona	170A Daytona	170S Daytona	256A Daytona
DISK/TREND GROUP	3	3	3	3	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 127	F: 127	F: 170	F: 170	F: 256
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	3	3	4
Tracks per surface	1704	1704	1704	1704	1704
Track density (TPI)	3100	3100	3100	3100	3100
Maximum linear density (BPI) (FCI)	71600 53700	71600 53700	71600 53700	71600 53700	71600 53700
Areal density (Mb/square inch)	222.0	222.0	222.0	222.0	222.0
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)	17	17	17	17	17
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	23.7	23.7	23.7	23.7	23.7
Data transfer rate (MBytes/sec) Internal, min/max External	2.7/4.5 11.1 PIO Mode 3 13.3 DMA Mode 1	2.7/4.5 10.0 synch.	2.7/4.5 11.1 PIO Mode 3 13.3 DMA Mode 1	2.7/4.5 10.0 synch.	2.7/4.5 11.1 PIO Mode 3 13.3 DMA Mode 1
SIZE: (mm) H x W x D	12.5 x 70 x 100	12.5 x 70 x 100	12.5 x 70 x 100	12.5 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	1/94	1/94			1/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	256S Daytona	270A Maverick	270S Maverick	341A Daytona	341S Daytona
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 256	F: 270	F: 270	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	4	2	2	6	6
Tracks per surface	1704	2856	2856	1704	1704
Track density (TPI)	3100	2950	2950	3100	3100
Maximum linear density (BPI) (FCI)	71600 53700	60204 45266	60204 45266	71600 53700	71600 53700
Areal density (Mb/square inch)	222.0	177.6	177.6	222.0	222.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	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)	17	14	14	17	17
Average rotational delay (msec)	6.7	8.3	8.3	6.7	6.7
Average access time (msec)	23.7	22.3	22.3	23.7	23.7
Data transfer rate (MBytes/sec) Internal, min/max External	2.7/4.5 10.0 synch.	2.3/4.5 6.0	2.3/4.5 10.0 synch. 5.0 asynch.	2.7/4.5 11.1 PIO Mode 3 13.3 DMA Mode 1	2.7/4.5 10.0 synch.
SIZE: (mm) H x W x D	12.5 x 70 x 100	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	1/94	6/94	6/94	1/94	1/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	365A Lightning	365S Lightning	420A Trailblazer	420S Trailblazer	514A Daytona
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG	MIG	Thin Film
Interface	IDE	SCSI-2	IDE	SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 365.7	F: 365.7	F: 420.97	F: 425.07	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	2	2	8
Tracks per surface	3673	3673	3653	3653	1704
Track density (TPI)	3794	3794	3794	3794	3100
Maximum linear density (BPI) (FCI)	63515 47636	63515 47636	74258 55694	74258 55694	71600 53700
Areal density (Mb/square inch)	241.0	241.0	281.7	281.7	222.0
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)	11	11	14	14	17
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	17.7	17.7	20.7	20.7	23.7
Data transfer rate (MBytes/sec) Internal, min/max External	--/5.9 11.1 PIO Mode 3 13.3 DMA Mode 1	--/5.9 10.0 asynch. 6.0 synch.	--/6.7 16.6 PIO Mode 4 16.6 DMA Mode 2	--/6.7 10 synch. 6 asynch.	2.7/4.5 11.1 PIO Mode 3 13.3 DMA Mode 1
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	19 x 70 x 100
FIRST CUSTOMER SHIPMENT	4/94	4/94	5/95	5/95	1/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	514S Daytona	540A Fireball	540A Lightning	540A Maverick	540AT Europa
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	65 mm
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	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 514	F: 544	F: 541.3	F: 540	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	8	2	3	4	4
Tracks per surface	1704	3835	3673	2856	2925
Track density (TPI)	3100	4700	3794	2950	5300
Maximum linear density (BPI) (FCI)	71600 53700	92982 98783	63515 47636	60204 45266	96373 108420
Areal density (Mb/square inch)	222.0	437.0	241.0	177.6	510.8
Recording code	1,7 RLL	PRML	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	4500	5400	4500	3600	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)	17	12	11	14	14
Average rotational delay (msec)	6.7	5.6	6.7	8.3	7.9
Average access time (msec)	23.7	17.6	17.7	22.3	21.9
Data transfer rate (MBytes/sec) Internal, min/max External	2.7/4.5 10.0 synch.	--/10.5 16.6 PIO Mode 4 16.6 DMA Mode 2	--/5.9 6.0	2.3/4.5 6.0	3.1/4.9 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	19 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	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	1/94	5/95	4/94	6/94	3Q95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	540S Fireball	540S Lightning	540S Maverick	640A Fireball	640S Fireball
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI-2	SCSI-2	IDE	SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 545.4	F: 541.3	F: 540	F: 642	F: 642
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	3	4	2	2
Tracks per surface	3835	3673	2856	4142	4142
Track density (TPI)	4700	3794	2950	4270	4270
Maximum linear density (BPI) (FCI)	92982 98783	63515 47636	60204 45266	108964 115774	108964 115774
Areal density (Mb/square inch)	437.0	241.0	177.6	465.3	465.3
Recording code	PRML	1,7 RLL	1,7 RLL	16/17 PRML	16/17 PRML
Rotational speed (RPM)	5400	4500	3600	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)	12	11	14	12	12
Average rotational delay (msec)	5.6	6.7	8.3	5.6	5.6
Average access time (msec)	17.6	17.7	22.3	17.6	17.6
Data transfer rate (MBytes/sec) Internal, min/max External	--/10.5 10 synch. 6 asynch.	--/5.9 10.0 synch. 6.0 asynch.	2.3/4.5 10.0 synch. 5.0 asynch.	--/10.5 16.6 PIO Mode 4 16.6 DMA Mode 2	--/10.5 10.0 synch. 5.0 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	5/95	4/94	6/94	10/95	10/95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	730A Lightning	730S Lightning	810AT Europa	850A Trailblazer	850S Trailblazer
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR Thin Film	MIG	MIG
Interface	IDE	SCSI-2	IDE	IDE	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 731.5	F: 731.5	F: 810	F: 850.07	F: 852.01
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	4
Tracks per surface	3673	3673	2925	3653	3653
Track density (TPI)	3794	3794	5300	3794	3794
Maximum linear density (BPI) (FCI)	63515 47636	63515 47636	96373 108420	74258 55694	74258 55694
Areal density (Mb/square inch)	241.0	241.0	510.8	281.7	281.7
Recording code	1,7 RLL	1,7 RLL	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	3800	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	14	14	14
Average rotational delay (msec)	6.7	6.7	7.9	6.7	6.7
Average access time (msec)	17.7	17.7	21.9	20.7	20.7
Data transfer rate (MBytes/sec) Internal, min/max External	 --/5.9 6.0	 --/5.9 10.0 synch. 6.0 asynch.	 3.1/4.9 16.6 PIO Mode 4 16.6 DMA Mode 2	 16.6 PIO Mode 4 16.6 DMA Mode 2	 10 synch. 6 asynch.
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 70 x 100	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/94	4/94	3Q95	5/95	5/95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	DSP3053L	1080A Fireball	1080AT Europa	1080S Empire	1080S Fireball
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	65 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	IDE	SCSI-3	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 684 F: 535	F: 1,089	F: 1,080	U: 1,232 F: 1,080	F: 1,092.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	8	8	4
Tracks per surface	3117	3835	2925	2874	3835
Track density (TPI)	3256	4700	5300	3014	4700
Maximum linear density (BPI) (FCI)	61509 46132	92982 98783	96373 108420	63600 47700	92982 98783
Areal density (Mb/square inch)	200.3	437.0	510.8	191.7	437.0
Recording code	1,7 RLL	PRML	PRML	1,7 RLL	PRML
Rotational speed (RPM)	5400	5400	3800	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	12	14	9.5 RD/11 WR	12
Average rotational delay (msec)	5.6	5.6	7.9	5.6	5.6
Average access time (msec)	15.1	17.6	21.9	15.1 RD/16.6 WR	17.6
Data transfer rate (MBytes/sec) Internal, min/max External	3.4/6.9 20.0 synch. 10.0 asynch.	--/10.5 16.6 PIO Mode 4 16.6 DMA Mode 2	3.1/4.9 16.6 PIO Mode 4 16.6 DMA Mode 2	3.7/6.0 20.0 synch. 10.0 asynch.	--/10.5 10 synch. 6 asynch.
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 70 x 100	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/94	5/95	3Q95	4Q93	5/95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	1280A Fireball	1280S Fireball	1400S Empire	DSP3107L	DSP3133L
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	SCSI-3	SCSI-3	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,282	F: 1,282	U: 1,604 F: 1,400	U: 1,368 F: 1,070	U: 1,709 F: 1,337
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	8	8	10
Tracks per surface	4142	4142	3115	3117	3117
Track density (TPI)	4270	4270	3200	3256	3256
Maximum linear density (BPI) (FCI)	108964 115774	108964 115774	80000 90000	61509 46132	61509 46132
Areal density (Mb/square inch)	465.3	465.3	256.0	200.3	200.3
Recording code	16/17 PRML	16/17 PRML	PRML	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)	12	12	9.5 RD/11 WR	9.5	9.5
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	17.6	17.6	15.1 RD/16.6 WR	15.1	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	--/10.5 16.6 PIO Mode 4 16.6 DMA Mode 2	--/10.5 10.0 synch. 5.0 asynch.	4.6/8.3 20.0 synch. 5.0 asynch.	3.4/6.9 20.0 synch. 10.0 asynch.	3.4/6.9 20.0 synch. 10.0 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	10/95	10/95	1Q94	10/94	10/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	VP31110 Capella	XP31070 Atlas	2100S Empire	DSP3210	VP32181 Empire II
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-3	SCSI-2	Ultra SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,412 F: 1,108	U: 1,344 F: 1,075	U: 2,406 F: 2,100	U: 2,688 F: 2,148	F: 2,180
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	12	16	5
Tracks per surface	4165	3832	3115	3045	3115
Track density (TPI)	4350	3858	3200	3256	5701
Maximum linear density (BPI) (FCI)	98600 73950	81765 61324	80000 90000	64000 48000	98000
Areal density (Mb/square inch)	428.9	315.4	256.0	208.4	558.7
Recording code	1,7 RLL	1,7 RLL	PRML	1,7 RLL	16/17 PRML
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)	8.5 RD/9.5 WR	8.5	9.5 RD/11 WR	9.5	8.9 RD/10.9 WR
Average rotational delay (msec)	5.6	4.17	5.6	5.6	5.6
Average access time (msec)	14.1 RD/15.1 WR	12.67	15.1 RD/16.6 WR	15.1	14.5 RD/16.5 WR
Data transfer rate (MBytes/sec) Internal, min/max External	5.8/8.7 20.0 synch. 10.0 asynch.	6.1/10.2 20.0 synch. 10.0 asynch.	4.6/8.3 20.0 synch. 5.0 asynch.	3.4/6.9 20.0 synch. 10.0 asynch.	--/11.3 40
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	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1Q95	4Q94	1Q94	1Q/94	4Q95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	VP32210 Capella	XP32150 Atlas	XP32151 Grand Prix	XP32181 Atlas II	VP34360 Empire II
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-3	Ultra SCSI-3	Ultra SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,824 F: 2,216	U: 2,689 F: 2,150	U: 2,619 F: 2,150	F: 2,180	F: 4,360
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	10	5	10
Tracks per surface	4165	3832	4066	5964	3115
Track density (TPI)	4350	3858	4000	6000	5701
Maximum linear density (BPI) (FCI)	98600 73950	81765 61324	79600	106000 79500	98000
Areal density (Mb/square inch)	428.9	315.4	318.4	636.0	558.7
Recording code	1,7 RLL	1,7 RLL	PRML	1,7 RLL	16/17 PRML
Rotational speed (RPM)	5400	7200	7200	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)	8.5 RD/9.5 WR	8.5	8.6 RD/10.6 WR	7.9	8.9 RD/10.9 WR
Average rotational delay (msec)	5.6	4.17	4.17	4.17	5.6
Average access time (msec)	14.1 RD/15.1 WR	12.67	12.77/14.77	12.07	14.5 RD/16.5 WR
Data transfer rate (MBytes/sec) Internal, min/max External	5.8/8.7 20.0 synch. 10.0 asynch.	6.1/10.2 20.0 synch. 10.0 asynch.	5.8/9.7 20.0 synch.	8.8/13.3 40	--/11.3 40
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	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1Q95	4Q94	4Q94	4Q95	4Q95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	VP39100 Empire II	XP34300 Atlas	XP34301 Grand Prix	XP34361 Atlas II	XP39100 Atlas II
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI-3	SCSI-2	SCSI-3	Ultra SCSI-3	Ultra SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 9,100	U: 5,378 F: 4,300	U: 5,238 F: 4,300	F: 4,360	F: 9,100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	20	20	20	10	20
Tracks per surface	3115	3832	4066	5964	5964
Track density (TPI)	6200	3858	4000	6000	6000
Maximum linear density (BPI) (FCI)	98000	81765 61324	79600	106000 79500	111000 83250
Areal density (Mb/square inch)	607.6	315.4	318.4	636.0	666.0
Recording code	16/17 PRML	1,7 RLL	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	7200	7200	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)	8.9 RD/10.9 WR	8.5	8.6 RD/10.6 WR	7.9	7.9
Average rotational delay (msec)	5.6	4.17	4.17	4.17	4.17
Average access time (msec)	14.5 RD/16.5 WR	12.67	12.77/14.77	12.07	12.07
Data transfer rate (MBytes/sec) Internal, min/max External	--/11.3 40	6.1/10.2 20.0 synch. 10.0 asynch.	5.8/9.7 20.0 synch.	8.8/13.3 40	8.8/13.9 40
SIZE: (mm) H x W x D	41.3 x 101.6 x 146	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146	41.3 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	4Q95	4Q94	4Q94	4Q95	4Q95
COMMENTS					FC AL interface available 1996.

