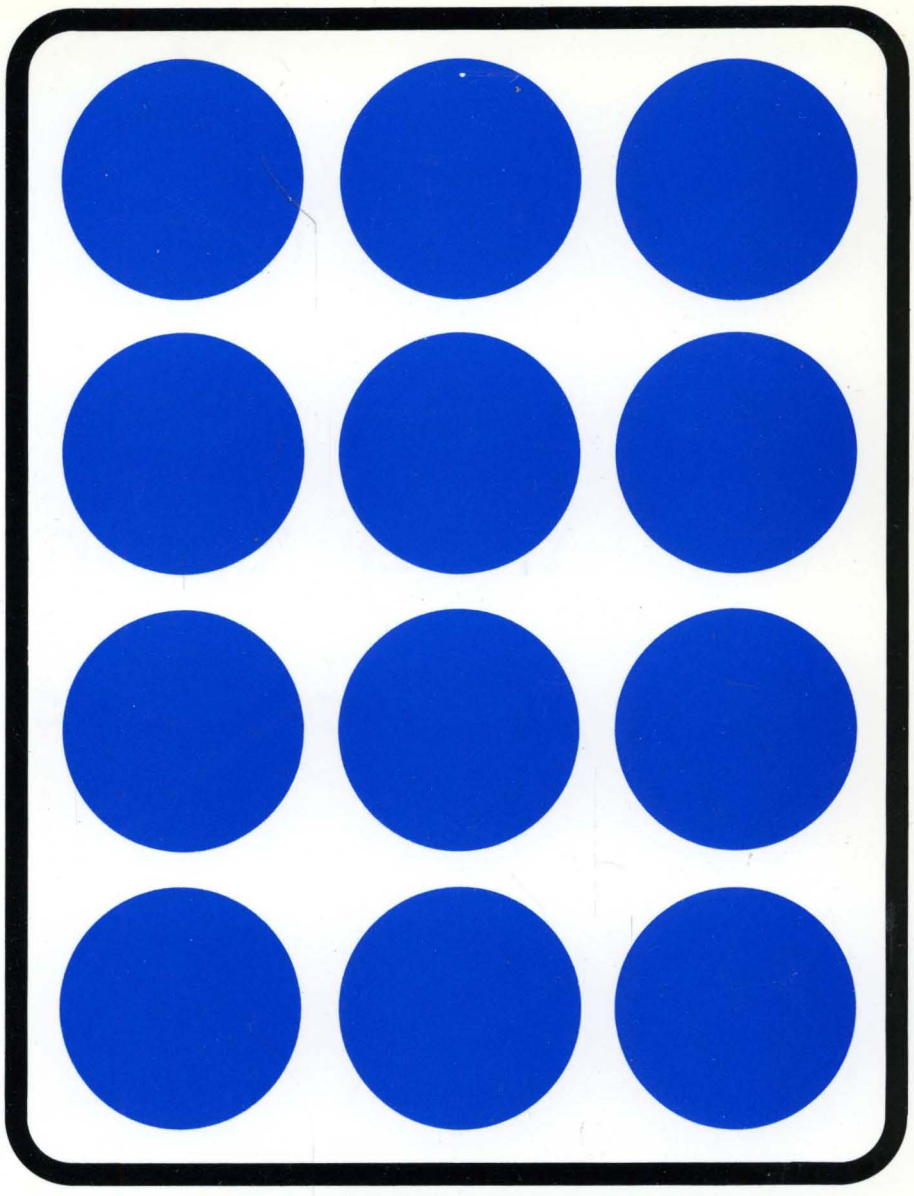
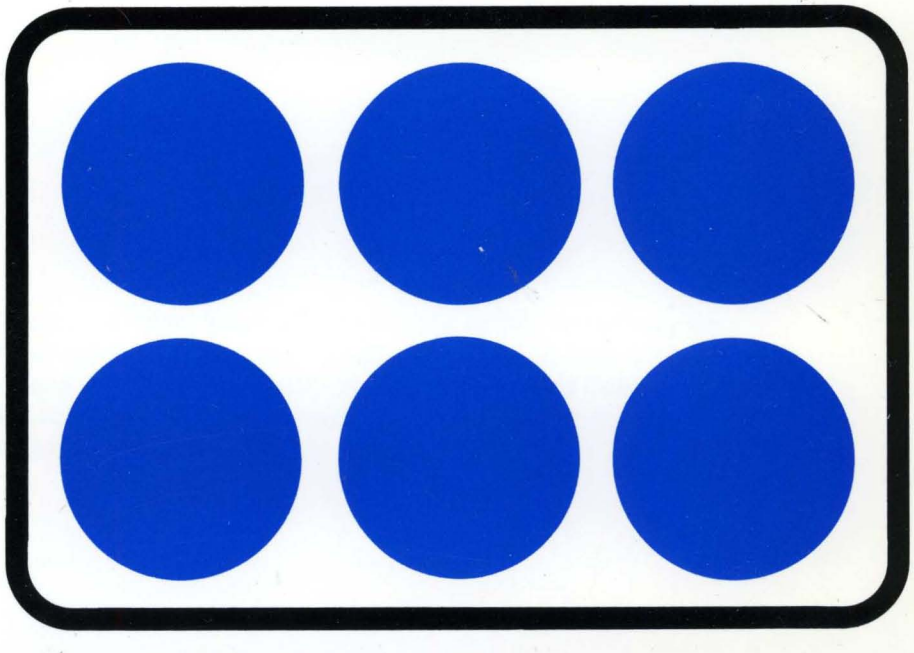


1996 DISK/TREND® REPORT



RIGID DISK DRIVES

1990 DISK/TREND® REPORT

RIGID DISK DRIVES

October, 1990

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FOREWORD

Despite gloomy predictions on the world economy, the threat of war in the Middle East, and the most unsettled political environment in the major countries in years, the disk drive industry continues to plunge ahead with new products and new manufacturing facilities.

Some voices in the industry have raised flags of caution regarding potential overexpansion of production capacity for disk drives, but we think this concern is misguided. Capacity to make declining products is largely irrelevant. The industry will always need capacity additions to make major new products, and the availability, or lack, of key components is probably the largest pacing factor in building new capacity. In any event, with a few exceptions, the independent drive manufacturers produce mostly for system manufacturers to fill specific orders, so mindless overproduction is not in the cards.

This is the fourteenth year of the DISK/TREND Report, now published in three volumes. The report on optical disk drives was published in July, and this report on rigid disk drives will be followed, as usual, with a separate report on flexible disk drives to be released in November.

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

The last year for disk pack drives
When the first DISK/TREND Report was published in 1977, disk pack drives were the most important product group in the industry, and continued to be the largest revenue producer for several years. However, those days are gone, and the expected worldwide shipments of disk pack drives in 1991 will be less than a thousand units. So this will be the last year that the DISK/TREND Report includes a section on disk pack drives, one of the product groups that built the industry to its current size.

A few drives have been reclassified to a different product group
We assign individual disk drives to DISK/TREND product groups on the basis of unformatted capacities. The IBM 9335 and 9336 drives have been moved from the 500 megabyte - 1 gigabyte group to the more than 1 gigabyte group, since each drive's unformatted capacity is actually over 1 gigabyte.

We've added a new continent
For years we've wanted to include coverage of disk drives in Brazil, and this year we've done it. Bob Katzive visited Brazil in March, and the result is our new South American manufacturer section.

Don't look for prices in the specification section
The information on U.S. OEM prices at the 100 unit level which was included for many years in the specification section has been deleted, starting in this edition. Unfortunately, the usefulness of the information had been reduced due to the rapid price changes in the industry and the lack of actual selling activity at low quantity levels.

Please note the market channel definitions used in DISK/TREND tables
Last year we made a change in the way shipment breakdowns by market channel are organized in the DISK/TREND Report. It is important to recognize that data for non-captive drives are broken down by separate PCM/Reseller and OEM/Integrator groups in most of the tables used in the individual product sections of the report. On the other hand, a few of the tables in the summary section combine both non-captive channels in order to summarize the data. Here are the terms, as used in this report:

* Captive -- no change; drives sold with systems also manufactured by the same company.

* PCM/Reseller -- drives used in add-on subsystems for use with computer systems of all types and sizes, plus aftermarket distribution through wholesalers, dealers and other resellers.

* OEM/Integrator -- drives sold to system manufacturers to be used as part of computer systems, plus sales to system integrators and value-added resellers which assemble complete systems.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

As always, the disk drive industry continues to struggle with the challenge of balancing the demand for rapidly changing product lines with the necessary modifications and improvements in manufacturing capacity required to exploit the market opportunity. Most of the concerns expressed this year about potential disk drive overcapacity fail to recognize the industry's continuing lack of capacity to make the new products most in demand.

Available production capacity is frequently not suitable to produce the newest drive models. And much of the industry's capacity is really in the hands of the hundreds of manufacturers of disks, heads, motors, semiconductors and other components, which must also carry out continuing development programs and expansion of capacity to keep up with the parade of new disk drive models.

After a slower 10.9% growth in total worldwide revenues in 1989, the industry is expected to increase 13.4% in 1990, boosted by important new IBM drives in several product groups and surging growth for OEM drives in the 60-100 megabyte and 100-300 megabyte groups. 30-60 megabyte drives now lead the industry in unit shipments, topping 12.5 million this year, and projected at 18.4 million in 1993.

1989's $22.6 billion revenue total is expected to reach $31.8 billion in 1993, but the path will not be smooth. The movement to drives with smaller disks, usually at lower prices, the product cycles of major captive manufacturing programs, and the up-and-down nature of major plug compatible drive programs all contribute to an uneven growth pattern.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	6,045.4	9,485.4	7,738.1	11,435.9	8,754.1	13,106.2	8,544.8	13,195.6	9,062.3	14,364.5
Other U.S. Captive	1,175.6	2,100.7	1,029.7	1,914.7	1,078.9	2,054.0	1,109.4	2,128.6	1,052.1	2,008.6
TOTAL U.S. CAPTIVE	7,221.0	11,586.1	8,767.8	13,350.6	9,833.0	15,160.2	9,654.2	15,324.2	10,114.4	16,373.1
PCM/Reseller	1,468.1	2,112.2	1,523.2	2,203.1	1,624.8	2,284.0	1,632.7	2,272.9	1,584.3	2,200.0
OEM/Integrator	2,304.0	3,461.4	2,763.3	4,262.8	2,873.1	4,727.6	3,207.1	5,296.4	3,070.1	5,278.5
TOTAL U.S. NON-CAPTIVE	3,772.1	5,573.6	4,286.5	6,465.9	4,497.9	7,011.6	4,839.8	7,569.3	4,654.4	7,478.5
TOTAL U.S. REVENUES	10,993.1	17,159.7	13,054.3	19,816.5	14,330.9	22,171.8	14,494.0	22,893.5	14,768.8	23,851.6
Non-U.S. Manufacturers										
Captive	149.4	2,822.2	133.2	3,006.9	204.5	2,998.6	374.8	3,179.7	618.1	3,471.0
PCM/Reseller	337.2	711.1	376.0	791.6	610.2	1,070.5	841.2	1,362.4	1,054.1	1,705.8
OEM/Integrator	706.2	1,967.3	716.6	2,072.3	950.9	2,454.3	1,031.0	2,719.1	1,035.3	2,812.5
TOTAL NON-U.S. REVENUES	1,192.8	5,500.6	1,225.8	5,870.8	1,765.6	6,523.4	2,247.0	7,261.2	2,707.5	7,989.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	12,185.9	22,660.3	14,280.1	25,687.3	16,096.5	28,695.2	16,741.0	30,154.7	17,476.3	31,840.9

Marketing channels

The total of 59 rigid disk drive manufacturers listed in Table 10 is almost the same as last year's count of 58, but there have been many changes, especially in the list of manufacturers headquartered in the United States.

Some of the U.S. deletions represent firms which had already reduced production to very low levels, such as Data General and DDC Pertec, or start-ups which never actually got started, such as Comport. Major names have disappeared, such as Control Data's Imprimis subsidiary, acquired by Seagate, and Miniscribe, whose production facilities and product lines were acquired by Maxtor in bankruptcy proceedings earlier this year. Priam also went into bankruptcy, and various pieces reemerged in Sequel, Atasi Technology and Orca Technology. This year's report also adds specific coverage of several Brazilian drive manufacturers and their rigid disk drive products.

An understanding of the relative price levels of captive, PCM/Reseller and OEM/Integrator drives is important in interpreting DISK/TREND revenue statistics, to avoid an exaggerated impression of the share of the industry's total unit shipments held by captive drives. Revenues are reported at the level of each drive's first public sale.

The price used for each drive is the estimated value at the first time it is sold to a non-affiliated buyer, at captive end user, PCM/Reseller or OEM/Integrator levels. Prices are based on disk drives alone, without controllers or other accessories, and leased drives are valued at the price they would command if actually sold.