MANUFACTURER	RAYMOND ENGINEERING	RAYMOND ENGINEERING	SAGEM	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	8440	84300	MSA 252-200	PLS-30854A	PLS-30854S
DISK/TREND GROUP	2	5	4	6	6
MARKET	OEM	OEM	OEM	Captive, OEM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	130 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Ferrite	Thin Film	Thin Film
Interface	SCSI	SCSI	SCSI	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	F: 850.1	F: 850.1
REMOVABLE	F: 40.55	F: 306	F: 200	--	--
Capacity per track (Bytes)	F: 11,264	F: 27,648	F: 23,040	Varies by zone	Varies by zone
Data surfaces per spindle	8	9	16	4	4
Tracks per surface	450	1231	720	3858	3858
Track density (TPI)	850	2075	950	4300	4300
Maximum linear density (BPI) (FCI)	17000 17000	46227 30818	19680 14760	73906 55430	73906 55430
Areal density (Mb/square inch)	14.4	95.9	18.7	317.8	317.8
Recording code	MFM	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3637	3688	3600	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	115	25	17	11	11
Average rotational delay (msec)	8.3	8.1	8.3	6.7	6.7
Average access time (msec)	123.3	33.1	25.3	17.7	17.7
Data transfer rate (MBytes/sec) Internal, min/max External	 0.4	 1.2	 1.5	 --/7.2 11.1 PIO Mode 3 13.3 DMA Mode 1	 --/7.2 10 synch. 5 asynch.
SIZE: (mm) H x W x D	58.4 x 106.7 x 188	58.4 x 106.7 x 188	220 x 440 x 500	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1987	1991	10/90	8/95	
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	PLS-31064A	PLS-31064S	PLS-31084A	PLS-31084S	PLS-31274A
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive, OEM	Captive, OEM	OEM, PCM	OEM, PCM	Captive, OEM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,060.9	F: 1,060.9	F: 1,080.3	F: 1,080.3	F: 1,272.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	5	5	5	5	5
Tracks per surface	3844	3844	3844	3844	3844
Track density (TPI)	4300	4300	4300	4300	4300
Maximum linear density (BPI) (FCI)	74584 55938	74584 55938	74584 55938	74584 55938	74504 55578
Areal density (Mb/square inch)	320.7	320.7	320.7	320.7	320.4
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)	11	11	11	11	11
Average rotational delay (msec)	6.67	6.67	6.7	6.7	6.67
Average access time (msec)	17.67	17.67	17.7	17.7	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	--/7.2 11.1 PIO Mode 3 16.6 DMA Mode 1	--/7.2 10 synch. 5 asynch.	--/7.2 11.1 PIO Mode 3 13.3 DMA Mode 1	--/7.2 10 synch. 5 asynch.	--/6.8 13.3 DMA Mode 1
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			8/95	8/95	7/95
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	PLS-31274S	PLS-31609A	TBR-31081A	ST9150AG Marathon 130sl	ST3250A Medalist 210xe
DISK/TREND GROUP	7	7	7	3	4
MARKET	Captive, OEM	OEM, PCM	Captive, OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,272.8	F: 1,600	F: 1,080	F: 131.2	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	5	5	4		2
Tracks per surface	3844		3789		
Track density (TPI)	4300		4504	3282	
Maximum linear density (BPI) (FCI)			82695 62006	44360 33270	
Areal density (Mb/square inch)			372.5	145.6	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	5400	3980	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)	11	11	9 RD/10 WR	16	14
Average rotational delay (msec)	6.67	6.67	5.6	7.5	7.87
Average access time (msec)	17.67	17.67	14.6 RD/15.6 WR	23.5	21.87
Data transfer rate (MBytes/sec) Internal, min/max	--/6.8		4.8/9.1	--/3.7	
External	10 synch. 5 asynch.	16.6 PIO Mode 4	16.6 PIO Mode 4	11.1 PIO Mode 3 13.3 DMA Mode 1	11.1 PIO Mode 3 13.3 DMA Mode 1
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	12.5 x 70.1 x 101.9	25.4 x 102.1 x 146.6
FIRST CUSTOMER SHIPMENT	7/95	8/95	7/95	1Q94	4Q93
COMMENTS				*Glass disk.	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3295A Medalist 275xe	ST9235AG	ST9240AG Marathon 210sl	ST9300AG ST9300AR Marathon 260sl	ST3390N
DISK/TREND GROUP	4	4	4	4	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	65 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film*	Thin Film*	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 272	F: 209.7	F: 210.4	F: 262.4	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	2	6			3
Tracks per surface					2676
Track density (TPI)		2750	3282	3282	3000
Maximum linear density (BPI) (FCI)		45500 30300	44360 33270	44360 33270	42700 32000
Areal density (Mb/square inch)		125.1	145.6	145.6	128.1
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3811	3449	3980	3980	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	Dedicated Surf.
Average positioning time (msec)	14	16	16	16	12
Average rotational delay (msec)	7.87	8.7	7.5	7.5	6.7
Average access time (msec)	21.87	24.7	23.5	23.5	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	 11.1 PIO Mode 3 13.3 DMA Mode 1	--/2.0 4.0	--/3.7 11.1 PIO Mode 3 13.3 DMA Mode 1	--/3.7 11.1 PIO Mode 3 13.3 DMA Mode 1	2.6/4.5 10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	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
FIRST CUSTOMER SHIPMENT	9/94	3Q92	1Q94	1Q94	3/93
COMMENTS			*Glass disk.	*Glass disk.	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3491A Medalist 425xe	ST9385AG Marathon 340	ST9420AG Marathon 420sl	ST9550AG Marathon 455	ST3620N ST3620NC ST3620ND Hawk 1LP
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	65 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film*	Thin Film*	Thin Film*	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 428	F: 341	F: 420.8	F: 455	U: 635 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	6	4	8	5
Tracks per surface					2700
Track density (TPI)		3282	3807	3282	3000
Maximum linear density (BPI) (FCI)		59124 44343	94000 70500	59124 44343	49000 36750
Areal density (Mb/square inch)		194.0	357.9	194.0	147.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3811	3980	4500	3980	5411
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)	14	16	16	16	9 RD/10.5 WR
Average rotational delay (msec)	7.87	7.54	6.7	7.54	5.54
Average access time (msec)	21.87	23.54	22.7	23.54	14.54/16.04
Data transfer rate (MBytes/sec) Internal, min/max External	 11.1 PIO Mode 3 13.3 DMA Mode 1	 2.0/3.4 11.1 PIO Mode 3 13.3 DMA Mode 1	 --/5.5 13.3 DMA Mode 1	 --/3.4 11.1 PIO Mode 3 13.3 DMA Mode 1	 3.2/5.9 10.0 synch.
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	19.5 x 70.1 x 101.9	12.5 x 70.1 x 101.9	19.05 x 70.1 x 101.9	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4Q93	4Q93	1Q95	4Q93	3Q93
COMMENTS		*Glass-ceramic disk.	*Glass disks.	*Glass-ceramic disk.	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3660A Medalist 545xe	ST3780A Medalist 720	ST5660N ST5660NC Decathlon 545	ST5850A Decathlon 850	ST9655AG Marathon 520
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	SCSI	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 545	F: 722	F: 545.3	F: 854.7	F: 524
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	8
Tracks per surface		3876	3420	4085	
Track density (TPI)				4250	3227
Maximum linear density (BPI) (FCI)				69355 52016	72100 54075
Areal density (Mb/square inch)				294.8	232.7
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3811	4500	4500	5400	3980
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	11	16
Average rotational delay (msec)	7.87	6.67	6.67	5.6	7.5
Average access time (msec)	21.87	18.67	18.67	16.6	23.5
Data transfer rate (MBytes/sec) Internal, min/max External	 11.1 PIO Mode 3 13.3 DMA Mode 1	 3.5/5.9 16.6 PIO Mode 4 16.6 DMA Mode 2	 3.1/5.2 10.0 synch. 5.0 asynch.	 4.0/7.7 16.6 DMA Mode 2	 2.0/3.5 11.1 PIO Mode 3 13.3 DMA Mode 1
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	25.4 x 102.1 x 146.6	19 x 102.1 x 127	19 x 102.1 x 127	19.05 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	9/94		1Q94	12/94	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST9816AG Marathon 810	ST31051 Hawk 2XL	ST31200N ST31200NC ST31200ND Hawk 1LP	ST31200W ST31200WC ST31200WD Hawk 1LP	ST31220A Medalist 1080
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	65 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film*	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 810.7	F: 1,050	U: 1,260 F: 1,050	U: 1,260 F: 1,052	F: 1,083.5
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	4	9	9	6
Tracks per surface		4569	2700	2700	3876
Track density (TPI)	3807		3000	3000	
Maximum linear density (BPI) (FCI)	90000 67500		55000 41250	55000 41250	
Areal density (Mb/square inch)	342.6		165.0	165.0	
Recording code	1,7 RLL	0,4,4 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	5411	5411	5411	4500
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)	16	9 RD/10.5 WR	9 RD/10.5 WR	9 RD/10.5 WR	12
Average rotational delay (msec)	6.7	5.5	5.54	5.54	6.67
Average access time (msec)	22.7	14.5 RD/16 WR	14.54/16.04	14.54/16.04	18.67
Data transfer rate (MBytes/sec) Internal, min/max External	 16.6 PIO Mode 4 16.6 DMA Mode 2	 5.0/8.8 20.0 synch.	 3.2/5.9 10.0 synch. 4.0 asynch.	 3.2/5.9 20.0 synch.	 3.5/5.9 16.6 PIO Mode 4 16.6 DMA Mode 2
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 102.1 x 146.6
FIRST CUSTOMER SHIPMENT	4/95	8/95	2Q93		
COMMENTS	*Glass disks.				