TABLE 2

CONSOLIDATED WORLDWIDE REVENUES
RIGID MAGNETIC DISK DRIVES
MARKET CLASS REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	1989 Revenues $M	1989 Revenues %	1990 $M	1990 %	1991 $M	1991 %	1992 $M	1992 %	1993 $M	1993 %
U.S. Manufacturers										
IBM Captive	9,485.4 +7.1%	41.8%	11,435.9 +20.6%	44.5%	13,106.2 +14.6%	45.6%	13,195.6 +.7%	43.7%	14,364.5 +8.9%	45.1%
Other U.S. Captive	2,100.7 +22.5%	9.2%	1,914.7 -8.9%	7.4%	2,054.0 +7.3%	7.1%	2,128.6 +3.6%	7.0%	2,008.6 -5.6%	6.3%
PCM/Reseller	2,112.2 +19.7%	9.3%	2,203.1 +4.3%	8.5%	2,284.0 +3.7%	7.9%	2,272.9 -.5%	7.5%	2,200.0 -3.2%	6.9%
OEM/Integrator	3,461.4 +10.8%	15.2%	4,262.8 +23.2%	16.5%	4,727.6 +10.9%	16.4%	5,296.4 +12.0%	17.5%	5,278.5 -.3%	16.5%
Total U.S. Manufacturers	17,159.7 +11.0%	75.5%	19,816.5 +15.5%	76.9%	22,171.8 +11.9%	77.0%	22,893.5 +3.3%	75.7%	23,851.6 +4.2%	74.8%
Non-U.S. Manufacturers										
Captive	2,822.2 +15.7%	12.4%	3,006.9 +6.5%	11.7%	2,998.6 -.3%	10.4%	3,179.7 +6.0%	10.5%	3,471.0 +9.2%	10.9%
PCM/Reseller	711.1 +3.0%	3.1%	791.6 +11.3%	3.0%	1,070.5 +35.2%	3.7%	1,362.4 +27.3%	4.5%	1,705.8 +25.2%	5.3%
OEM/Integrator	1,967.3 +7.1%	9.0%	2,072.3 +5.3%	8.4%	2,454.3 +18.4%	8.9%	2,719.1 +10.8%	9.3%	2,812.5 +3.4%	9.0%
Total Non-U.S. Manufacturers	5,500.6 +10.8%	24.5%	5,870.8 +6.7%	23.1%	6,523.4 +11.1%	23.0%	7,261.2 +11.3%	24.3%	7,989.3 +10.0%	25.2%
Worldwide Recap										
Captive	14,408.3 +10.8%	63.6%	16,357.5 +13.5%	63.7%	18,158.8 +11.0%	63.3%	18,503.9 +1.9%	61.4%	19,844.1 +7.2%	62.3%
PCM/Reseller	2,823.3 +15.0%	12.5%	2,994.7 +6.1%	11.7%	3,354.5 +12.0%	11.7%	3,635.3 +8.4%	12.1%	3,905.8 +7.4%	12.3%
OEM/Integrator	5,428.7 +9.4%	23.9%	6,335.1 +16.7%	24.6%	7,181.9 +13.4%	25.0%	8,015.5 +11.6%	26.5%	8,091.0 +.9%	25.4%
Total All Manufacturers	22,660.3 +10.9%	100.0%	25,687.3 +13.4%	100.0%	28,695.2 +11.7%	100.0%	30,154.7 +5.1%	100.0%	31,840.9 +5.6%	100.0%

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

Product mix

Fixed disk drives in the 30-60 megabyte product group now provide more than 46% of the industry's worldwide unit shipments. They also account for almost 15% of total revenues, exceeded only by the product group over 1 gigabyte in capacity.

The 30-60 megabyte product group passed up fixed disk drives below 30 megabytes in 1989, with 10.2 million units, an increase of almost 75%. The main application for drives below 30 megabytes is the personal computer market, and while there is enough overall growth in PCs to sustain significant current shipments for this group, higher capacity drives are faring better, due to greater software complexity and heightened user sophistication. The outlook for drives below 30 megabytes is continued decline, with this group expected to provide barely 1% of the industry's 1993 unit shipments.

The most rapid growth in unit shipments is now being achieved by drives in the 100-300 megabyte group, which is expected to jump 123% in shipments for 1990, and by 1993 to hold 25% of the industry's unit shipment total. Among the drive groups below 1 gigabyte, 100-300 megabyte drives are expected to be the leader this year in total capacity shipped, with 619 terabytes.

Underlying the growth in total unit shipments for all product groups below 1 gigabyte is the vitality of the industry's 3.5" product lines. Within these capacity levels, 3.5" drives are expected to capture the lead in all fixed disk drive product groups by 1993. Of course, the impact of 2.5" drives will have been felt before 1993, and by that year 2.5" drives are expected to have captured the unit shipment lead for drives below 30 megabytes.

Driven by rapid acceptance of the new "notebook" computers in the five to seven pound range, 2.5" drives seem destined to have a major impact in all of the lower capacity ranges. 2.5" drives with capacities below 30 megabytes are expected to achieve shipments of 730,000 units in 1990, but are forecasted to peak at 1 million units in 1991, impacted by 2.5" drives to be available in 1991 with capacities up to 120 megabytes. 2.5" drives in the 30-60 megabyte range will be introduced by numerous manufacturers by the end of this year and are expected to quickly dominate notebook computer markets, with shipments approaching 5 million drives in 1993.

However, it should not be forgotten that high-end drives provide a major part of the industry's revenues -- with drives over 500 megabytes providing half of the industry's total revenues. 5.25" drives now provide more than half of the 300-500 megabyte drive shipments and are expected to provide more than half of the unit shipments for drives over 1 gigabyte by 1992. A by-product of that development will be slower revenue growth for high-end drives, due to the lower average prices the smaller drives will command.

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue

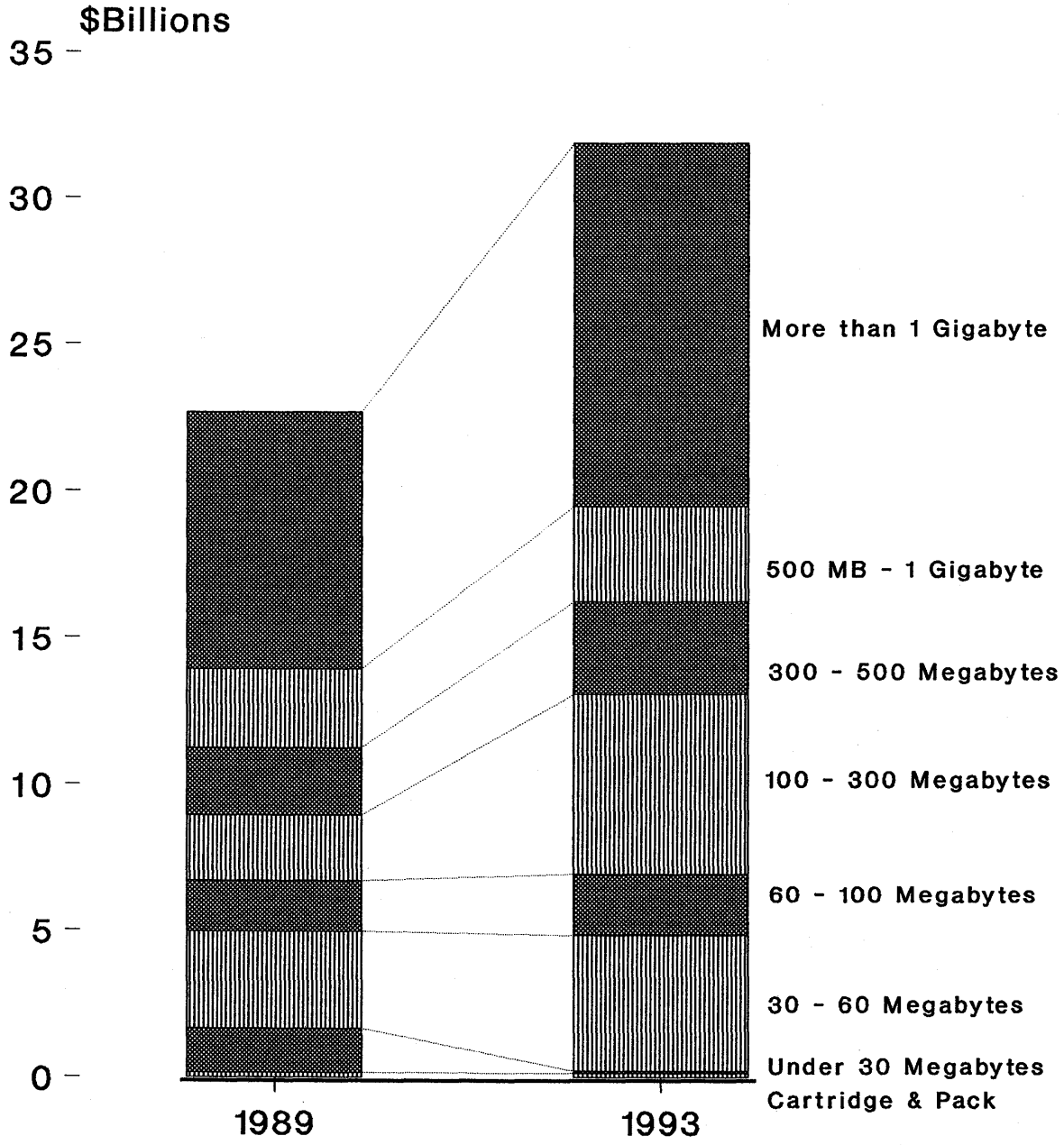

TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1989 Revenues $M	1989 Revenues %	Forecast 1990 $M	Forecast 1990 %	Forecast 1991 $M	Forecast 1991 %	Forecast 1992 $M	Forecast 1992 %	Forecast 1993 $M	Forecast 1993 %
DISK CARTRIDGE DRIVES	65.9 -2.4%	.3%	68.1 +3.3%	.3%	91.5 +34.4%	.3%	118.5 +29.5%	.4%	139.5 +17.7%	.4%
DISK PACK DRIVES	91.4 -53.1%	.4%	20.9 -77.1%	.1%	2.7 -87.1%	--	-- --	--	-- --	--
FIXED DISK DRIVES less than 30 Megabytes	1,502.9 -33.9%	6.6%	963.7 -35.9%	3.8%	479.2 -50.3%	1.7%	208.9 -56.4%	.7%	76.4 -63.4%	.2%
FIXED DISK DRIVES 30 - 60 Megabytes	3,309.2 +51.9%	14.6%	3,731.8 +12.8%	14.5%	4,248.8 +13.9%	14.8%	4,493.8 +5.8%	14.9%	4,624.7 +2.9%	14.5%
FIXED DISK DRIVES 60 - 100 Megabytes	1,733.8 +8.9%	7.7%	1,778.2 +2.6%	6.9%	1,975.3 +11.1%	6.9%	2,099.8 +6.3%	7.0%	2,095.1 -.2%	6.6%
FIXED DISK DRIVES 100 - 300 Megabytes	2,229.3 +9.8%	9.8%	3,226.1 +44.7%	12.6%	4,519.2 +40.1%	15.7%	5,554.8 +22.9%	18.4%	6,131.3 +10.4%	19.3%
FIXED DISK DRIVES 300 - 500 Megabytes	2,296.8 -4.5%	10.1%	3,029.3 +31.9%	11.8%	3,170.0 +4.6%	11.0%	3,221.8 +1.6%	10.7%	3,147.0 -2.3%	9.9%
FIXED DISK DRIVES 500 Megabytes to 1 GB	2,696.0 -23.8%	11.9%	2,481.6 -8.0%	9.7%	2,553.3 +2.9%	8.9%	2,811.0 +10.1%	9.3%	3,250.6 +15.6%	10.2%
FIXED DISK DRIVES more than 1 Gigabyte	8,735.0 +42.2%	38.5%	10,387.6 +18.9%	40.3%	11,655.2 +12.2%	40.6%	11,646.1 --	38.6%	12,376.3 +6.3%	38.9%
Total Worldwide Revenue	22,660.3 +10.9%	100.0%	25,687.3 +13.4%	100.0%	28,695.2 +11.7%	100.0%	30,154.7 +5.1%	100.0%	31,840.9 +5.6%	100.0%
% U.S. Mfg.	75.7%		77.1%		77.2%		75.9%		74.9%	

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

Figure 2

WORLDWIDE SHIPMENT SUMMARY

Total Rigid Disk Drives

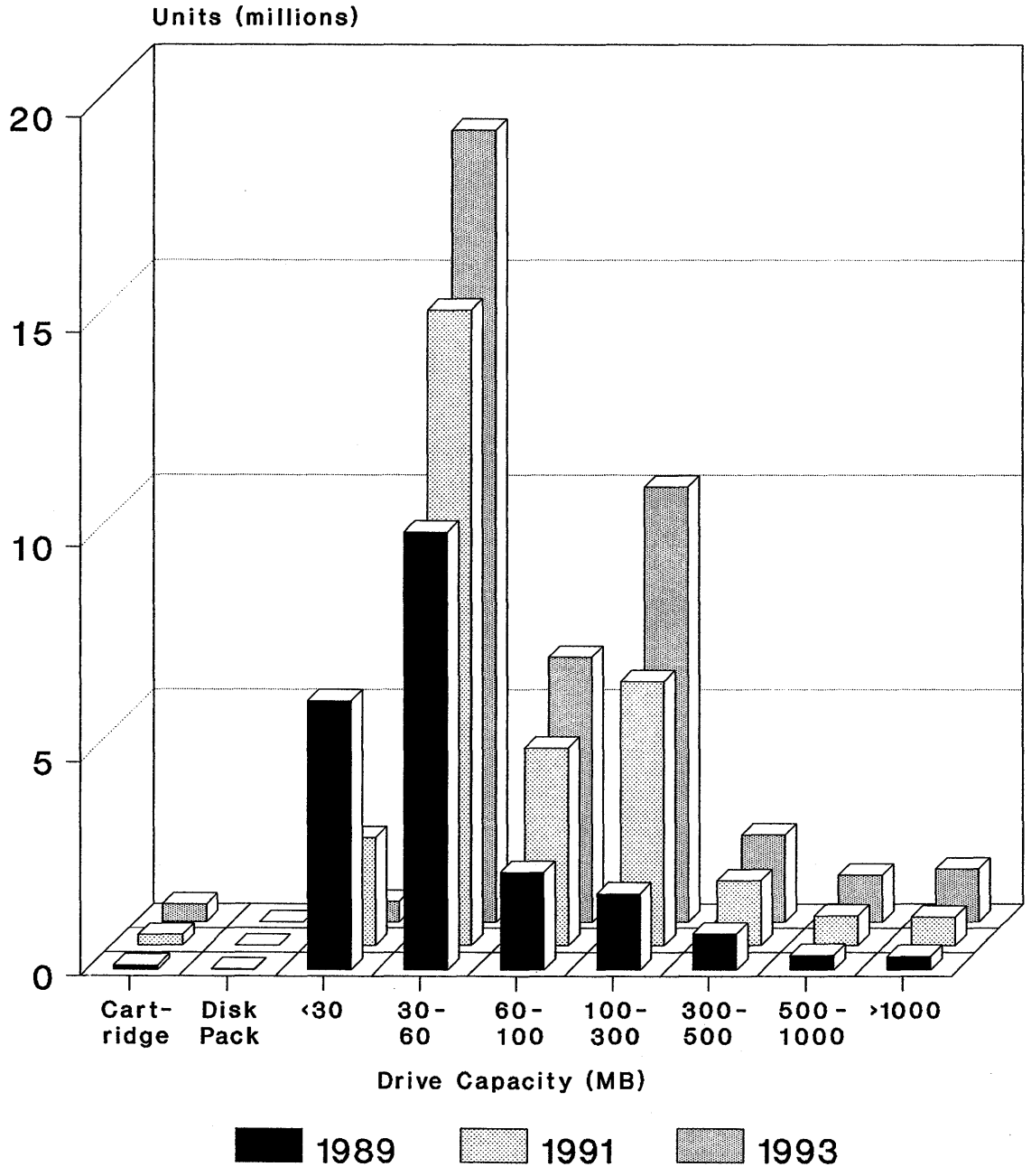

TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1989 Shipments Units	1989 Shipments %	Forecast 1990 Units	Forecast 1990 %	Forecast 1991 Units	Forecast 1991 %	Forecast 1992 Units	Forecast 1992 %	Forecast 1993 Units	Forecast 1993 %
DISK CARTRIDGE DRIVES	107.5 +63.6%	.5%	171.4 +59.4%	.6%	251.1 +46.5%	.8%	336.0 +33.8%	.9%	409.0 +21.7%	1.0%
DISK PACK DRIVES	10.3 -58.5%	--	3.0 -70.9%	--	.7 -76.7%	--	-- --	--	-- --	--
FIXED DISK DRIVES less than 30 Megabytes	6,279.9 -21.0%	28.3%	4,388.0 -30.1%	16.4%	2,548.0 -41.9%	8.1%	1,189.0 -53.3%	3.3%	474.0 -60.1%	1.2%
FIXED DISK DRIVES 30 - 60 Megabytes	10,209.3 +74.8%	46.0%	12,504.4 +22.5%	46.8%	14,811.0 +18.4%	47.3%	16,908.0 +14.2%	46.7%	18,430.0 +9.0%	46.1%
FIXED DISK DRIVES 60 - 100 Megabytes	2,284.1 +36.8%	10.3%	3,491.9 +52.9%	13.1%	4,630.5 +32.6%	14.8%	5,600.0 +20.9%	15.5%	6,170.0 +10.2%	15.4%
FIXED DISK DRIVES 100 - 300 Megabytes	1,783.4 +51.6%	8.0%	3,987.6 +123.6%	14.9%	6,161.0 +54.5%	19.7%	8,494.0 +37.9%	23.5%	10,140.0 +19.4%	25.3%
FIXED DISK DRIVES 300 - 500 Megabytes	842.7 +53.2%	3.8%	1,182.4 +40.3%	4.4%	1,524.7 +28.9%	4.9%	1,830.0 +20.0%	5.1%	2,050.0 +12.0%	5.1%
FIXED DISK DRIVES 500 Megabytes to 1 GB	344.7 +13.6%	1.6%	542.3 +57.3%	2.0%	707.6 +30.5%	2.3%	910.0 +28.6%	2.5%	1,100.0 +20.9%	2.7%
FIXED DISK DRIVES more than 1 Gigabyte	318.6 +67.3%	1.4%	469.2 +47.3%	1.8%	673.8 +43.6%	2.1%	908.5 +34.8%	2.5%	1,236.0 +36.0%	3.1%
Total Worldwide Shipments	22,180.5 +24.8%	100.0%	26,740.2 +20.6%	100.0%	31,308.4 +17.1%	100.0%	36,175.5 +15.5%	100.0%	40,009.0 +10.6%	100.0%
% U.S. Mfg.	80.4%		79.9%		76.1%		72.1%		68.0%	
Total Capacity (Terabytes)	2,435.9		3,528.7		4,652.7		6,121.3		7,612.2	

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

Figure 3

CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

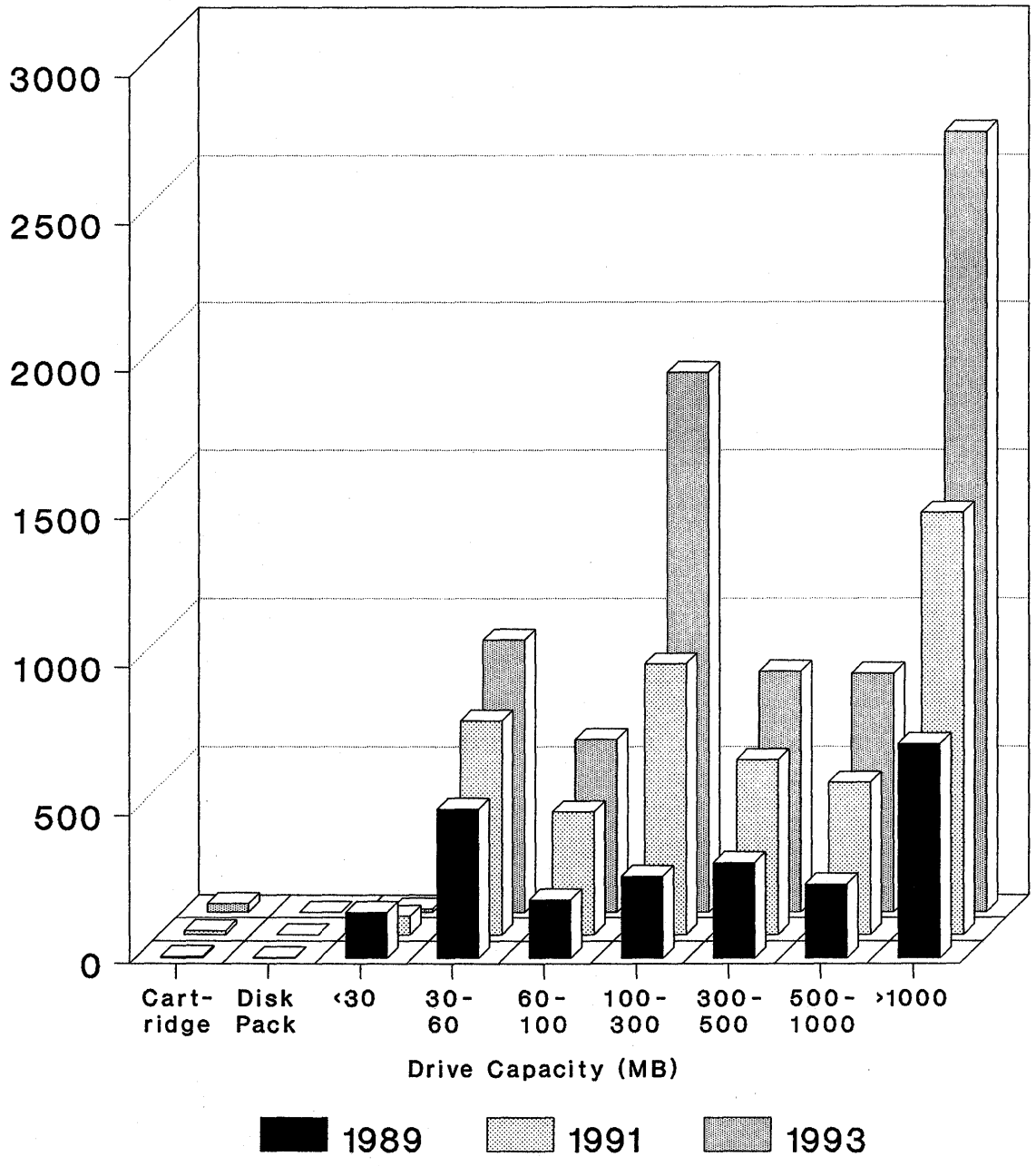

TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1989 Shipments Tbytes	1989 Shipments %	1990 Forecast Tbytes	1990 Forecast %	1991 Forecast Tbytes	1991 Forecast %	1992 Forecast Tbytes	1992 Forecast %	1993 Forecast Tbytes	1993 Forecast %
DISK CARTRIDGE DRIVES	4.8 +138.3%	.2%	8.7 +79.2%	.2%	12.5 +43.4%	.3%	20.1 +60.6%	.3%	28.6 +42.0%	.4%
DISK PACK DRIVES	2.2 -44.9%	.1%	.5 -77.0%	--	-- --	--	-- --	--	-- --	--
FIXED DISK DRIVES less than 30 Megabytes	156.4 -21.2%	6.4%	109.0 -30.3%	3.1%	63.7 -41.6%	1.4%	29.7 -53.3%	.5%	11.8 -60.1%	.2%
FIXED DISK DRIVES 30 - 60 Megabytes	502.7 +74.8%	20.6%	609.5 +21.2%	17.3%	722.7 +18.6%	15.5%	837.0 +15.8%	13.7%	918.9 +9.8%	12.1%
FIXED DISK DRIVES 60 - 100 Megabytes	196.9 +75.0%	8.1%	312.6 +58.7%	8.9%	415.0 +32.8%	8.9%	518.4 +24.9%	8.5%	583.2 +12.5%	7.7%
FIXED DISK DRIVES 100 - 300 Megabytes	277.4 +46.4%	11.4%	619.4 +123.3%	17.6%	912.6 +47.3%	19.6%	1,386.1 +51.9%	22.6%	1,819.8 +31.3%	23.9%
FIXED DISK DRIVES 300 - 500 Megabytes	322.5 +49.7%	13.2%	450.5 +39.7%	12.8%	590.2 +31.0%	12.7%	716.9 +21.5%	11.7%	810.5 +13.1%	10.6%
FIXED DISK DRIVES 500 Megabytes to 1 GB	249.5 +10.6%	10.2%	400.6 +60.6%	11.4%	513.8 +28.3%	11.0%	655.4 +27.5%	10.7%	804.1 +22.7%	10.6%
FIXED DISK DRIVES more than 1 Gigabyte	723.2 +41.3%	29.7%	1,017.7 +40.7%	28.7%	1,421.7 +39.7%	30.6%	1,957.4 +37.7%	32.0%	2,635.1 +34.6%	34.5%
Total Capacity (Terabytes)	2,435.9 +39.4%	100.0%	3,528.7 +44.9%	100.0%	4,652.7 +31.9%	100.0%	6,121.3 +31.6%	100.0%	7,612.2 +24.4%	100.0%
% U.S. Mfg.	78.2%		79.0%		78.4%		76.4%		74.0%	

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

Non-captive market

Tables 6, 7 and 8 in the summary section of this year's DISK/TREND Report include worldwide data for all non-captive drives, in a format which combines the OEM/Integrator summary tables from previous reports with data for the PCM/Reseller distribution channel.

Most of the dramatic growth in shipments of small disk drives during the last ten years was driven by development of new drive formats by independent disk drive manufacturers for the OEM market, including full size 5.25", half high 5.25", various 3.5" form factors, and the new 2.5" drives. Although most of these rigid disk drive formats were patterned after box sizes already established for floppy drives, OEM drives in each of these form factors arrived in the market well before captive drives and set the patterns for the entire industry.

The role of the PCM/reseller channel, a diverse mixture of computer dealers and wholesalers, subsystem manufacturers, electronic component distributors, mail order retailers and others has also become prominent. The majority of shipments of 5.25" drives below 100 megabytes are made through PCM/resellers, responding to demand for replacement and upgrade of older drives. However, most major personal computer manufacturers are now bundling at least one rigid disk drive in all mid-range and high-end PCs at the factory, so the practice of many dealers of upgrading new systems by installing drives in the store is fading. The outlook for future PCM/reseller sales continues to be good, but not at the same percentage of shipments that the industry saw during the 1980's.

OEM/Integrator shipments are expected to continue to lead the disk drive industry's growth, with leadership from very small drives for portable systems and high-end models for workstations and servers.