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST31230DC ST31230N ST31230NC ST31230ND Hawk 2LP	ST31230W ST31230WC ST31230WD Hawk 2LP	ST31250N ST31250ND Barracuda 2LP	ST31250W ST31250WC ST31250WD Barracuda 2LP	ST31640A Medalist 1640
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film			Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,200 F: 1,050	U: 1,200 F: 1,050	U: 1,205 F: 1,021	U: 1,205 F: 1,021	F: 1,625.4
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	5	5	6
Tracks per surface	3892	3892			4834
Track density (TPI)	4200	4200			4800
Maximum linear density (BPI) (FCI)	78000 58500	78000 58500			78000 58500
Areal density (Mb/square inch)	327.6	327.6			374.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5411	5411	7200	7200	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.	Embedded
Average positioning time (msec)	9 RD/10.5 WR	9 RD/10.5 WR	8 RD/9 WR	8 RD/9 WR	10.5
Average rotational delay (msec)	5.54	5.54	4.17	4.17	5.6
Average access time (msec)	14.54/16.04	14.54/16.04	12.17/13.17	12.17/13.17	16.1
Data transfer rate (MBytes/sec) Internal, min/max External	4.0/7.3 10.0 synch.	4.0/7.3 20.0 synch.	6.2/9.0 10.0 synch.	6.2/9.0 20.0 synch.	--/8.4 16.6 PIO Mode 4
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 102.1 x 146.6
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	4Q94	4Q94	3Q95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41800K Elite 2, 2HP	ST51080A Medalist 1080sl	ST51080N Medalist 1080sl	ST12400N ST12400NC ST12400ND Hawk 2	ST12450W ST12450WD Barracuda 2,2HP
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IPI-2	IDE	SCSI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,986	F: 1,080	F: 1,080	U: 2,537 F: 2,148	U: 2,437 F: 2,134
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 84,000	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	18	4	4	19	18
Tracks per surface	2627	4826	4826	2626	2710
Track density (TPI)		4923	4923	3000	
Maximum linear density (BPI) (FCI)		73444 55083	73444 55083	50000 37500	
Areal density (Mb/square inch)		361.6	361.6	150.0	
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	5411	7200
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)	11	12.5	12.5	9 RD/10.5 WR	8 RD/9 WR
Average rotational delay (msec)	5.56	5.6	5.6	5.54	4.17
Average access time (msec)	16.56	18.1	18.1	14.54/16.04	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	7.5	4.1/8.3 16.6 PIO Mode 4 16.6 DMA Mode 2	4.1/8.3 10.0 synch.	3.4/5.4 10.0 synch. 5.0 asynch.	4.3/7.1 20.0 synch.
SIZE: (mm) H x W x D	82.6 x 146.1 x 216	19 x 102.1 x 127	19 x 102.1 x 127	41.3 x 101.6 x 146.1	41.3 x 101.6 x 151.6
FIRST CUSTOMER SHIPMENT	3Q91	10/95	10/95	2Q93	2Q94
COMMENTS	2 head parallel version of Elite 2.				2 head parallel version of Barracuda 2.