TABLE 6

NON-CAPTIVE WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1989 Revenues $M	1989 Revenues %	1990 $M	1990 %	1991 $M	1991 %	1992 $M	1992 %	1993 $M	1993 %
DISK CARTRIDGE DRIVES	65.9 +22.9%	.8%	68.1 +3.3%	.7%	91.5 +34.4%	.9%	118.5 +29.5%	1.0%	139.5 +17.7%	1.2%
DISK PACK DRIVES	71.3 -44.9%	.9%	20.9 -70.7%	.3%	2.7 -87.1%	--	-- --	--	-- --	--
FIXED DISK DRIVES less than 30 Megabytes	1,129.2 -18.9%	13.7%	841.7 -25.5%	9.0%	447.8 -46.8%	4.2%	196.7 -56.1%	1.7%	71.6 -63.6%	.6%
FIXED DISK DRIVES 30 - 60 Megabytes	2,525.8 +67.0%	30.7%	2,680.1 +6.1%	28.8%	3,035.9 +13.3%	29.0%	3,232.7 +6.5%	27.9%	3,151.7 -2.5%	26.3%
FIXED DISK DRIVES 60 - 100 Megabytes	671.7 +6.6%	8.1%	956.1 +42.3%	10.2%	1,163.5 +21.7%	11.0%	1,221.7 +5.0%	10.4%	1,160.0 -5.1%	9.7%
FIXED DISK DRIVES 100 - 300 Megabytes	874.8 +5.3%	10.6%	1,685.3 +92.6%	18.1%	2,202.0 +30.7%	20.9%	2,829.8 +28.5%	24.3%	3,034.5 +7.2%	25.3%
FIXED DISK DRIVES 300 - 500 Megabytes	894.2 +5.0%	10.8%	867.1 -3.0%	9.3%	1,047.0 +20.7%	9.9%	1,190.2 +13.7%	10.2%	1,259.6 +5.8%	10.5%
FIXED DISK DRIVES 500 Megabytes to 1 GB	556.2 -7.7%	6.8%	704.8 +26.7%	7.6%	738.8 +4.8%	7.0%	786.0 +6.4%	6.8%	740.6 -5.8%	6.2%
FIXED DISK DRIVES more than 1 Gigabyte	1,462.9 +3.6%	17.6%	1,505.7 +2.9%	16.0%	1,807.2 +20.0%	17.1%	2,075.2 +14.8%	17.7%	2,439.3 +17.5%	20.2%
Total Worldwide Revenues	8,252.0 +11.3%	100.0%	9,329.8 +13.1%	100.0%	10,536.4 +12.9%	100.0%	11,650.8 +10.6%	100.0%	11,996.8 +3.0%	100.0%
% U.S. Mfg.	67.5%		69.3%		66.5%		64.9%		62.3%	

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

TABLE 7

NON-CAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1989 Shipments Units	1989 Shipments %	1990 Forecast Units	1990 Forecast %	1991 Forecast Units	1991 Forecast %	1992 Forecast Units	1992 Forecast %	1993 Forecast Units	1993 Forecast %
DISK CARTRIDGE DRIVES	107.5 +67.7%	.6%	171.4 +59.4%	.8%	251.1 +46.5%	1.0%	336.0 +33.8%	1.1%	409.0 +21.7%	1.3%
DISK PACK DRIVES	8.8 -56.4%	--	3.0 -65.9%	--	.7 -76.7%	--	-- --	--	-- --	--
FIXED DISK DRIVES less than 30 Megabytes	5,724.1 -13.7%	30.8%	4,202.0 -26.6%	18.9%	2,504.0 -40.4%	9.8%	1,170.0 -53.3%	4.0%	466.0 -60.2%	1.5%
FIXED DISK DRIVES 30 - 60 Megabytes	9,187.1 +78.0%	49.1%	10,846.3 +18.1%	48.4%	12,715.0 +17.2%	49.8%	14,540.0 +14.4%	49.7%	15,405.0 +5.9%	49.1%
FIXED DISK DRIVES 60 - 100 Megabytes	1,430.7 +31.3%	7.7%	2,635.4 +84.2%	11.8%	3,620.5 +37.4%	14.2%	4,338.0 +19.8%	14.8%	4,620.0 +6.5%	14.6%
FIXED DISK DRIVES 100 - 300 Megabytes	1,250.0 +46.0%	6.7%	3,185.7 +154.9%	14.2%	4,628.8 +45.3%	18.1%	6,499.0 +40.4%	22.2%	7,621.0 +17.3%	24.3%
FIXED DISK DRIVES 300 - 500 Megabytes	643.7 +61.5%	3.4%	737.6 +14.6%	3.3%	1,037.0 +40.6%	4.0%	1,335.9 +28.8%	4.5%	1,562.0 +16.9%	4.9%
FIXED DISK DRIVES 500 Megabytes to 1 GB	217.5 +48.8%	1.2%	411.2 +89.1%	1.9%	515.1 +25.3%	2.0%	621.0 +20.6%	2.2%	662.0 +6.6%	2.1%
FIXED DISK DRIVES more than 1 Gigabyte	114.5 +40.8%	.5%	185.0 +61.6%	.7%	294.8 +59.4%	1.1%	478.5 +62.3%	1.5%	711.0 +48.6%	2.2%
Total Worldwide Shipments	18,683.9 +29.3%	100.0%	22,377.6 +19.8%	100.0%	25,567.0 +14.3%	100.0%	29,318.4 +14.7%	100.0%	31,456.0 +7.3%	100.0%
% U.S. Mfg.	80.6%		79.6%		75.2%		71.9%		68.8%	
Total Capacity (Terabytes)	1,560.3	100.0%	2,342.1	100.0%	2,993.1	100.0%	4,047.4	100.0%	5,048.6	100.0%

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

TABLE 8

NON-CAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT CATEGORY REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPPED IN TERABYTES	1989 Capacity Units	1989 Capacity %	1990 Forecast Units	1990 Forecast %	1991 Forecast Units	1991 Forecast %	1992 Forecast Units	1992 Forecast %	1993 Forecast Units	1993 Forecast %
DISK CARTRIDGE DRIVES	4.8	.3%	8.7	.4%	12.5	.4%	20.1	.5%	28.6	.6%
	+143.2%		+79.2%		+43.4%		+60.6%		+42.0%	
DISK PACK DRIVES	1.8	.1%	.5	--	--	--	--	--	--	--
	-42.9%		-72.1%		-88.8%		--		--	
FIXED DISK DRIVES less than 30 Megabytes	142.6	9.2%	104.4	4.5%	62.6	2.1%	29.2	.7%	11.6	.2%
	-13.9%		-26.8%		-40.0%		-53.3%		-60.2%	
FIXED DISK DRIVES 30 - 60 Megabytes	459.3	29.5%	542.3	23.2%	635.7	21.4%	727.0	18.1%	770.2	15.4%
	+78.0%		+18.1%		+17.2%		+14.4%		+5.9%	
FIXED DISK DRIVES 60 - 100 Megabytes	133.3	8.6%	250.1	10.7%	340.4	11.3%	409.6	10.1%	437.6	8.6%
	+37.0%		+87.6%		+36.1%		+20.3%		+6.8%	
FIXED DISK DRIVES 100 - 300 Megabytes	199.2	12.7%	503.0	21.5%	636.6	21.3%	1,024.0	25.3%	1,355.2	26.9%
	+41.5%		+152.5%		+26.5%		+60.8%		+32.3%	
FIXED DISK DRIVES 300 - 500 Megabytes	245.4	15.8%	281.8	12.0%	407.1	13.6%	530.9	13.1%	626.0	12.4%
	+61.1%		+14.8%		+44.5%		+30.4%		+17.9%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	158.2	10.1%	306.8	13.1%	384.6	12.9%	459.6	11.4%	481.2	9.5%
	+65.6%		+94.0%		+25.3%		+19.5%		+4.7%	
FIXED DISK DRIVES more than 1 Gigabyte	215.4	13.7%	344.3	14.6%	513.3	17.0%	846.8	20.8%	1,337.9	26.4%
	+34.7%		+59.8%		+49.1%		+65.0%		+58.0%	
Total Capacity (Terabytes)	1,560.3	100.0%	2,342.1	100.0%	2,993.1	100.0%	4,047.4	100.0%	5,048.6	100.0%
	+45.2%		+50.1%		+27.8%		+35.2%		+24.7%	
% U.S. Mfg.	73.9%		75.0%		72.5%		70.1%		67.3%	

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

TABLE 9

1989 ESTIMATED MARKET SHARES

WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES
(Value of non-U.S. currencies estimated at average 1989 rates)

	CAPTIVE		PCM/RESELLER		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Conner Peripherals	--	--	13.9	.5	687.9	12.7	701.8	3.1
Data General	121.8	.8	--	--	--	--	121.8	.5
Digital Equipment	1,254.5	8.7	--	--	--	--	1,254.5	5.5
Hewlett-Packard	513.2	3.6	--	--	20.2	.4	533.4	2.4
IBM	9,485.2	65.8	9.6	.3	155.5	2.9	9,650.3	42.5
Kalok	--	--	32.6	1.2	3.5	.1	36.1	.2
Maxtor	--	--	101.2	3.6	310.9	5.7	412.1	1.8
Memorex Telex	--	--	37.4	1.3	--	--	37.4	.2
Micropolis	--	--	102.8	3.6	199.0	3.7	301.8	1.3
Microscience International	--	--	19.4	.7	56.2	1.0	75.6	.3
Miniscribe	--	--	266.8	9.4	202.3	3.7	469.1	2.1
Priam	--	--	30.7	1.1	41.4	.8	72.1	.3
Quantum	--	--	100.1	3.6	282.5	5.2	382.6	1.7
Seagate Technology	66.0	.5	1,172.4	41.5	1,239.5	22.8	2,477.9	10.9
Storage Technology	--	--	125.2	4.4	--	--	125.2	.6
Syquest Technology	--	--	30.8	1.1	4.5	.1	35.3	.2
Unisys	145.0	1.0	--	--	--	--	145.0	.6
Western Digital	--	--	61.6	2.2	204.6	3.8	266.2	1.2
Other U.S.	.4	--	7.7	.3	53.4	1.0	61.5	.3
U.S. Total	11,586.1	80.4	2,112.2	74.8	3,461.4	63.8	17,159.7	75.7
NON-U.S. MANUFACTURERS								
DZU	--	--	--	--	127.7	2.4	127.7	.6
Fuji Electric	--	--	21.7	.8	40.0	.7	61.7	.3
Fujitsu	979.9	6.8	144.9	5.1	678.4	12.5	1,803.2	8.0
Hitachi	562.3	3.9	445.0	15.8	162.7	3.0	1,170.0	5.2
JVC	--	--	--	--	42.2	.8	42.2	.2
Kyocera	--	--	--	--	57.2	1.1	57.2	.3
Mitsubishi Electric	20.3	.1	32.5	1.2	32.9	.6	85.7	.4
NEC	1,000.7	6.9	--	--	365.0	6.7	1,365.7	6.0
Northern Telecom	30.5	.2	1.0	--	22.1	.4	53.6	.2
Rodime	--	--	34.6	1.3	44.8	.8	79.4	.3
Siemens	65.0	.5	--	--	18.8	.3	83.8	.4
Sony	4.8	--	--	--	122.4	2.3	127.2	.6
Tokico	1.1	--	--	--	35.0	.6	36.1	.2
Toshiba	103.6	.7	15.8	.5	83.9	1.5	203.3	.8
Other Non-U.S.	54.0	.4	15.6	.5	134.2	2.5	203.8	.8
Non-U.S. Total	2,822.2	19.6	711.1	25.2	1,967.3	36.2	5,500.6	24.3
WORLDWIDE TOTAL	14,408.3	100.0	2,823.3	100.0	5,428.7	100.0	22,660.3	100.0

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

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

Codes: 2 = 2.5" C = Captive
3 = 3"-3.9" P = PCM
5 = 5.25" O = OEM
8 = 8"-9.5"
10 = 10.5"-10.8"
14 = 14"

TABLE 10

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	Type	Disk Cartridge Drives	Disk Pack Drives	Fixed Disk Drives <30 MB	Fixed Disk Drives 30-60 MB	Fixed Disk Drives 60-100 MB	Fixed Disk Drives 100-300 MB	Fixed Disk Drives 300-500 MB	Fixed Disk Drives 500 MB-1 GB	Fixed Disk Drives >1 GB
Alpha Data	O								14	
Areal Technology	O				2					
Atasi Technology	O						5	5		
Brand Technologies	O						3			
Cardiff Peripherals	O						3	3		
Cerplex Technologies	P,O	8						8	8	
Conner Peripherals	O			2,3	3	3	3			
Digital Equipment	C						5	5	5,14	8
DMA Technologies	O	5								
Hewlett-Packard	C,O			3		5	3,5	3,5	5,8	5
Ibis	O									14
IBM	C,O			3	2,3,5	2,3,5	3,5,8,14	3,5,8,14	5,8,14	5,10,14
Kalok	O			3	3	3				
Maxtor	O				3	3,5	3,5	3,5	3,5	5
MFM Technology	O	5								
Micropolis	O					5	5	5	5	5
Microscience International	O				3,5	5	3,5		5	5
Miltope	O			5	5		5	5		
Northern Telecom	O						8	8	8	8
Orca Technology	O							3	5	
Plus Development	P,O			3	3	3	3			
PrairieTek	O			2	2					
Quantum	O				2,3	2,3	3	3	3	
Seagate Technology	O		8	3,5	3,5	3,5	3,5	3,5,8	5,8	5,8
Sequel	O					8	8	8		
Storage Technology	P,O									14
SyQuest Technology	P,O	5								
Western Digital	P,O			3	2,3	2	3	3		
Asian Manufacturers										
Alps Electric	O			3	3		3			
Espert	O				3	3				
Fuji Electric	O			3	3		3			
Fujitsu	C,P,O			3,5	3,5	5	3,5,8	5,8,10	5,8,10	5,8,10
Goldstar Telecommunication	O			3	3					
Hitachi	C,P,O			3,5	3,5,8	5,8	3,5,8	5,8	5,8,14	5,8,14
Hyosung Computer	O					5	5			
JVC (Victor Company)	O			2,3	3					
Kyocera	O			3	3		3			
Magtron	P,O						5			
Mitsubishi Electric	C,O				3,5	3	3,8	8	8	
Mitsumi Electric	O				3	3	3			
NEC	C,O			3,5	3,5		3,5	5	5,8	5,8
Ricoh	O	5								
Samsung Electronics	C,O				3					
Sony	O				3					
Teac	O				3	3				
Tokico	O				3	3	3			
Toshiba	C,O				3	5	3,5,8	5,8	5,8	
Y-E Data	O				3	3	3			
Zentek	P,O				3	3	3			
European Manufacturers										
DZU	O				5		14	14	14	
Kovo	O		14							
Rodime	P,O					3	3	3	3	
Sagem	O				5		5			
South American Manufacturers										
Digirede	O				5	5	5	5	5	
Edisa Informatica	C,O						5	5	5	
Elebra	O			3	5	5			8	
Flexdisk	O			3						
Microlab	O			5	5	5				
Prologica	C,O					3				

TECHNICAL REVIEW

Competing technologies

The history of magnetic disk recording is one of continually improving recording densities, which translates directly into lower cost for data storage. Higher density means fewer heads and disks for a given capacity, thus reduced physical size, smaller motors, less heat, and lower power. And as densities have been improved, development in head positioning techniques has provided faster access to data, and reduction of complex drive electronics to a few chips has made it easier to achieve smaller packaging.

Research results indicate that the industry may expect improvements in disk drive technology to continue for many years -- in fact, the end isn't in sight. As a result, sponsors of would-be alternatives to magnetic disk recording technology have had a difficult time. The press always prints announcements of new "disk replacement" products, but system manufacturers don't buy many. Even a proposed disk substitute with performance and price equal to existing disk drives usually isn't enough, since system designers are familiar with the magnetic disk drive industry and feel comfortable with the system integration requirements for disk drives. In order to penetrate the market, the proposed substitute must be significantly better.

The technologies which are currently the leading candidates to provide major 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.

* Optical disk drives: Because they use track densities of 15,000 tracks per inch or more, optical disk drives are capable of higher areal densities than magnetic disk drives now in use. Optical disk drives now available or entering the market use various recording technologies, and are able to provide capacities per side per disk in the range of one hundred megabytes to several gigabytes. However, the current technologies cannot provide performance equivalent to magnetic disk technology, nor can optical drives yet compete on a product cost basis. The primary reasons for using optical disk drives relate to removability of the media, such as use in an automated library or for security concerns.

  Although not yet demonstrated, advocates of the various types of optical disk media technologies believe 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. More recently introduced media using organic dyes as the recording material have no metallic films and may offer improved stability.

  Although no storage devices using removable media have been large commercial successes without having media interchangeable among drives of various manufacturers, optical drive producers have been slow to agree upon complete standards except in the read-only area. Write-once drives are largely non-standardized, but 5.25" and 3.5" rewritable drives appear likely to be mostly standardized using a format worked out by various national and international standards bodies.

* Non-reversible optical disks: The first optical disk recording systems to enter the market were "non-reversible" or "write-once" systems. After many years of costly development programs undertaken by several European and Japanese manufacturers, such devices are purchased and shipped routinely by major system manufacturers, including IBM, Eastman Kodak, Toshiba, Hitachi, and Digital Equipment Corporation. Whereas the initial products manufactured were 12" in diameter, the trend is increasingly to 5.25" diameter drives. A 4.72" drive for professional use was introduced by Yamaha in 1989 and by Sony in 1990, but there is little interest in 3.5" write-once optical drives.

  Write-once drives operate by using a diode laser and suitable optics and positioning mechanisms to produce a concentrated beam that can remove, deform, or change the reflectivity of material at the focal point of the beam. For readback, a diode laser, operating at a lower power, scans the disk, and the varying light

reflected from regions of differing reflectivity is translated into bit patterns. Once an area of the disk is written, it cannot be changed or rewritten, although it could be overwritten and destroyed.

Obviously, the market for write-once optical disk systems will be limited to the niches which can tolerate non-reversibility. In some applications, the ability of write-once storage systems to maintain an audit trail or indicate whether or not stored data has been modified is a significant benefit. Large automated libraries that provide random access to tens or hundreds of disks make the use of large scale write-once optical storage attractive for users of permanent records such as governmental agencies, banks, insurance companies and other organizations with massive records that must be easily accessed. Library systems are needed in order to make optical storage practical in a larger system environment.

Little displacement of magnetic disk drives by non-reversible optical storage will result in the foreseeable future. Some displacement of tape in archival applications is probable, but the growth of write-once technology will be limited by the availability of rewritable optical drives.

* Erasable optical disks: When cost-effective rewritable drives with improved performance become available, the possibility for real inroads into the market for magnetic disk drives exists. Magneto-optical recording has seen development activity for more than twenty years, and rewritable phase change optical recording emerged as a competitor this year. 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 somewhat faster for a given laser power, reducing latency and improving data transfer rate. However, 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 close the gap.

  Most current magneto-optical development programs involve using a low power laser to change the magnetic state of the active layer on a disk. The laser raises the temperature of the active layer into the range of the Curie point while a magnetic field is present, causing individual magnetic domains on the disk to align with the direction of the external field. Changes in magnetic orientation are detected during reading, as the affected spot on the disk causes a small rotation in the polarized light reflected from the surface or transmitted through the disk. However, magneto-optical drives now going into production have not yet shown the ability to overwrite in place: A complete sector must be erased before the sector can be rewritten. Industry expectations are for elimination of the overwrite problem by the end of 1992.

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 non-crystalline state, during which light is absorbed. Fujitsu has revealed a comparable process in which different crystalline states are used to vary reflectivity. Phase change recording is capable of only 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 as being a practical product. Phase change erasable media arrived in the marketplace in 1990.

A third possibility, potentially the least expensive to manufacture, is erasable dye-based technology. As of yet, only limited success has been obtained with this technique because developers have not been able to demonstrate an adequately high number of write/erase cycles, but there are applications, such as backup, where this is not a major disadvantage. In mid-1988, Tandy Corporation announced its intention to supply such a drive in the future but unexpected problems have delayed its development effort.

Individual firms are also working on other proposed reversible optical recording technologies, but none of them have overcome all of the problems, which have included: Slow completion of the reversal cycle, 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.

Magneto-optical storage has entered the manufacturing stage, with over 46,000 drives shipped in 1989. While adequate media supplies remain a problem, some producers have committed to the heavy investment required to establish volume production capability. Rewritable drives are now in volume production from Canon, Sony, Maxoptix and Ricoh (using an Olympus mechanism). A 3.5" magneto-optic drive has been announced by MOST, a Nakamichi subsidiary, and others are expected to be announced in 1990.

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.

* Read-only optical disks: The read-only optical disk category is dominated by the CD-ROM. High storage capacities of 550 to 600 megabytes, but long access times, are typical of CD-ROM technology, which borrows heavily from the designs of the 4.72" CD audio players now in volume production, keeping CD-ROM costs low. Further, CD-ROM acceptance benefits from industry agreement on the CD standards developed jointly by Sony and Philips. A 3.5" version of the CD-ROM drive under development by several firms appeared in 1990 as part of a Sony portable CD-ROM player system.

It is technically feasible to use read-only media with write-once drives, and 3M and other companies have proposed such media in a 5.25" format. However, the low costs of the CD-ROM relative to read-write drives make it unlikely that read/write drives will significantly inhibit the growth of the CD-ROM market.

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 systems as an adjunct to a rigid disk drive rather than as a replacement device.

* Magnetic bubbles: Bubble memories continue to succeed in markets requiring specialized packaging or operation under environmental stress. At one time considered a possible challenger to magnetic disk storage, bubble memory suffered a serious loss of credibility after the 1981 departure of National Semiconductor, Texas Instruments and Rockwell International from the field. Even AT&T, with manufacturing by Western Electric, lagged behind in developing internal bubble applications, despite the fact that the basic technology was invented at Bell Laboratories. In Japan, Hitachi and Fujitsu developed a modest production capability for bubble memory chips.

  The rate at which the market for magnetic bubbles developed was clearly not acceptable for the dropouts, who wanted more immediate returns on their investments. But bubbles started to find suitable applications, once they were actually in production and support chips became available. The highest manufacturing levels are still maintained by Hitachi, with most production used by Nippon Telephone and Telegraph for a variety of telecommunication applications. Hitachi is currently exploring 64 megabit bubble devices.

  The bubble program of Intel Magnetics was especially instrumental in developing a wide variety of applications. Intel led the market with 1 megabit chips, the introduction of support circuits and a guaranteed future price reduction policy. The company attracted a variety of customers in specialized and harsh environment applications -- at least sufficient to establish quantity production and start down the learning curve. However, Intel elected to withdraw from the business in order to concentrate resources on more critical areas, and sold its magnetic bubble business to MemTech Technology Corporation in 1986.

  Bubble memories for both military and industrial applications are also manufactured by Magnesys, which was formed in 1983 by five ex-Intel managers. In 1988, Magnesys licensed Science Applications International Corporation (SAIC), a defense contractor, as a second manufacturing source for its bubble memories. In January, 1990, Magnesys was purchased by Group Technology, a military contractor. Magnesys has begun offering bubble cartridge storage

systems in 360 kilobyte, 720 kilobyte, and 1.2 megabyte configurations, but the price is 10 to 15 times that of equivalent flexible disk drives. The bubble memories are packaged in 5.25" half height or 3.5" form factors and are intended to substitute for the equivalent floppy drive.

The non-volatility of magnetic bubbles and their suitability for capacities too small to be cost-effective for magnetic disk drives has proven to be attractive to system manufacturers for applications such as industrial control systems, robots, point of sale terminals, portable computers, medical instrumentation, avionic systems and militarized systems. Although bubble memory densities have reached 4 megabits per device, they are still not cost competitive with magnetic disk technology. It is improbable that bubbles' prices will approach disks' prices -- and bubbles will now have to defend their specialized markets against encroachments from ferro-electric semiconductor memory.

By the late 1990's, content addressable, high density bubble memories based upon Vertical Bloch Line (VBL) domains and bubble logic might be able to challenge disk memory in some applications. Such memory chips might contain from 100 megabits to 1 gigabit of data. R&D efforts at Purdue, Carnegie Mellon University, Boston University and at NEC and Kyushu University in Japan have shown promise, but much remains to be done to make VBL a practical technology. In the industrial sector, Magnesys has begun commercial development of VBL memory technology in conjunction with Jet Propulsion Laboratories and Boston University. A development period of several years is anticipated.

* High capacity flexible disk drives: It is within the capabilities of today's technology to fabricate a 3.5" floppy disk drive offering over 40 megabytes of storage capacity, and drives with 20 megabyte capacity are expected to be in volume production in 1991. These high capacity floppy drives could compete in the very low end of magnetic and optical disk drive markets and against tape drives for backup applications.

  10 and 20 megabyte 5.25" flexible disk drives available in the market over the past several years have achieved only marginal success. However, the 3.5" drives with capacity in the 20 megabyte range which have been announced by Brier Technology, Citizen and Insite Peripherals have created considerable interest. Several other firms in Japan are working on 10 megabyte to 30 megabyte floppy disk drives. Brier has announced a 43 megabyte 3.5" drive using a 26,000 BPI and 1,021 TPI format.

  Unfortunately, none of the new high capacity flexible disk drive formats are compatible with each other. Insite's 3.5" drive uses standard magnetic media with an optical servo pattern on the disk surface, combined with optical tracking methods. Citizen uses standard media, with magnetic embedded servo. Brier uses a dual layer writing technique to embed its servo data beneath the data

on each track. Each manufacturer has recognized the need for read and write downward compatibility with one and two megabyte 3.5" floppy disks, delaying volume manufacturing in some cases to incorporate downward compatibility.

Perpendicular recording for flexible disks has the potential to increase capacity without any significant increases in track density. By using a sputtered thin film, metal powder, or a barium ferrite coating on a Mylar substrate, perpendicular recording disks could achieve linear densities potentially several times higher than today's drives. Higher track densities achieved through embedded servo techniques or optical tracking methods could increase capacities by a factor of four or more.

* Stretched surface recording: SSR, as this technique is commonly known, was originally devised by the 3M Corporation. It employs a disk composed of a plastic film with a magnetic coating stretched across concentric cylindrical rings. The chief characteristic of this technology is that it allows a head to fly on an air cushion backed by a deformable surface under the head. This provides close head-media separation needed for high capacity but also prevents head crashes. Disk drives using this design technique could be produced in either fixed or removable format and could offer the same capacity as a small Winchester drive. The media, however, might have a cost only 1/3 to 1/4 that of the rigid disk media in current or projected use. 3M has had various arrangements with other firms interested in developing SSR drives, most of which are now active. Reports of joint activity between 3M and Sony appeared in the trade press in the first half of 1989.

* Semiconductor memory: The fast response time of semiconductor memory has already won it a secondary storage role in some large and small systems where it serves as a substitute for rigid drives when very fast access to data or programs is required. Even personal computer operating systems can allow part of main memory to be designated for use as a virtual disk. However, 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 is vitally necessary for the system to meet requirements.

  DRAM and SRAM memory chips, now available in 4 megabit configurations, are expected to become readily available in 16 megabit configurations by the mid-1990s. Small quantities of 16 megabit chips from Matsushita, Toshiba and Hitachi are expected in the early 1990s, and IBM will be producing them for its own use. The arrival of 64 megabit chips, not expected until the very late 1990s, is expected to signal the first real opportunity for semiconductor memory to compete with magnetic disks across a broader range of applications. Until that point, the cost and performance of the rigid magnetic drive will have improved enough to keep its solid state competitor at bay.

It is not likely that progress in semiconductor memory technology over the next ten years can proceed at the rate of improvement shown in the last 20 years. Because the complexity, packaging problems, and performance requirements of semiconductor memory have increased, the investment in time and capital required to produce succeeding generations of chips has also increased. As a result, the rate of semiconductor memory price decreases is expected to slow.

Besides dynamic and static RAM chips, other forms of semiconductor memory may compete with magnetic disk storage in the future. These include ferro-electric memory chips and a form of EPROM known as flash memory. Ferro-electric memories make use of the properties of the electrically reversible polarization of ferro-electric materials to form a capacitor, which is required in the circuitry of semiconductor memories. Proper design can produce a non-volatile memory cell that can be fabricated with conventional planar processes but has smaller dimensions than cells made with silicon dioxide capacitor dielectrics. Sub-microsecond access times are possible. The number of write/erase cycles possible exceeds a trillion cycles for the best materials. Operating speed is equivalent to that of typical DRAM, but not quite as fast as conventional SRAM. The fabrication techniques required to construct ferro-electric chips are substantially the same as used for CMOS, which is a well understood technology.