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST12550N ST12550ND Barracuda 2	ST12550W ST12550WD Barracuda 2	ST32140A Medalist 2140	ST32151 Hawk 2XL	ST32171DC ST32171W ST32171WC ST32171WD Barracuda 4LP
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	IDE	SCSI-2	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,572 F: 2,139	U: 2,572 F: 2,139	F: 2,167.2	F: 2,147	F: 2,150
-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	8	8	6
Tracks per surface	2707	2707	4834	4569	5288
Track density (TPI)			4800		5500
Maximum linear density (BPI) (FCI)			78000 58500		120000
Areal density (Mb/square inch)			374.4		660.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	0,4,4 RLL	PRML (0,4,4)
Rotational speed (RPM)	7200	7200	5400	5411	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.	Embedded	Embedded	Embedded
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	10.5	9 RD/10.5 WR	8 RD/9 WR
Average rotational delay (msec)	4.17	4.17	5.6	5.5	4.17
Average access time (msec)	12.17/13.7	12.17/13.17	16.1	14.5 RD/16 WR	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	4.3/7.0 10.0 synch.	4.3/7.0 20.0 synch.	--/8.4 16.6 PIO Mode 4	5.0/8.8 20.0 synch.	9.4/15.0 40.0 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 102.1 x 146.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	2/93	7/93	3Q95	8/95	4Q95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32171FC Barracuda 4LP	ST32171N ST32171ND Barracuda 4LP	ST32430DC ST32430N ST32430NC ST32430ND Hawk 2LP	ST32430W ST32430WC ST32430WD Hawk 2LP	ST32550DC ST32550W ST32550WC ST32550WD Barracuda 2LP
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	
Interface	FC AL	Ultra SCSI	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,150	F: 2,150	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	6	6	9	9	11
Tracks per surface	5288	5288	3892	3892	3711
Track density (TPI)	5500	5500	4200	4200	
Maximum linear density (BPI) (FCI)	120000	120000	78000 58500	78000 58500	
Areal density (Mb/square inch)	660.0	660.0	327.6	327.6	
Recording code	PRML (0,4,4)	PRML (0,4,4)	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	5411	5411	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)	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	5.54	5.54	4.17
Average access time (msec)	12.17/13.17	12.17/13.17	14.54/16.04	14.54/16.04	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	9.4/15.0 200 synch.	9.4/15.0 20.0 synch.	4.6/7.9 10.0 synch.	4.6/7.9 20.0 synch.	5.8/8.8 20.0 synch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	25.4 x 101.6 x 146	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	4Q95	4Q95	2Q94	2Q94	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32550N ST32550ND 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, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	130 mm	130 mm	130 mm	130 mm
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	3711	2627	2738	2738	2627
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
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	10 RD/11 WR	10 RD/11 WR	10 RD/11 WR
Average rotational delay (msec)	4.17	5.6	5.6	5.6	5.6
Average access time (msec)	12.17/13.17	16.6	15.6 RD/16.6 WR	15.6 RD/16.6 WR	15.6 RD/16.6 WR
Data transfer rate (MBytes/sec) Internal, min/max External	5.8/8.8 10.0 synch.	3.8/5.0 10.0 synch.	8.8/13.0 25	4.4/6.5 10.0 synch. 6.0 asynch.	4.4/6.5 20.0 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	ST15150DC ST15150N ST15150ND Barracuda 4	ST15150FC Barracuda 4	ST15150W ST15150WC ST15150WD Barracuda 4	ST15230DC ST15230W ST15230WC ST15230WD Hawk 4	ST15230N ST15230NC ST15230ND Hawk 4
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film		
Interface	SCSI-2	Fibre Channel	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 5,062 F: 4,294	U: 5,062 F: 4,294	U: 5,062 F: 4,294	U: 5,160 F: 4,294	U: 5,160 F: 4,294
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	21	19	19
Tracks per surface	3711	3711	3711	3892	3892
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	7200	5411	5411
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	8 RD/9 WR	9 RD/10.5 WR	9 RD/10.5 WR
Average rotational delay (msec)	4.17	4.17	4.17	5.54	5.54
Average access time (msec)	12.17/13.17	12.17/13.17	12.17/13.17	14.54/16.04	14.54/16.04
Data transfer rate (MBytes/sec) Internal, min/max External	6.0/9.0 10.0 synch.	5.9/9.0 100.0	6.0/9.0 20.0 synch.	4.3/7.9 20.0 synch.	4.3/7.9 10.0 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 151.6	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q94	2Q95	2Q94	2Q94	2Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST18771DC ST18771W ST18771WC ST18771WD Barracuda 8	ST18771FC Barracuda 8	ST18771N ST18771ND Barracuda 8	ST34371DC ST34371W ST34371WC ST34371WD Barracuda 4LP	ST34371FC Barracuda 4LP
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	FC AL	Ultra SCSI	Ultra SCSI	FC AL
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 10,800 F: 8,700	U: 10,800 F: 8,700	U: 10,800 F: 8,700	F: 4,350	F: 4,350
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	20	20	20	10	10
Tracks per surface	5333	5333	5333	5288	5288
Track density (TPI)	5500	5500	5500	5500	5500
Maximum linear density (BPI) (FCI)	120000	120000	120000	120000	120000
Areal density (Mb/square inch)	660.0	660.0	660.0	660.0	660.0
Recording code	PRML (0,6,6)	PRML (0,6,6)	PRML (0,6,6)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	7200	7200	7200	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 RD/9.5 WR	8 RD/9.5 WR	8 RD/9.5 WR	8 RD/9 WR	8 RD/9 WR
Average rotational delay (msec)	4.17	4.17	4.17	4.17	4.17
Average access time (msec)	12.17/13.67	12.17/13.67	12.17/13.67	12.17/13.17	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	9.4/15.0 40 synch.	9.4/15.0 200 synch.	9.4/15.0 20 synch.	9.4/15.0 40 synch.	9.4/15.0 200 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	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	4Q95	4Q95	4Q95	4Q95	4Q95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEIKO EPSON	SEQUEL
DRIVE	ST34371N ST34371ND Barracuda 4LP	ST410800N ST410800ND Elite 9	ST410800W ST410800WD Elite 9	EHDD170 Hard Disk Card	XT-1085
DISK/TREND GROUP	9	9	9	3	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	PCM	OEM
MEDIA: Disk diameter	95 mm	130 mm	130 mm	48 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film*	Thin Film
DRIVE: Heads	MR Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	Ultra SCSI	SCSI-2	SCSI-2	PCMCIA-ATA	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,350	U: 10,800 F: 9,090	U: 10,800 F: 9,090	--	U: 85.32
REMOVABLE	--	--	--	F: 170.8	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	U: 10,416
Data surfaces per spindle	10	27	27	4	8
Tracks per surface	5288	4925	4925	1370	1024
Track density (TPI)	5500			3800	1070
Maximum linear density (BPI) (FCI)	120000			84000 63000	9934
Areal density (Mb/square inch)	660.0			319.2	10.6
Recording code	PRML (0,4,4)	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	7200	5400	5400	4500	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)	8 RD/9 WR	11 RD/12 WR	11 RD/12 WR	12	27
Average rotational delay (msec)	4.17	5.6	5.6	6.7	8.3
Average access time (msec)	12.17/13.17	16.6 RD/17.6 WR	16.6 RD/17.6 WR	18.7	35.3
Data transfer rate (MBytes/sec) Internal, min/max External	9.4/15.0 20 synch.	5.5/8.2 10.0 synch.	20.0 synch.	12.0	0.625
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	82.6 x 146.1 x 203.2	82.6 x 146.1 x 203.2	10.5 x 54 x 85.6	82.6 x 146.1 x 208.3
FIRST CUSTOMER SHIPMENT	4Q95	2Q94	2Q94	3/94	2Q83
COMMENTS				PCMCIA Type III Ramp loaded heads. *Untextured disks. Mfg by Integral Peripherals.	

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	806	XT-1120R	XT-1140	XT-1240R	XT-2190
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	200 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Priam,SMD,SCSI	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 227	U: 127.99*	U: 143.42	U: 239.98*	U: 191.23
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 15,624*	U: 10,416	U: 15,624*	U: 10,416
Data surfaces per spindle	11	8	15	15	15
Tracks per surface	1023	1024	918	1024	1224
Track density (TPI)	1040	1070	1070	1070	1070
Maximum linear density (BPI) (FCI)	9167	14901 9934	9280	14901 9934	11155
Areal density (Mb/square inch)	9.5	15.9	9.9	15.9	11.9
Recording code	MFM	2,7 RLL*	MFM	2,7 RLL*	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
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)	20	27	25.8	27	28.9
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	35.3	34.1	35.3	37.2
Data transfer rate (MBytes/sec) Internal, min/max External	1.21	0.938*	0.625	0.938*	0.625
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	5/84	2Q87	2Q83	2Q87	3Q84
COMMENTS		*With RLL controller.		*With RLL controller.	

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-4170E	XT-4170S	XT-4230E	807	XT-4380E
DISK/TREND GROUP	3	3	3	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	200 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Thin Film
Interface	ESDI	SCSI	ESDI	Priam,SMD,SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 179.45	F: 157.93	U: 230.6	U: 344	U: 384.53
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,940	F: 18,432	U: 20,940	U: 20,160	U: 20,940
Data surfaces per spindle	7	7	9	11	15
Tracks per surface	1224	1224	1224	1552	1224
Track density (TPI)	1070	1070	1070	1040	1070
Maximum linear density (BPI) (FCI)	21064 14043	21064 14043	21064 14043	12096	21064 14043
Areal density (Mb/square inch)	22.5	22.5	22.5	12.6	22.5
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	MFM	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	14	16	25	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	22.3	24.3	33.3	24.3
Data transfer rate (MBytes/sec) Internal, min/max External	1.25	4.8 synch.	1.25	1.21	1.25
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	2Q87	2/86	3Q90	6/84	2Q87
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-4380S	XT-8380EH	XT-8380SH	XT-8760EH	XT-8760SH
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 338.41	U: 410.0	F: 360.31	U: 768.9	F: 675.58
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 31,410	F: 27,648	U: 31,410	F: 27,648
Data surfaces per spindle	15	8	8	15	15
Tracks per surface	1224	1632	1632	1632	1632
Track density (TPI)	1070	1376	1376	1376	1376
Maximum linear density (BPI) (FCI)	21064 14043	31596 21064	31596 21064	31596 21064	31596 21064
Areal density (Mb/square inch)	22.5	43.5	43.5	43.5	43.5
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	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)	16	14.5	14.5	16.5	16.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	22.8	22.8	24.8	24.8
Data transfer rate (MBytes/sec) Internal, min/max External	4.8 synch.	1.875	4.8 synch.	1.875	4.8 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	4Q87	1Q87	1Q88	1Q87	1Q88
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	5350	5400	SQ1080	SQ3105A	SQ3105S
DISK/TREND GROUP	9	9	1	1	1
MARKET	OEM	OEM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	48 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MIG	MIG
Interface	SCSI-2	SCSI-2	PCMCIA-ATA	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,572	F: 4,000	--	--	--
REMOVABLE	--	--	F: 80	F: 110	F: 110
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	25	26	2	2	2
Tracks per surface	3055	3055	1472	2043	2043
Track density (TPI)	2756	2756	3200	2100	2100
Maximum linear density (BPI) (FCI)	44000 33000	49000 36750	72000 54330	40000 30000	40000 30000
Areal density (Mb/square inch)	121.3	135.0	230.4	84.0	84.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	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.	Embedded	Embedded	Embedded
Average positioning time (msec)	11.5	11.5	15	14.5	14.5
Average rotational delay (msec)	5.6	5.6	5.6	8.3	8.3
Average access time (msec)	17.1	17.1	20.6	22.8	22.8
Data transfer rate (MBytes/sec) Internal, min/max External	3.6/5.5 20.0 synch. 10.0 asynch.	3.6/5.5 20.0 synch. 10.0 asynch.	2.2/4.2 10.0	1.6/2.3 4.0	1.6/2.3 4.0 synch.
SIZE: (mm) H x W x D	82.6 x 146 x 208.8	82.6 x 146 x 208.8	10.5 x 54 x 85.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q93	8/93	3Q95	3Q92	3/93
COMMENTS			PCMCIA Type III with removable data cartridge.	Removable data cartridge.	Removable data cartridge.

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	SQ3270A	SQ3270S	SQ5110	SQ5200C	EZ135A
DISK/TREND GROUP	1	1	1	1	1
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	130 mm	130 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG		Ferrite	Ferrite	MIG
Interface	IDE	SCSI-2	SCSI	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 270	F: 270	F: 88.8	F: 200	F: 135
Capacity per track (Bytes)	F:	F:	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	1
Tracks per surface	3140	3140	1774	2260	3140
Track density (TPI)	3280	3280	1470	1875	3280
Maximum linear density (BPI) (FCI)	60000 45000	60000 45000	28546 19031	49820 37365	60000 45000
Areal density (Mb/square inch)	196.8	196.8	42.0	93.4	196.8
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3220	3220	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)	13.5	13.5	20	18	13.5
Average rotational delay (msec)	8.3	8.3	9.32	9.32	8.3
Average access time (msec)	21.8	21.8	29.32	27.32	21.8
Data transfer rate (MBytes/sec) Internal, min/max External	2.3/4.0 4.0	2.3/4.0 4.0	1.4/1.8 4.0 synch. 1.25 asynch.	2.6/3.6 5.0 synch. 3.0 asynch.	2.3/4.0 4.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 150	25.4 x 101.6 x 150	41.3 x 146.1 x 203.2	41.3 x 146.1 x 203.2	25.4 x 101.6 x 150
FIRST CUSTOMER SHIPMENT	4Q93	2/94	2/91	2Q94	7/95
COMMENTS	Removable data cartridge. Read/write compatible with 105 MB & 270 MB cartridge.	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. Internal model.

MANUFACTURER	SYQUEST TECHNOLOGY	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	EZ135S	MK-1722FCV	MK-1724FCV	MK-1824FBV	MK-1824FCV
DISK/TREND GROUP	1	3	4	5	5
MARKET	OEM, PCM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	IDE	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 131	F: 262	F: 352	F: 352
REMOVABLE	F: 135	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	1	2	4	4	4
Tracks per surface	3140	1920	1920	2050	2050
Track density (TPI)	3280	3528	3528	3810	3810
Maximum linear density (BPI) (FCI)	60000 45000	68350 51050	68350 51050	87630 65532	87630 65532
Areal density (Mb/square inch)	196.8	241.1	241.1	333.9	333.9
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	4000	4000	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)	13.5	13	13	13	13
Average rotational delay (msec)	8.3	7.5	7.5	7.14	7.14
Average access time (msec)	21.8	20.5	20.5	20.14	20.14
Data transfer rate (MBytes/sec) Internal, min/max External	2.3/4.0 4.0 synch.	2.3/3.9 11.1 PIO Mode 3	2.3/3.9 11.1 PIO Mode 3	10.0 synch. 6.0 asynch.	3.1/5.4 11.1 PIO Mode 3
SIZE: (mm) H x W x D	25.4 x 101.6 x 150	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT	7/95	3/94	1Q94	9/94	9/94
COMMENTS	Removable data cartridge. External model.				

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-2326FB	MK-2326FCH	MK-1924FBV	MK-1924FCV	MK-1926FBV
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film			
Interface	SCSI-2	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 340	F: 340	F: 543	F: 543	F: 815
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	4	4	6
Tracks per surface	1830	1830	2920	2920	2920
Track density (TPI)	3528	3528			
Maximum linear density (BPI) (FCI)	62200 46650	62200 46650			
Areal density (Mb/square inch)	219.4	219.4			
Recording code	1,7 RLL	1,7 RLL			
Rotational speed (RPM)	4200	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)	13	12	13	13	13
Average rotational delay (msec)	7.14	7.14	7.14	7.14	7.14
Average access time (msec)	20.14	19.14	20.14	20.14	20.14
Data transfer rate (MBytes/sec) Internal, min/max External	2.3/3.7 10.0 synch. 6.0 asynch.	2.2/3.6 11.1 PIO Mode 3	3.1/5.6 10.0 synch.	3.1/5.6 16.6 PIO Mode 4 16.6 DMA Mode 2	3.1/5.6 10.0 synch. 6.0 asynch.
SIZE: (mm) H x W x D	19 x 70 x 100	19 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT	3Q93	5/93	3/95	1Q95	
COMMENTS					

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-1926FCV	MK-2428FB	MK-2428FC	MK-2526FB	MK-2526FC
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film		
Interface	IDE	SCSI-2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 815	F: 524	F: 524	F: 528	F: 528
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	8	8	6	6
Tracks per surface	2920	1920	1920	2050	2050
Track density (TPI)		3528	3528		
Maximum linear density (BPI) (FCI)		68355 51266	68355 51266		
Areal density (Mb/square inch)		241.2	241.2		
Recording code		1,7 RLL	1,7 RLL		
Rotational speed (RPM)	4200	4000	4000	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)	13	12	12	13	13
Average rotational delay (msec)	7.14	7.5	7.5	7.14	7.14
Average access time (msec)	20.14	19.5	19.5	20.14	20.14
Data transfer rate (MBytes/sec) Internal, min/max External	3.1/5.6 16.6 PIO Mode 4 16.6 DMA Mode 2	2.3/3.9 10.0 synch. 6.0 asynch.	2.3/3.9 6.0	--/5.4 10.0 synch. 6.0 asynch.	--/5.4 11.1 PIO Mode 3 13.3 DMA Mode 1
SIZE: (mm) H x W x D	12.7 x 70 x 100	19 x 70 x 100	19 x 70 x 100	19 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT		12/93	12/93	2/95	11/94
COMMENTS					