Ramtron, which has been the most visible developer of ferro-electric memory technology, has licensed it to NMB Semiconductor company, ITT and Seiko. Ramtron and NMB are jointly developing a 4 megabit ferro-electric memory chip as well as 16 megabit DRAM chips. Krysalis Corporation plans to offer sample 16 kilobit ferro-electric chips by the end of 1989, organized as 2,048 bytes, and Ramtron expects to have an 8 kilobit chip ready for sampling at the same time. Krysalis has licensing arrangements with National Semiconductor.

64 kilobit ferro-electric chips are anticipated by early 1991. By the 1992-1993 time frame, chips with 1 to 4 megabit capacity could be available selling at $10 to $20 per megabyte. 16 megabit chips, probably available in 1995, should sell in the $3 to $4 per megabyte range. Additional packaging and system costs will be incurred to make the equivalent of a disk drive.

Ferro-electric memories will contend for acceptance in portable computers, "smart cards" and in applications where loss of memory due to a power lapse is a critical problem. Mechanical counting devices are also subject to replacement. Ferro-electric 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 non-volatile memory requirements served by rotating memory. Develop-

ment of ferro-electric memory is lagging that of the flash memory, and it isn't clear that there is room for both in the market.

Flash memories are a form of EEPROM in which a block of cells can be erased by an electrical signal. Current fabrication technology can fabricate flash memories with up to 4 megabits per chip. They are being developed by Intel, SunDisk, Seeq Technology and other firms. While flash memories can be erased, it is not possible to change only a few bits; an entire block must be erased and this can take as long as half a second for the equivalent of a disk sector. This means that 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 much slower. There is also a limit to the number of times the memory device can be rewritten. At present, flash memory chips degrade beyond usability after about 100,000 write/erase cycles. Some chips are specified at only 10,000 cycles. To the extent that rotating disk drives storing non-changing or rarely changing data are used with computers embedded in process oriented equipment or in specialized portable applications, they may eventually become vulnerable to inroads from flash memories.

At present, semiconductor memory modules packaged in 5.25" form factor enclosures are available in capacities from 20 to 80 megabytes from NEC and Hitachi, but at prices approximating $200 per megabyte they are suitable only for specialized applications.

Portable computers will probably make extensive use of removable semiconductor memory packaged in a flat "credit card" format. Pin interconnect and packaging standards have been worked out, with the final result being a 68 pin connector and a package 3.3 millimeters thick. The cards are able to accept a variety of memory forms, including PROM, ROM, SRAM, DRAM, and, eventually, flash or ferro-electric memory.

High density, high capacity packaging for large semiconductor memory is getting closer. For instance, Anamartic is working on a 40 megabyte wafer-scale integration project using two 6 inch wafers, each carrying 200 megabits. Wafer fabrication is done by Fujitsu. A few have been delivered to Tandem Computers for trial.

Another possible packaging technique is the stacking of chips vertically to make a three dimensional or "Z-plane" package. Assuming that a 4 megabit chip design were used, one module proposed would have 320 megabit capacity in a package roughly a half inch on a side and a quarter inch high. However, formidable heat dissipation and fabrication problems are yet to be resolved. The most probable early applications are in military or aerospace equipment, possibly by mid-decade.

* Holographic storage: Holographic storage is a type of optical storage in which an array of spots representing the mathematical

transform of 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 reading 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 ongoing research and development efforts by many organizations worldwide.

One of the more ambitious holographic storage programs is being conducted by MCC (Microelectronics and Computing Corporation), a research consortium sponsored by major U.S. technology firms. MCC is planning to show working prototypes of holographic memories in a 5.25" form factor in early 1992. The devices will have 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. Once the prototypes are working, it will be up to the companies supporting the research effort to convert the technology into working, practical products. Among the supporters of the MCC effort have been DEC, NCR, Imprimis, Eastman Kodak, General Dynamics and E-Systems.

Because holographic storage systems have no moving mechanical parts, they have applications in military, industrial, and other applications where ruggedized storage is essential. MCC is projecting that the cost per megabyte of its holographic storage will be 2 to 4 times the cost of magnetic storage of equivalent unit capacity. If practical, holographic storage can virtually eliminate the current limitations on throughput caused by mechanical drives, and thus must be considered as having the potential to effectively compete with magnetic and optical rotating disk drives for selected applications in the late 1990s.

Disk drive enhancements

Disk drive technology has been continually improved since IBM introduced the first rigid magnetic disk drive in 1956. After two decades of disk technology leadership, IBM contributions were outstripped by a legion of aggressive competitors in the area of small diameter drives. But the 1980's saw a resurgence in IBM contributions, especially in packaging -- such as IBM's 320 megabyte 3.5" drive with 8 disks and 857 megabyte 5.25"

drive with 12 disks. The critical areas being addressed by IBM and others are discussed below.

* Head flying height: For some of today's latest high density rigid disk drives, head flying height is in the 4 microinch range. Several firms are attempting to design drives in which there is no measurable flying height, and IBM has discussed advanced research projects in which the head "flies" at 2 microinches above the surface, essentially contact recording. Because head flying height determines the achievable areal density, reductions are of critical importance, but each reduction requires a new level of sophistication in the preparation of substrates, coatings, overcoatings, heads and test equipment. For instance, it appears that glass substrates may be required to obtain the required smoothness and flatness for the lowest flying heights. Determining reliable processes for manufacturing, coating, texturing and testing disk media using glass substrates are major challenges, and the ability of substrate and media producers to ramp up production is an unproven capability.

* Recording heads: Monolithic ferrite heads patterned after IBM's 3350 designs dominated in early Winchester disk drives. During the following years, PCM drives using heads designed to compete against IBM's 3370, 3375, 3380, and other new drives with ferrite heads having sliders with 3370 contours (mini-sliders) became common. The outpouring of small diameter disk drives from multiple OEM sources in the last decade embraced the small head contours and drove the demand for high performance small heads. These pressures, in turn, drove the development of composite and digital application metal-in-gap heads.

  Packaging requirements for small drives have also stimulated development of new head contours and suspensions, as spacing between disks diminishes. New micro sliders are smaller than ever, with less mass to inhibit rapid positioner movement or cause damaging head/disk interference. Some new designs also utilize ramp loaded heads, eliminating the possibility of stiction and reducing power requirements for starting drive motors.

  Conventional and composite ferrite heads, now available from multiple sources, are routinely produced with good manufacturing yields, and are competitively priced. They will continue to be used for the majority of captive and OEM drives, while metal-in-gap and thin film heads gradually reach high production levels and become price competitive with ferrite monolithic and composite heads. Single crystal ferrite heads, expected to be available in volume in 1991, provide improved performance and should extend the life of ferrite head technology. Risk is low, as single crystal technology has been used in video heads for a number of years.

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

1984 saw the beginning of thin film head shipments for small diameter OEM disk drives. Production has overcome startup disasters and is increasing as more vendors start to master the process and gain control of process yields. Current major producers include PCI (Seagate), Applied Magnetics, Dastek and Read-Rite. However, MIG heads have proven capable of operation in many of the applications originally targeted by thin film heads, so until the last few years the demand for thin film heads has been much slower to develop than many prospective producers had hoped. As a result, production capacity was slow to develop and the surge of small drives using very high recording densities in 1989-90 has created a current shortage of thin film heads. The ability of thin film heads to operate at areal densities well above those achievable by other head technologies guarantees them a role in future high capacity, high performance designs. Magneto-resistive (MR) thin film heads may start to appear in small form factor drives as early as late 1991.

* Recording disks: As the disk drive industry progressed through succeeding generations of disk drives, disk media underwent a refinement of the basic coating process to achieve a continually thinner application of a uniform coating, plus improvements in surface lubricants. Today, thin film media is rapidly displacing oxide, because oxide coated media is increasingly unable to satisfy areal density requirements. Even IBM, a longtime oxide champion, now ships large quantities of drives with thin film media, much of it produced internally by IBM.

  For several years, there was a stampede by numerous established and new firms to install production capability for thin film disks. Most aimed at the market for 5.25" and smaller disk drives, and the managements involved recognized the need to establish credibility by offering facilities capable of producing large quantities of disks, with adequate process controls, at prices competitive with oxide disks of comparable quality. Most of this activity has been generated because of the higher density potential of thin film disks. Almost all new designs for small form factor drives require higher density than oxide disks offer.

  Many of the early manufacturers of sputtered and plated disks lacked adequate process control and were unable to sustain high production yields or to meet delivery commitments on a consistent

basis. A second wave of companies using sputtering methods to deposit thin magnetic films are shipping disks in significant quantities. These firms claim that the sputtering process is easier to control than the plating process, usually resulting in substantially higher yields. Sputtering is also less subject to water contamination. Sputtering lines are less flexible than a plating line, however, which is a factor in the difficulty that producers of 8" disk drives have in obtaining assured sources of sputtered 8" media. 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. Media producers are beginning to discuss standards for 1.8" media, which appears to be the next step in the size progression. Media with coercivity in the 1200 to 1500 Oersted range is routinely producible, and some companies have demonstrated fabrication of media up to 2300 Oersted coercivity on production quality sputtering systems.

Many firms use both plating and sputtering technologies in multiple layer disks, sputtering the magnetic recording layer on a layer of plated nickel that isolates the substrate from the magnetic layer. Like the plated disk, disks with sputtered magnetic layers usually have overcoats for protection. Whether sputtering or plating is used, thin film media producers have automated their production processes to insure consistent process control and to build production volume.

While most thin film media production has been from independent producers, major system manufacturers, including Hewlett-Packard, Digital Equipment and IBM, have begun to produce much of their media requirements. This has had the effect of displacing some of the disk purchases by these drive manufacturers,but the effect on the independent disk media manufacturers has been masked by the very strong demand for 3.5" and 2.5" drives.

Aluminum has always been the substrate of choice for rigid disk media, but some high capacity disk drives in the 3.5" and 2.5" diameter range, such as those of Areal Technology, will be using glass or glass/ceramic as a substrate material. Glass substrates are potentially smoother and flatter 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. However, because of low production volume, they currently cost significantly more than aluminum substrates. There is also limited industry production capacity at present. The inherent smoothness of glass and ceramic substrates requires them to be textured during manufacturing to avoid stiction.

* Head positioning methods: The industry is not moving forward rapidly with TPI improvements. Some small drives operate at up to 2,000 TPI, but such precision is costly. The industry still has plenty of room for innovation in this area. IBM's 3390 operates at 2,235 TPI, and some firms are investigating the use of

optical tracking techniques to obtain higher TPI. IBM has shown the feasibility in the laboratory of creating media with very narrow tracks with sub-micron dimensions. However, considerable work will have to be done to develop heads capable of working with such narrow track widths.

New materials and designs are being developed to improve vibration suppression damping in head gimbal assemblies and positioning mechanisms. This also should assist in reaching higher track densities.

* 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. More than 100,000 BPI 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.

  A very large amount of development activity in perpendicular recording has been underway 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, was withdrawn when they decided to discontinue disk drive operations.

  Lanx supplied sputtered small diameter disks to manufacturers of existing high performance drives, with the objective of making significant increases in capacity possible for existing drive mechanisms at modest cost increases, but the firm ran out of money before the drive manufacturers adopted the technology. Censtor has announced production availability for a matched set of disks and heads, and hopes to entice manufacturers of high-end drives to improve the capacity of existing drive models. Northern Telecom became the first manufacturer to use the Censtor technology in an announced product, but decided to withdraw from the manufacture of disk drives in 1990. Censtor has since redirected its efforts to recording systems for in-contact recording.

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

* Multiple spindle arrays: A single high capacity drive can be replaced with an array of smaller capacity drives having aggregate equivalent capacity and a file organization that appears to

the host system to be similar to that of the larger drive. Data is typically "striped" across each drive in the array, and the drives operate with their rotation rate and phase synchronized to minimize the skew between related bits.

Such arrays can offer substantially higher performance than a single large drive limited by a single actuator. Depending upon the way the array is configured and upon the degree of sophistication of associated subsystems, it can also offer redundancy, very high data transfer rates, or volumetric efficiencies, compared to single large drives. Options such as caching and multiple data pathing can also be added. The term RAID (Redundant Array of Inexpensive 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-1, RAID-2, etc. through RAID-5.

Most of the pioneering in development of disk arrays has been done to satisfy fault-tolerant requirements for on-line transaction systems, and it is believed that the OLTP markets will continue to drive most array development. Drive manufacturers considering supplying complete multi-spindle arrays have discovered that most of their prospective customers would prefer to buy the drives and design and manufacture arrays themselves for value-added considerations and because of sensitive interrelationships with system software.

* Performance: Significant improvements in data transfer rate and average access time are expected during the next few years. The single most important factor in initiating these improvements will be the increase in disk rotation rate, which both decreases latency and increases data transfer rate. A secondary, but significant 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.

  Drives having rotation rates in the range of 5,400 RPM appeared in 1989 when Imprimis announced a family of high capacity 5.25" drives operating at 5,400 RPM. Hitachi had earlier announced a 5.25" 600 megabyte drive operating at 4,876 RPM and IBM announced a 320 megabyte (formatted) 3.5" drive rotating at 4,318 RPM at the 1989 Spring Comdex show.

  The use of parallel transfer from multiple heads to achieve data rates of 12 megabytes or more per second has been a practice for several years, with such drives typically used for supercomputers and high-end imaging applications. Drives with data transfer rates of 24 megabytes per second are in demand for supercomputing applications and are expected soon.

  Average seek times have now dipped under 12 milliseconds for the fastest drives, although 14 to 16 millisecond seek times are more

common in high performance 5.25" and 3.5" drives. Higher energy magnetic materials and lower mass microslider heads are contributing to the improved performance. 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.