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	WESTERN DIGITAL
DRIVE	MK-2628FB	MK-2628FC	MK-2720FB	MK-2720FC	WDAC1365 Caviar
DISK/TREND GROUP	6	6	7	7	5
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MR Thin Film	MR Thin Film			
Interface	SCSI-2	IDE	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 811	F: 811	F: 1,350	F: 1,350	F: 365.4
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	10	2
Tracks per surface	2360	2360	2920	2920	
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
Recording code					1,7 RLL
Rotational speed (RPM)	4200	4200	4200	4200	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)	13	13	13	13	10 RD/12.5 WR
Average rotational delay (msec)	7.14	7.14	7.14	7.14	6.7
Average access time (msec)	20.14	20.14	20.14	20.14	16.7 RD/18.7 WR
Data transfer rate (MBytes/sec) Internal, min/max	--/5.3	--/5.3	3.1/5.6	3.1/5.6	
External	10.0 synch. 6.0 asynch.	11.1 PIO Mode 3 13.3 DMA Mode 1	10.0 synch. 6.0 asynch.	16.6 PIO Mode 4 16.6 DMA Mode 2	11.1 PIO Mode 3 13.3 DMA Mode 1
SIZE: (mm) H x W x D	19 x 70 x 100	19 x 70 x 100	19 x 70 x 100	19 x 70 x 100	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2/95	12/94	9/95	6/95	11/94
COMMENTS					

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAC1425 Caviar	WDAC2700 Caviar	WDAC2850 Caviar	WDHC2635 Caviar	WDAC31000 Caviar
DISK/TREND GROUP	5	6	6	6	7
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film			Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 426.8	F: 730.8	F: 853.6	F: 639.9	F: 1,083.8
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	3	6
Tracks per surface					
Track density (TPI)		4000			4000
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
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)	10 RD/12.5 WR	10 RD/12 WR	10 RD/12 WR	10 RD/12 WR	10 RD/12.5 WR
Average rotational delay (msec)	6.7	6.67	6.67	6.67	6.67
Average access time (msec)	16.7 RD/18.7 WR	16.67/18.67	16.67/18.67	16.67/18.67	16.67/19.17
Data transfer rate (MBytes/sec) Internal, min/max External	11.1 PIO Mode 3 13.3 DMA Mode 1	11.1 PIO Mode 3 13.3 DMA Mode 1	11.1 PIO Mode 3 13.3 DMA Mode 1	11.1 PIO Mode 3 13.3 DMA Mode 1	11.1 PIO Mode 3 13.3 DMA Mode 1
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	4/94	11/94	11/94	4/94
COMMENTS					

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL			
DRIVE	WDAC31200 Caviar	WDAC31600 Caviar			
DISK/TREND GROUP	7	7			
MARKET	OEM, PCM	OEM, PCM			
MEDIA: Disk diameter	95 mm	95 mm			
Recording medium	Thin Film	Thin Film			
DRIVE: Heads	Thin Film	Thin Film			
Interface	IDE	IDE			
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,281.9	F: 1,624.6			
REMOVABLE	--	--			
Capacity per track (Bytes)	Varies by zone	Varies by zone			
Data surfaces per spindle	6	6			
Tracks per surface					
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
Recording code	1,7 RLL	PRML			
Rotational speed (RPM)	4500	5200			
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil			
Servo type	Embedded	Embedded			
Average positioning time (msec)	10 RD/12.5 WR	10 RD/12 WR			
Average rotational delay (msec)	6.67	5.77			
Average access time (msec)	16.67/19.17	15.77/17.77			
Data transfer rate (MBytes/sec) Internal, min/max External	11.1 PIO Mode 3 13.3 DMA Mode 1	16.6 PIO Mode 4 16.6 DMA Mode 2			
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1			
FIRST CUSTOMER SHIPMENT	11/94	4/95			
COMMENTS					

MANUFACTURER PROFILES

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 "1994 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. "1994 total net sales" covers the fiscal year ending December 31, 1994, 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 1994 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	5.55
Germany	Deutschmark	1.62
Japan	Yen	102.2
South Korea	Won	807.0
Taiwan	Dollar	26.5
United Kingdom	Pound	0.652

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

U.S. Manufacturers

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 1989. A 2.5" 50 megabyte drive was also announced. The drives were to be among the first to use glass substrates, with Nippon Sheet Glass a major investor in Areal. In 1990, management reorganizations resulted in Swartz leaving the company, along with the 3.5" development effort, and Areal subsequently concentrated entirely on 2.5" drives. The firm entered into an agreement with Sanyo Electric to produce Areal's drives in Japan at its Tottori facility, and Sanyo, with other Japanese investors, acquired control of Areal. Production of a 2.5" single disk 62 megabyte drive began at Areal's factory and at Sanyo in 1991, and in recent years the product line extended up to 700 megabyte drives. In mid-1995, the investors closed the U.S. facilities except for service personnel, although drives were still being manufactured in Japan, for the time being.

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 for production by NEC, but for which Aura also retained 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 never went into operation.

Aura has phased out active marketing of the 1.8" disk drive product line and the company is now concentrating on an electronic camera which will use a PC Card disk, following acquisition of a camera development company in 1994.

AVATAR SYSTEMS CORPORATION
1455 McCarthy Boulevard
Milpitas, CA 95035

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

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

1994 disk sales: $1,962,200,000
1994 total net sales: $2,365,152,000 Net income: $109,687,000

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 both the Italy and Scotland sites. 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 several 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, and has stayed in the black since, but has never reestablished a high growth rate. In September, 1995, Conner announced an agreement with Seagate Technology, under which Conner would be acquired. Both firms' boards have ratified the agreement, under which the acquisition could be completed in early 1996 if governmental approvals are obtained.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1994 disk sales: $678,000,000
1995 total net sales: $13,813,062,000 (FY ending 7/01/95) Net income: ($64,503,000)

Digital maintained internal disk drive manufacturing programs for more than 20 years, initially with disk cartridge drives, and eventually with high-end drives for minicomputer and mainframe applications. 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 plant established at Penang, Malaysia. The high-end 3.5" drives were produced 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 in October, 1994. Digital retained its StorageWorks data storage subsystem business and Video Interactive Information Services units, for which Quantum is now a drive supplier. In this edition of the DISK/TREND Report, Digital's estimated disk drive sales are credited to Digital, through the date on which ownership of the disk drive operation was transferred, in both captive and noncaptive marketing channels. Subsequent to that date, all sales of the appropriate drives are included in noncaptive disk drive shipments by Quantum.

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 assembled 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. Gigastorage has designed a 1.1 gigabyte 5.25" drive designed to be sold at a very low price per megabyte, with manufacturing at Belfort scheduled to start in late 1995.

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

1994 disk sales: $1,103,500,000
1994 total net sales: $24,991,000,000 (FY ending 10/31/94) Net income: $1,599,000,000

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 4 gigabytes.

H-P's received widespread attention with its announcement of the pioneering 1.3" "Kittyhawk" drive in 1992. The original 21 megabyte 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 PrairieTek. The company was the first to design and manufacture 1.8" disk drives. Its initial product was a 20 megabyte drive, first produced in the second half of 1991, and for which the available market was minimal. Integral had somewhat better luck with a 42 megabyte model, in production since early 1992, and 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 specifications, with low power requirements, in anticipation of wide usage in subnotebook computers and other mobile computer applications. Integral began its high volume manufacturing in Singapore in mid-1992, and has since added 105, 260, and 340 megabyte models in PC Card Type III format.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1994 disk sales: $6,332,300,000
1994 total net sales: $64,052,000,000 Net income: $3,021,000,000

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 39 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 1.7 gigabytes on 2 platters and 2.5" drives with up to 1.2 gigabytes on 3 platters. 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 has been 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, but an upgrade to 4 gigabyte Starfire drives was delayed until the end of October, 1995. A further upgrade for IBM's mainframe array subsystems, to 9 gigabyte Scorpion drives, will probably wait for IBM's promised "Seascape" disk controller family, presumably due in mid-1996. The Scorpion 3.5" 9.1 gigabyte drives are still scheduled for first deliveries by the end of 1995, but the 10.8 gigabyte Scorpion model has been pushed back to the second quarter of 1996, probably with a boost in capacity before initial shipment.

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 will produce the last of the 10.8" 3390 series, plus older 3.5" high-end drives, but a new $100 million factory has been established in Singapore to manufacture the newer 3.5" high-end drives and all future models. Fujisawa (Japan) transferred its manufacturing activities for 3.5" and 2.5" drives for the personal computer market to a contract manufacturing organization in Thailand. Mainz (Germany), traditionally the internal IBM second source for mainframe drives, is reorganizing to make smaller drives. A new disk drive manufacturing plant has been established in Hungary for personal computer drives. The Havant (U.K.) plant has been spun off in an employee buy out under the Xyratex name (see European manufacturers section).