* Form factor: Sub-3.5" drives will become an increasingly significant part of the market. Driven by demands from manufacturers of notebook and laptop computers, small footprint, low power drive designs will proliferate over the next several years. The first of these, 2.5" 20 megabyte drives from PrairieTek, JVC and Conner have already gone into production, as well as a 40 megabyte PrairieTek model. The 2.5" drive should be able to exploit the rapidly growing market for notebook computers, most of which cannot make use of larger drives.

  Competition in providing higher capacity and thinner (3/4" or less) profiles in 3.5" and 2.5" disk diameter drives will be keen. 19 millimeter heights or less are expected 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 15 millimeter high range, to allow maximum volume for batteries in notebook computers.

  The first indications of the next reduction in form factor are starting to appear. Sample rigid media in the 48 millimeter diameter range is being sampled and discussions about standards for such media are underway. However, it is expected to take another 18 months at least for prototype 1.8" drives to appear in the market.

  Technologically, form factor reduction is being driven by improvements in media capacity (areal density), smaller heads, and higher energy magnetic materials that permit fabrication of smaller motors and actuators without reducing performance.

* Interfaces and controllers: There is an established trend to intelligent interfaces embedded within the disk drive and able to communicate with a host system data bus without the need for a separate controller. Embedded SCSI and PC/AT controllers have become widely used in drives for personal computer applications, and embedded SCSI is now used with the majority of drives used with workstations, servers and equivalent applications. Intelligent controllers provide disk drive suppliers with an opportunity to add value, but more importantly to give them freedom to design the drive to meet various needs while maintaining a common interface to the host system. For small diameter drives under 500 megabytes capacity, some version of SCSI will probably be employed in 20 to 25 percent of the drives shipped in 1990. However, PC/AT interfaces far outnumber SCSI interfaces in the personal computer market.

The use of embedded intelligent interfaces has allowed drive manufacturers to make use of techniques such as varying bit density by zones over the band of recording tracks and advanced data coding. Other features, such as on-board error monitoring and diagnostics, error correction, digital servos, intelligent caching, zero latency read/write and multiport buffering can be included but 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.

Disk drives for use with portable computers require controllers that can shut down certain functions when the drive is not in active use in order to conserve power. Power conservation logic is being incorporated into overall integrated controller logic for 2.5" drives and some 3.5" drives.

Digital servos are increasingly popular as VLSI density improves and smaller form factors make printed circuit board space a scarcer commodity. The ability to incorporate programmable servo function in a single chip or chip set provides both functional and economic advantages. By the mid-1990s, it is probable that over 80% of the rigid disk drives produced will incorporate digital servos.

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

  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 a strong incentive to adopt error correction techniques.

DEFINITIONS

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

MARKET CLASSIFICATION

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

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

Examples:

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

* In the case of a joint venture disk drive manufacturer, such as Conner Peripherals Europe (owned by Conner Peripherals and Olivetti), drive sales are considered captive or non-captive depending upon the method of sale by each joint venture partner.

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

Example:

* Shipments by Fujitsu are non-captive, except for drives sold with systems made by the parent company or other subsidiaries.

* Shipments made by Microscience International are non-captive.

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 drive-on-a-card products such as those of Plus Development.

* Disk drives sold by Storage Technology to end users of IBM equipment.

* On an arbitrary basis, drives manufactured by Fujitsu or Hitachi and resold in the PCM/Reseller market by other companies are included in PCM/Reseller totals, in order 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 or libraries 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 Micropolis or Maxtor for sale to system manufacturers.

* Drives sold by Quantum but made to Quantum designs by Matsushita Kotobuki Electronics.

GEOGRAPHIC CLASSIFICATION

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

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

Examples:

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

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

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

Examples:

* Seagate is considered a U.S. manufacturer, even though the firm manufactures many of its disk drives in non-U.S locations.

* Northern Telecom is considered a non-U.S. manufacturer, since it is owned by a non-U.S. organization.

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 certain large fixed disk drives used with mainframe systems, certain models have been arbitrarily counted on the basis that two or more spindles are equivalent to one IBM 3380 spindle (noted in the statistical tables as appropriate).

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 1990 constant dollars.

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

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

* Innovations such as non-standard 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:

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

Minicomputers/multiple user microcomputers: Drives attached to smaller general purpose processors typically serving multiple users, including network file servers. Examples: IBM System AS/400, AT&T 3B2, Hewlett-Packard 3000.

Personal computers: Attached to a general purpose microcomputer normally used by a single user. Examples: IBM PS/2, Apple Macintosh.

Office systems/workstations: Specialized equipment for dedicated use in specific office applications such as word processing, electronic mail or document storage. Specialized hardware is normally used. Examples: Wang OIS series, Toshiba TOSFILE.

Non-office systems/workstations: Attached to dedicated processors and workstations used in a non-office application, such as order processing/shipping, point-of-sale, medical, factory production control, law enforcement, CAD/CAM/CAE, military, etc.

Consumer and hobby computers: Systems sold primarily to consumers for non-business applications. Examples: Commodore 64, MSX systems, most Atari models (Apple II is considered to be a professional/business microcomputer).

Other applications: Any application not included above.

DISK CARTRIDGE DRIVES

1990 DISK/TREND REPORT

DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Cerplex (Century Data)	7110, 7130

5.25" disk diameter

DMA Technologies	360
MFM Technology	11/11, 20R
Ricoh	RH5130, RH5260
SyQuest Technology	SQ555

This product group includes all drives using a removable disk cartridge, which is sometimes combined with one or more fixed disks in a single drive. Each fixed/removable combination drive is counted as one spindle. All disk cartridge drives are now included in this group; in DISK/TREND Reports through 1986, disk cartridge drives were divided into two groups according to capacity.

The number of disk cartridge drives in production continues to shrink, as older models are discontinued. None of the companies which led in shipments of 14" OEM disk cartridge drives during the heyday of this group -- Control Data, Diablo or Western Dynex -- are currently represented with products, and, in fact, all production of 14" drives has been phased out.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	41.2	60.4	79.2	99.8	115.4
All manufacturers	65.9	68.1	91.5	118.5	139.5

As expected, 1989 was the year that disk cartridge drive shipments reestablished a growth trend, after years of decline. Total revenues were flat, but worldwide unit shipments grew from 65,700 in 1988 to 107,500 in 1989. Revenues were impacted by the continuing phase out of older drives produced in the Eastern Bloc, which were typically sold at substantially higher prices than in the West.

Last year's growth in unit shipments was attributable entirely to expansion of the market for 5.25" disk cartridge drives, with worldwide shipments up 186%, to 91,300 units, with shipments in 1990 projected to increase to 169,000 drives. Shipments of 14" disk cartridge drives ended last year, and 1990 is expected to be the last year for significant 8" and 3.9" drive production.

Older 14" and 8" captive disk cartridge drive programs by Digital Equipment, Control Data and other companies have been phased out, accounting for absence in captive revenues. Unfortunately, the growth expectations of several years ago for 14" and 8" drives have been largely unfulfilled.

Disk cartridge drives are more difficult to design and manufacture than fixed disk drives of the same capacity and disk diameter, due to increased mechanical complexity and greater risk of contamination. The extent of these problems was not clearly recognized by most would-be producers of 8" and 5.25" drives, resulting in long delays for availability of announced products, shipment of many unreliable disk drives, and several failed programs.

With this history, it is entirely understandable that many system manufacturers which previously used 14" disk cartridge drives in small

office and engineering systems, and would have liked to continue with removable disk drives in smaller sizes, tired of waiting and switched to fixed disk drives.

SyQuest has emerged as the dominant leader in shipments for this product group, at first exploiting the security markets for removable disk storage, and in recent years developing a new market with personal computers used in graphics and desktop publishing applications. SyQuest accounted for 82.4% of 1989's worldwide unit shipments, for a total of 88,700 drives, mostly 5.25" models.

Marketing trends

5.25" drives will continue to provide the expected growth for this product group, as user preferences in the specialized market for disk cartridge push drive manufacturers toward higher capacity models, rather than smaller package size, at least for the moment. SyQuest plans to ship an 88 megabyte model in early 1991.

The average annual increase in unit shipments for the 1991-93 period is 34.7%, with total shipments for 1993 projected at 409,000 drives, all 5.25" models. SyQuest is clearly leading this new surge in disk cartridge drive shipments, but Ricoh is also a participant, and new drives in this capacity range are also expected from the existing low-volume manufacturers of 5.25" disk cartridge drives, MFM Technology and DMA Technologies.

Given the background of technical difficulties, shaky financial status of some manufacturers, lack of media interchange standards and excellent competition from fixed disk drives, it is easy to understand why a majority of the computer industry's system manufacturers are no longer using disk cartridge drives.

Despite the negative influences, disk cartridge drives provide removability, which is highly desirable for some applications. The long-term mainstay consists of a variety of requirements frequently called the "security" market -- the various government offices and defense contractors which are required to remove all data from computer systems when not in use, so that it may be kept under lock and key.

Other current markets for disk cartridge drives consist of specialized systems which utilize exchangeable data bases and some personal computer users with specialized requirements. Graphics applications such as desktop publishing, the preparation of camera-ready originals for the printing press, have generated a new group of customers for disk cartridge drives, prompting development of specialized marketing programs aimed primarily at Macintosh users.

Technical trends

The basic recording technologies now in use for products in this group will continue to predominate for years. The smaller drives introduced to date incorporate elements of the older technologies, but utilize head designs similar to Winchester heads, sometimes with "mini" sliders. The 8" drives now approaching end of life use oxide coated disks, while the newer 5.25" models use thin film disks. All use embedded servo techniques in order to maximize the disk surface area available for recording.

The major difference in high density recording between disk cartridge drives and fixed disk drives is higher probability of particulate contamination in removable disk drives. At the higher areal densities already in use with high capacity fixed disk drives, heads must fly at lower altitudes, increasing the need for reduced contamination levels.

It is possible to increase density in removable disk drives, building upon the design experience accumulated with today's 5.25" drives. Changes in heads, filtration systems and seals may be necessary, and thin film disks will be used because of improved surface durability. Due to the new growth being experienced by this product group, it is reasonable to expect that manufacturers will invest the resources needed for both high capacity in existing form factors, plus drives using smaller disks.

Forecasting assumptions

1. Shipments of 3.9" and 8" drives will decline to insignificant levels in 1990 due to competition from higher capacity 5.25" drives and from floppy drives in the 20 megabyte range.

2. Production for 5.25" disk cartridge drives with capacities over 40 megabytes will continue to increase, driven by security requirements and graphics applications.

TABLE 11

DISK CARTRIDGE DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	26.5	31.0	43.2	50.7	57.6	69.5	66.5	85.8	71.4	95.2
OEM/Integrator	7.8	10.2	7.9	9.7	8.7	9.7	11.7	14.0	16.1	20.2
TOTAL U.S. NON-CAPTIVE	34.3	41.2	51.1	60.4	66.3	79.2	78.2	99.8	87.5	115.4
TOTAL U.S. REVENUES	34.3	41.2	51.1	60.4	66.3	79.2	78.2	99.8	87.5	115.4
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	2.5	24.7	6.3	7.7	9.0	12.3	12.5	18.7	14.8	24.1
TOTAL NON-U.S. REVENUES	2.5	24.7	6.3	7.7	9.0	12.3	12.5	18.7	14.8	24.1
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	36.8	65.9	57.4	68.1	75.3	91.5	90.7	118.5	102.3	139.5
OEM Average Price ($000)	.5	1.1	.4	.4	.3	.3	.3	.3	.3	.3

TABLE 12

DISK CARTRIDGE DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989 Shipments		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	66.0	77.3	115.2	135.2	160.0	193.0	190.0	245.0	210.0	280.0
OEM/Integrator	13.6	14.9	18.1	19.2	25.1	28.1	36.0	43.0	51.0	64.0
TOTAL U.S. NON-CAPTIVE	79.6	92.2	133.3	154.4	185.1	221.1	226.0	288.0	261.0	344.0
TOTAL U.S. SHIPMENTS	79.6	92.2	133.3	154.4	185.1	221.1	226.0	288.0	261.0	344.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	5.0	15.3	14.0	17.0	22.0	30.0	32.0	48.0	40.0	65.0
TOTAL NON-U.S. SHIPMENTS	5.0	15.3	14.0	17.0	22.0	30.0	32.0	48.0	40.0	65.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	84.6	107.5	147.3	171.4	207.1	251.1	258.0	336.0	301.0	409.0
Total Capacity (Terabytes)	4.0	4.8	7.5	8.7	10.3	12.5	15.4	20.1	21.0	28.6
Cumulative Shipments (Units in thousands)										
IBM	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0
Non-IBM	1,122.9	1,895.2	1,270.2	2,066.6	1,477.3	2,317.7	1,735.3	2,653.7	2,036.3	3,062.7
WORLDWIDE TOTAL	1,176.2	1,974.2	1,323.5	2,145.6	1,530.6	2,396.7	1,788.6	2,732.7	2,089.6	3,141.7

TABLE 13

DISK CARTRIDGE DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues				Forecast						
					1990			1991		1992	1993
	14"	8"	5.25"	<5.25"	8"	5.25"	<5.25"	8"	5.25"	5.25"	5.25"
U.S. MANUFACTURERS											
PCM/Reseller	--	--	30.3	.7	--	50.7	--	--	69.5	85.8	95.2
OEM/Integrator	--	2.4	5.7	2.1	1.2	7.7	.8	.3	9.4	14.0	20.2
TOTAL U.S. REVENUES	--	2.4	36.0	2.8	1.2	58.4	.8	.3	78.9	99.8	115.4
NON-U.S. MANUFACTURERS											
OEM/Integrator	21.3	--	3.4	--	--	7.7	--	--	12.3	18.7	24.1
TOTAL NON-U.S. REVENUES	21.3	--	3.4	--	--	7.7	--	--	12.3	18.7	24.1
WORLDWIDE RECAP											
PCM/Reseller	--	--	30.3	.7	--	50.7	--	--	69.5	85.8	95.2
	--	--	+765.7%	-70.8%	--	+67.3%	-100.0%	--	+37.1%	+23.5%	+11.0%
OEM/Integrator	21.3	2.4	9.1	2.1	1.2	15.4	.8	.3	21.7	32.7	44.3
	-5.3%	-14.3%	-43.1%	-67.2%	-50.0%	+69.2%	-61.9%	-75.0%	+40.9%	+50.7%	+35.5%
Total Revenues	21.3	2.4	39.4	2.8	1.2	66.1	.8	.3	91.2	118.5	139.5
	-30.2%	-72.4%	+102.1%	-68.2%	-50.0%	+67.8%	-71.4%	-75.0%	+38.0%	+29.9%	+17.7%
ANNUAL SHARE, BY DIAMETER	32.4%	3.6%	59.8%	4.2%	1.8%	97.2%	1.0%	.3%	99.7%	100.0%	100.0%