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 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".

IOMEGA CORPORATION
1821 West Iomega Way
Roy, UT 84067

1994 total net sales: $141,380,000 Net income: ($1,882,000)

Iomega, founded in 1980, was successful in establishing production capability for its unique 8" flexible disk drive, which maintained control of head/disk contact with the Bernoulli effect. The product was originally intended as an OEM drive, but Iomega had much better luck with subsystems sold in the personal computer add-on market. The original 8" subsystem for the IBM PC market provided most of the company's early revenue growth until surpassed by the 20 megabyte half high 8" drives introduced in 1985. However, half high 5.25" models in production since 1987 have largely displaced 8" drives, and Iomega discontinued 8" drives in 1991. The 5.25" product line currently includes a 90 megabyte model (1991), a 150 megabyte model (1992), and a 230 megabyte model (1994).

Attempting to broaden its product coverage, Iomega licensed the Insite Peripherals "floptical" drive and media, and selected Chinon as a manufacturing partner for the drive. Iomega's 20 megabyte "floptical" drive was introduced in 1992, but was discontinued in 1994 after only limited sales success.

The 100 megabyte "Zip" 3.5" floppy drive, which began shipments in early 1995, has found a much broader market, due to its unique combination of 100 megabyte disk capacity and less than $200 drive list price. Seiko Epson has been established as a second manufacturing source for the Zip drive. The one gigabyte "Jaz" drive, expected to ship in late 1995, marks Iomega's entry into the rigid cartridge disk drive market.

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 the 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, 420 and 540 megabyte versions of the product were produced, but only the 540 megabyte model is currently offered.

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. The current JTS program is centered on the "Nordic" 3" drive, which is intended to offer extremely aggressive price competition to 2.5" drives for notebook computer applications. Manufacturing plans include contract production at Havant, U.K., by Xyratex and at Madras, India, at a facility controlled by the Tandon family.

MAXTOR CORPORATION
150 River Oaks Parkway
San Jose, CA 95134

1994 disk sales: $861,300,000
1995 total net sales: $906,799,000 (FY ending 3/25/95) Net income: ($82,222,000)

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 approximately 40% of the firm. In September, 1995, Maxtor announced the sale of all of its manufacturing facilities to Hyundai, which will produce disk drives under contract for Maxtor in Singapore and Korea.

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 applications. After a strong initiative to secure leadership in 1.8" PCMCIA disk drives found a much smaller available market than anticipated, Maxtor discontinued the 1.8" drives in 1995. The firm is now concentrating on 3.5" drives for the desktop personal computer market, plus the new "Laramie" 2.5" drives with up to 1.3 gigabyte capacity, for the notebook computer market.

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 continued until 1994.

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1994 disk sales: $330,000,000
1994 total net sales: $346,314,000 Net income: ($30,675,000)

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 hoped that its high-end 5.25" and 3.5" disk drives would give it a strong position in the nascent video-on-demand server market and that VOD related sales would reignite company growth. It was clear by mid-1995 that the array and video equipment markets would not immediately restart Micropolis' earlier growth, and a change in management occurred. The firm is now concentrating on a successful introduction of its next generation of high capacity 3.5" drives.

MINISTOR PERIPHERALS CORPORATION
2801 Orchard Parkway
San Jose, CA 95134

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 managed to acquire the necessary resources to continue its program and establish manufacturing in Singapore. By mid-1994, MiniStor offered 1.8" drives up to 170 megabytes, plus 260 megabyte and 340 megabyte models that incorporated data compression, with an emphasis on marketing through distribution channels to a hoped-for emerging notebook computer market for PC Card drives.

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. MiniStor became a publicly traded company in July, 1994. Unfortunately, the expected growth market in 1.8" add-on drives for the notebook computer market proved to be an illusion, and the company ceased operations in April, 1995.

QUANTUM CORPORATION
500 McCarthy Boulevard
Milpitas, CA 95035

1994 disk sales: $2,900,600,000
1995 total net sales: $3,367,984,000 (FY ending 3/31/95) Net income: $81,591,000

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, but shipment was late, 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" and 2.5" drives, manufacturing drives for personal computer and mobile applications is done by MKE, in factories located in Japan, Singapore and Ireland. MKE has rights to distribute drives it manufactures within Japan, under a Quantum license. 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.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1994 disk sales: $3,770,400,000
1995 total net sales: $4,539,570,000 (FY ending 6/30/95)   Net income: $260,082,000

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. High-end 3.5" drives in both 5,400 and 7,200 RPM models offer capacities up to 8.7 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 4.3 gigabytes. The Elite 5.25" drive series offers 9 gigabytes with an extremely competitive price per megabyte, and is expected to be extended to at least 20 gigabytes in 1996.

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. In 1994, Seagate's sales topped the $1 billion per quarter mark, and during the last year Seagate has begun diversifying into additional markets, acquiring several firms specializing in storage related software. In September, 1995, Seagate announced an agreement to acquire Conner Peripherals, which, if approved by the applicable government agencies, would probably be consummated in early 1996.

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

Sequel was created in November, 1989, as the result of a management buy out 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, plus some of the Digital Equipment and Seagate Technology older drives.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

1994 disk sales: $111,000,000
1994 total net sales: $221,001,000 (FY ending 9/30/94) Net income: $5,405,000

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

In 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. The EZ135, a 135 megabyte drive marketed as a counter to the Iomega "Zip" drive, began shipping in mid-1995. SyQuest also manufactures the disk cartridges for the drives, and cartridges accounted for a majority of the firm's revenue. A unique 1.8" drive was introduced in 1995, utilizing a disk cartridge which is removable from a PC Card Type III disk drive.

WESTERN DIGITAL CORPORATION
8105 Irvine Center Drive
Irvine, CA 92718

1994 disk sales: $1,717,900,000
1995 total net sales: $2,130,867,000 (FY ending 7/01/95) Net income: $123,302,000

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 has maintained a disk drive development facility in San Jose for several years to develop drives for the personal computer market. 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. In April, 1994, the company began shipping a three platter drive family, which pioneered the 1.6 gigabyte personal computer market in early 1995.

Although the impact of the 1993 disk drive price wars resulted in further losses, the firm has been profitable in recent quarters. Western Digital is currently engaged in a major expansion program to enter the high capacity 3.5" drive market, with a high-end development facility in Rochester, Minnesota, and a new factory in Singapore, all pointed toward introduction of a multiproduct high-end program in 1996.

Asian Manufacturers

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

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

1995 total net sales: $3,910,930,000 Net income: $44,139,000

Alps Electric, founded in 1948, is a manufacturer of electronic components (including magnetic heads) 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 24% of Alps' shipments are computer peripherals, mostly floppy 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. 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. The company continued the development of its 3.5" rigid disk drives including a 2 disk 545 megabyte drive, plus a 246 megabyte model. However, Alps was unable to gain a significant market share and elected to leave the rigid disk drive market in 1994.

EPSON (See Seiko Epson)

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

1995 total net sales: $8,378,718,000 Net income: $37,378,000

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 6.9% 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), spindle motors and rigid 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 in recent years have included 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 obtained rights to also sell 1.8" drives intended for the Japanese market, although it did not do so. Due to continuing low-priced competition from offshore competitors, the company has indicated that it intends to withdraw from the rigid disk drive and spindle motor markets during 1995. Rigid media production will continue.

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

1994 disk sales: $1,038,700,000
1995 total net sales: $31,875,793,000 Net income: $440,509,000

Fujitsu derives about 68% 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 magnetic disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters. Fujitsu is a leading producer of 3.5" optical drives and 3.5" optical libraries.

Fujitsu manufactures some high performance drives at a plant near Portland, Oregon. Over 90% of Fujitsu's rigid drive production is currently done outside Japan, mostly in Thailand. Intellistor, located in Longmont, Colorado, is a Fujitsu subsidiary developing small diameter disk drives and drive arrays. A disk drive production facility in the Philippines is scheduled to begin production in 1996. Fujitsu also has 44% ownership in Amdahl.

Fujitsu has marketed most of its captive drives also in OEM versions, using industry standard 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 then 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. Development of new 5.25" drives was halted in mid-1994 in favor of 3.5" drive development. An extensive 3.5" line ranges from 45 megabytes to 8.8 gigabytes. A 240 megabyte 2.5" drive was added in 1993, followed by a series of drives with increasing capacities, through 1 gigabyte in 1995.

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

1994 disk sales: $864,000,000
1995 total net sales: $74,288,317,000 Net income: $1,114,599,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. 50% 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, making high-end rigid disk drives and 5.25" optical disk drives. The company also manufactures an extensive line of 3.5" disk drives that range from 169 megabytes to 4.3 gigabytes.

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 that now reaches to 1 gigabyte. Plans for 1.8" drives terminated after MiniStor went out of business.

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

1995 total net sales: $4,388,777,000 Net income: $83,180,000

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. In more recent years MKE has become the largest producer of CD-ROM drives, which are sold mostly through other Matsushita group companies, and is undertaking a new manufacturing program for 120 megabyte 3.5" "floptical" drives, which will be initially targeted to a Compaq program. 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 produces rigid disk drives in Japan and in a recently expanded Singapore facility, and established a subsidiary in Ireland to manufacture Quantum products for the European market.

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

1994 disk sales: $266,800,000
1995 total net sales: $36,882,162,000 Net income: $345,558,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 49% 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 enhanced by 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.

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

1994 disk sales: $253,700,000
1994 total net sales: $14,275,000,000 Net income: $1,171,000,000

Samsung Electronics, founded in 1969, is Korea's largest electronics company, producing a variety of consumer, industrial and computer products. The firm is the leading supplier of DRAM chips and is becoming increasingly visible in the rigid disk drive market. Semiconductors and computers together accounted for 46.5% of 1994 revenues.

Samsung made a minority investment in Comport, a 1987 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 currently entirely in 1" high 3.5" models targeted for the higher capacity range used with personal computers, from 850 megabytes to 1.6 gigabytes. In a move to speed up market entry, Samsung arranged for development of 2.5" drives by Integral Peripherals, which are planned for introduction in 1996. 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

1995 total net sales: $1,074,853,000 Net income: ($108,973,000)

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 65% 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" rigid disk drives, with rights to market the drives in Japan and the Far East. After limited success with 5.25" rigid 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 produced JTS drives on a contract manufacturing basis, as well as offering them under its own name. In 1994, the company decided to withdraw from the rigid disk drive market, due to severe price competition from major offshore disk drive manufacturers.

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

1994 disk sales: $865,400,000
1995 total net sales: $46,876,380,000 Net income: $437,309,000

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. About 61% of 1994 revenues were derived from computing and communications products.

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 continued to expand its U.S. operations, establishing a design center in Southern California. Toshiba then 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, 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. Toshiba's 2.5" line now extends to 1.3 gigabytes. Like many other Japanese companies, Toshiba is shifting its rigid drive production offshore, with a factory in the Philippines scheduled to start production in mid-1996.

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

Zentek, was established as a joint venture between semiconductor producer Universal Scientific Industrial Co., Ltd. and Longshine Electronics in September, 1989. Much of the original engineering team came from Longshine and Priam. Zentek manufactured 60 megabyte and 100 megabyte 3.5" drives based on designs developed by ITRI, a government research agency, and extended the 3.5" product line to 360 megabytes. Newer products with capacities to 1 gigabyte were announced, with production scheduled in late 1994 to early 1995, and Zentek expanded its manufacturing facilities in 1994, taking over the old Microscience plant in Hsin Chu, and obtaining additional investment capital to finance its expansion. However, the company ceased manufacturing operations in 1995, due to financial difficulties.

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, the pioneer manufacturer of 3.5" drives, and many were previously with the Burroughs disk drive manufacturing facility in Glenrothes. Calluna occupied a new industrial building early in 1992 and started production of disk drives in the PCMCIA Type III PC Card format in mid-1993. The PC Card drive product line has since been expanded, and currently includes 85, 105, 130, 170 and 260 megabyte drives. The drives use disks with glass substrates.

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 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 controls distribution of Hitachi mainframes and peripherals in Germany and Eastern Europe, and HDS handles 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.

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

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

The company more recently announced the development of high capacity 3.5" rigid disk cartridge drives, which it plans to make available by the end of 1995. The basic 540 megabyte drive design was done in Scotland by Myrica (U.K.) Limited, a design firm staffed with Rodime graduates, with technology assistance from universities in the U.K. and France. The drive will be manufactured at Havant in the U.K. by Xyratex, the IBM spin-off.

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 used 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. Although several other companies have signed up for Rodime licenses, legal proceedings have lingered on. A U.S. appeals court ruled some of the Rodime patent claims invalid in September, 1995, ruling in favor of Quantum. Rodime continues to argue that other patent claims are still valid in a separate legal action against Seagate Technology.

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.

XYRATEX (Havant International Ltd.)
P.O. Box 6, Langstone Road
Havant, Hampshire PO9 1SA
United Kingdom

Xyratex was created in December, 1994, as the result of a management buy out of IBM's Havant facilities. Xyratex, the firm's brand name at the time of the buy out, became the trading name for the new company. Products include disk drives, flexible circuits, storage subsystems (including disk drive arrays), test systems and networking equipment, some produced under contract for a number of clients, including IBM, JTS and Nomai. Xyratex also develops and sells specialized software products.

Although "new", the company is of significant size, occupying about 600,000 square feet of space and employing about 2,000 people. The Havant facility manufactured over two million small disk drives in 1994.

DISK/TREND ON DISK

1995 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 1995 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1995 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.

Trademarks

Getting started

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

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

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

DISK/TREND ON DISK 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
   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 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:

- FORMLINA.PRN — Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
- FORMLINB.PRN — Used with Table 2.
- FORMLINF.PRN — Used with Tables 3 and 4.
- FORMLIND.PRN — Used with Application tables.
- FORMLINE.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	Drive height, Drive capacity	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	1995 Rigid Report	1995 Removable Report	1995 Optical Report	1995 Array Report
1	MASKA	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA	MASKB
3	MASKC	MASKC	MASKB	MASKC
4	MASKC	MASKC	MASKB	MASKC
5	MASKC	MASKC	MASKC	MASKC
6	MASKC	MASKC	MASKC	MASKC
7	MASKH	--	MASKC	MASKC
8	MASKH	--	MASKC	--
9	MASKC	MASKA	MASKC	--
10	MASKC	MASKA	MASKC	MASKA
11	MASKC	MASKC	MASKC	MASKA
12	--	MASKC	MASKC	--
13	--	--	--	--
14	MASKA	MASKI	--	--
15	MASKA	--	--	--
16	--	MASKI	--	MASKA
17	--	--	MASKA	MASKA
18	MASKD	MASKI	MASKA	--
19	MASKI	--	--	--
20	--	MASKI	--	--
21	MASKA	--	MASKD	MASKD
22	MASKA	MASKA	--	--
23	--	MASKA	MASKA	MASKA
24	--	MASKC	MASKA	MASKA
25	MASKD	MASKC	--	--
26	MASKI	MASKA	--	--
27	--	MASKA	--	--
28	MASKA	MASKA	--	--
29	MASKA	MASKA	MASKE	MASKA
30	--	MASKA	MASKD	MASKA
31	--	MASKH	--	--
32	MASKD	MASKD	MASKA	--
33	MASKI	--	MASKA	--
34	--	MASKA	--	--
35	MASKA	MASKA	--	
36	MASKA	--	MASKE	
37	--	--	MASKD	
38	--	MASKI	--	
39	MASKD	MASKD	MASKA	
40	MASKI	--	MASKA	
41	--	MASKA	--	
42	MASKA	MASKA	--	
43	MASKA	--	MASKA	
44	--	--	MASKA	
45	--	MASKD	--	
46	MASKD	--	--	
47	MASKI	MASKA	MASKE	

Cross-reference (continued)

Table Number	1995 Rigid Report	1995 Removable Report	1995 Optical Report	1995 Array Report
48	--	MASKA	MASKA	
49	MASKA	--	MASKA	
50	MASKA	--	--	
51	--	MASKD	--	
52	--	--	MASKE	
53	MASKD	MASKA	MASKA	
54	MASKI	MASKA	MASKA	
55	--	--	--	
56	MASKA	--	--	
57	MASKA	MASKE	MASKE	
58	--	MASKE		
59	--	MASKD		
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, including the extension, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.95R OT14.95O AT19.95A VT6.95V

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

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

   Examples: RT4 OT14 AT19 VT6

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

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

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

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

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select "File" using the 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, O, A or V), nn is the table number and yy is the report year.

   Example: RT50.95R

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

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the top left of the report table. Now select "Lines" from the menu bar, then select "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= 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: RS195 Rigid disk specification table, Groups 1 to 5
RS295 Rigid disk specification table, Groups 6 to 9
RS395 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 commands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

Expanding the input or output ranges: The predefined output range is of a nominal size, and a search with broad parameters may result in overflowing the output range. In such a case, merely extend the output range (add more rows) using the Lotus 1-2-3 /DQEO command. Similarly, it is possible to extend the input range to add more products, but be sure you move the output range so that there is no overlap.

Memory overflow: If you should receive a memory overflow message while manipulating the specification data, it is usually because:

- 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 at least 640K of RAM memory, you will probably get this message.

Combining specification data bases: Lotus 1-2-3 makes it possible 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 RS195 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 RS295 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 <u>second</u> 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 <u>new</u> 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 RS195.WK1 contains DISK/TREND Product Groups 1 through 5. File RS295.WK1 contains Product Groups 6 through 9. File RS395.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 RS395.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.

Drive specifications: 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.