TABLE 14

DISK CARTRIDGE DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments				Forecast						
					1990			1991		1992	1993
	14"	8"	5.25"	<5.25"	8"	5.25"	<5.25"	8"	5.25"	5.25"	5.25"
U.S. MANUFACTURERS											
PCM/Reseller	--	--	75.6	1.7	--	135.2	--	--	193.0	245.0	280.0
OEM/Integrator	--	.8	8.9	5.2	.4	16.8	2.0	.1	28.0	43.0	64.0
TOTAL U.S. SHIPMENTS	--	.8	84.5	6.9	.4	152.0	2.0	.1	221.0	288.0	344.0
NON-U.S. MANUFACTURERS											
OEM/Integrator	8.5	--	6.8	--	--	17.0	--	--	30.0	48.0	65.0
TOTAL NON-U.S. SHIPMENTS	8.5	--	6.8	--	--	17.0	--	--	30.0	48.0	65.0
WORLDWIDE RECAP											
PCM/Reseller	--	--	75.6	1.7	--	135.2	--	--	193.0	245.0	280.0
	--	--	--	-71.7%	--	+78.8%	-100.0%	--	+42.8%	+26.9%	+14.3%
OEM/Integrator	8.5	.8	15.7	5.2	.4	33.8	2.0	.1	58.0	91.0	129.0
	-5.6%	-33.3%	-37.7%	-67.5%	-50.0%	+115.3%	-61.5%	-75.0%	+71.6%	+56.9%	+41.8%
Total Shipments	8.5	.8	91.3	6.9	.4	169.0	2.0	.1	251.0	336.0	409.0
	-15.0%	-55.6%	+186.2%	-68.6%	-50.0%	+85.1%	-71.0%	-75.0%	+48.5%	+33.9%	+21.7%
ANNUAL SHARE, BY DIAMETER	7.9%	.7%	85.0%	6.4%	.2%	98.7%	1.1%	--	100.0%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	--	--	4.3	.1	--	7.8	--	--	11.1	17.3	24.1

TABLE 15

DISK CARTRIDGE DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	11.3	10.5	24.5	6.0
PERSONAL COMPUTERS Business and professional, single user	75.1	69.8	335.4	82.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	10.8	10.1	16.4	4.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	10.3	9.6	32.7	8.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	107.5	100.0	409.0	100.0

TABLE 16

DISK CARTRIDGE DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	<5.25"	Total		14"	8"	5.25"	<5.25"	Total	
Syquest Technology	--	--	70.5	6.9	77.4	91.5	--	--	81.8	6.9	88.7	82.5
Ricoh	--	--	5.0	--	5.0	5.9	--	--	6.8	--	6.8	6.3
Other U.S.	--	.5	1.7	--	2.2	2.6	--	.8	2.7	--	3.5	3.3
Other Non-U.S.	--	--	--	--	--	--	8.5	--	--	--	8.5	7.9
TOTAL	--	.5	77.2	6.9	84.6	100.0	8.5	.8	91.3	6.9	107.5	100.0

DISK PACK DRIVES

1990 DISK/TREND REPORT

DISK PACK DRIVES

Coverage

Examples of disk drives in this group include:

9" disk diameter

Seagate Technology	ST683J (Imprimis 9710)

IBM's 1971 introduction of the 3330, with 19 data surfaces, set the physical model for larger disk pack drives. The Control Data 300 megabyte SMD was the major large disk pack drive in production, until it was finally phased out this year. Among the large disk pack files introduced in more recent years, the Digital Equipment RA60 (14" 205 MB using 6 data surfaces) survived until last year.

Control Data's "storage module drives," introduced in 1974, exerted broad influence in the industry. "SMD" became the generally used term for drives using 3330 technology in packs with five data surfaces, as well as for the larger 19 surface drives. The SMD interface also became the industry standard for high performance OEM disk drives.

The only remaining disk pack drive still in production, the Seagate ST683J, was originally known as the Control Data (later Imprimis) "RSD," or 9710. It was functionally similar to the 80 megabyte 14" SMD, except for smaller size and lower price. Its size was matched to the Control Data "FSD" 9" family of fixed disk drives, now also approaching end of life.

Until recently, the continuing Eastern Bloc production of drives equivalent to the IBM 3330 and the older IBM 2314 looked like they would continue indefinitely, but 1990 now appears to be their last year.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	39.4	7.9	2.7	--	--
All manufacturers	91.4	20.9	2.7	--	--

End of life for the disk pack product group is now clearly in view, after years of declining shipments. The steep decline for this group has continued, from worldwide unit shipments of 24,800 drives in 1988, to 10,300 in 1989, to an estimated total of 3,000 in 1990. This year's worldwide revenue is expected to be only $20.9 million.

Production of non-captive disk pack drives in 1989 was considered to be too low to include the usual market share table in this year's report.

Marketing trends

This year is expected to be the last production year for all disk pack drives except Seagate's 9" RSD. Even Eastern Bloc production of 14" drives, previously expected to experience a long, slow decline, is also expected to finish in 1990.

The trend is also moving against 9" disk pack drives, once expected to find continued growth due to the security requirements of the U.S. government -- which requires that many types of applications connected with national defense utilize disk media which is removable, to facilitate secure storage of confidential data. Shipments of 9" drives are now forecasted to end in 1991. Disk pack drives of all types have suffered from intense competition from fixed disk drives, first 14", then 8" and now 5.25" and 3.5" models -- offering lower price, improved reliability, and smaller size.

Nothing on the horizon is likely to reverse the basic trend. Fixed disk drives are obviously being designed into most new systems requiring capacities in this range. For those applications requiring removable media for security requirements or other reasons, erasable 5.25" optical disk drives with similar capacities are now available, at lower prices, using less physical space and requiring much less power.

Technical trends

We do not expect any significant new disk pack drives to be introduced. Higher effective areal densities were achieved by DEC's 1983 introduction of the RA60, partially through use of run-length-limited encoding. However, there are no known plans by any drive manufacturer to develop a new drive in this group using today's technology.

Forecasting assumptions

1. Worldwide shipments of drives in this group will decline, due to displacement by newer systems and disk drives.

TABLE 17

DISK PACK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	14.7	20.1	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	14.7	20.1	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	12.6	19.3	5.5	7.9	1.9	2.7	--	--	--	--
TOTAL U.S. NON-CAPTIVE	12.6	19.3	5.5	7.9	1.9	2.7	--	--	--	--
TOTAL U.S. REVENUES	27.3	39.4	5.5	7.9	1.9	2.7	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	52.0	--	13.0	--	--	--	--	--	--
TOTAL NON-U.S. REVENUES	--	52.0	--	13.0	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	27.3	91.4	5.5	20.9	1.9	2.7	--	--	--	--
OEM Average Price ($000)	5.2	8.1	4.5	6.9	3.8	3.8	--	--	--	--

TABLE 18

DISK PACK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989 Shipments		Forecast							
			1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	1.1	1.5	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1.1	1.5	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	2.4	3.6	1.2	1.7	.5	.7	--	--	--	--
TOTAL U.S. NON-CAPTIVE	2.4	3.6	1.2	1.7	.5	.7	--	--	--	--
TOTAL U.S. SHIPMENTS	3.5	5.1	1.2	1.7	.5	.7	--	--	--	--
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	5.2	--	1.3	--	--	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	--	5.2	--	1.3	--	--	--	--	--	--
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3.5	10.3	1.2	3.0	.5	.7	--	--	--	--
Total Capacity (Terabytes)	.6	2.2	.1	.5	--	--	--	--	--	--
Cumulative Shipments (Units in thousands)										
IBM	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6
Non-IBM	533.0	970.9	534.2	973.9	534.7	974.6	534.7	974.6	534.7	974.6
WORLDWIDE TOTAL	574.3	1,043.5	575.5	1,046.5	576.0	1,047.2	576.0	1,047.2	576.0	1,047.2

TABLE 19

DISK PACK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues		Forecast				
			1990		1991	1992	1993
	14"	9"	14"	9"	9"	All Dia.	All Dia.
U.S. MANUFACTURERS							
Other U.S. Captive	20.1	--	--	--	--	--	--
OEM/Integrator	10.5	8.8	2.6	5.3	2.7	--	--
TOTAL U.S. REVENUES	30.6	8.8	2.6	5.3	2.7	--	--
NON-U.S. MANUFACTURERS							
OEM/Integrator	52.0	--	13.0	--	--	--	--
TOTAL NON-U.S. REVENUES	52.0	--	13.0	--	--	--	--
WORLDWIDE RECAP							
Captive	20.1	--	--	--	--	--	--
	-69.2%	--	--	--	--	--	--
OEM/Integrator	62.5	8.8	15.6	5.3	2.7	--	--
	-42.4%	-58.1%	-75.0%	-39.8%	-49.1%	--	--
Total Revenues	82.6	8.8	15.6	5.3	2.7	--	--
	-52.4%	-58.1%	-81.1%	-39.8%	-49.1%	--	--
ANNUAL SHARE, BY DIAMETER	90.5%	9.5%	74.7%	25.3%	100.0%	--	--

TABLE 20

DISK PACK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments 14"	1989 Shipments 9"	Forecast 1990 14"	Forecast 1990 9"	Forecast 1991 9"	Forecast 1992 All Dia.	Forecast 1993 All Dia.
U.S. MANUFACTURERS							
Other U.S. Captive	1.5	--	--	--	--	--	--
OEM/Integrator	1.3	2.3	.3	1.4	.7	--	--
TOTAL U.S. SHIPMENTS	2.8	2.3	.3	1.4	.7	--	--
NON-U.S. MANUFACTURERS							
OEM/Integrator	5.2	--	1.3	--	--	--	--
TOTAL NON-U.S. SHIPMENTS	5.2	--	1.3	--	--	--	--
WORLDWIDE RECAP							
Captive	1.5	--	--	--	--	--	--
	-67.4%	--	--	--	--	--	--
OEM/Integrator	6.5	2.3	1.6	1.4	.7	--	--
	-54.5%	-61.0%	-75.4%	-39.1%	-50.0%	--	--
Total Shipments	8.0	2.3	1.6	1.4	.7	--	--
	-57.7%	-61.0%	-80.0%	-39.1%	-50.0%	--	--
ANNUAL SHARE, BY DIAMETER	77.8%	22.2%	53.4%	46.6%	100.0%	--	--
TOTAL CAPACITY (Terabytes)	.7	.2	.1	.1	.1	--	--

TABLE 21

DISK PACK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %
MAINFRAME/SUPERMINI General purpose	4.9	47.4
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	3.7	35.7
PERSONAL COMPUTERS Business and professional, single user	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	1.4	14.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	.3	2.9
CONSUMER AND HOBBY COMPUTERS	--	--
OTHER APPLICATIONS	--	--
Total	10.3	100.0

No units in this product category are forecasted to be shipped in 1993

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

1990 DISK/TREND REPORT

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	M2235AS
DZU	ES 5300, CM 5508
Hitachi	DK505-2*
Microlab	DFW 5025*
Miltope	RDS-1500
NEC	D5126H*
Seagate Technology	ST225*, ST225N*

3.5" disk diameter

Alps Electric	DRP020A**, DRP020Q*
Conner Peripherals	CP3020**, CP3024**
Elebra	W320
Flexdisk	FX 325
Fuji Electric	FK309X-26*, FK311A-26**
Fujitsu	M2225D2*
Goldstar Telecommunication	GSH-3026*
Hewlett-Packard	97501B
Hitachi	DK302-2*
IBM	WD-325*
JVC	JD-3824T**
Kalok	KL320*
Kyocera	KC20B*
NEC	D3821*
Plus Development	Hardcard 20**, Passport*
Seagate Technology	ST125*, ST3025N**
Western Digital	WD93024-A*

2.5" disk diameter

Conner Peripherals	CP-2020**, CP-2024**
JVC	JD-E2825P**
PrairieTek	120**, 220**

*Indicates drives with maximum 41.3 mm height, or less.
**Indicates drives with maximum 25.4 mm height, or less.

All drives in this group use variations of the technology loosely described as "Winchester." Some use 3340/3350-type ferrite heads, but most of the newer drives use "mini-slider" heads in 3370/3380-type sliders. The majority of 5.25" drives in the group use conventional oxide disks, but most of the 3.5" drives, and all of the 2.5" drives, use thin film disks.

The majority of the drives in the group use head positioning systems driven by stepping motors, with relatively slow average access times, but low costs. Many newer drives use voice coil or torque motor actuators, rotary or linear, to produce access times suitable for high end single user personal computers or multiple workstation systems.

Utilizing the higher areal densities now possible with advanced heads and disks, Conner's one inch high 20 megabyte drive using a single 3.5" disk appeared in 1988, signaling a major trend, and Conner introduced a 3/4" high model in 1989. The PrairieTek original 2.5" drive introduced in 1988 has also been the pathfinder for many drives to follow. JVC and Conner are also shipping 2.5" drives with 20 megabyte capacities. Other manufacturers are also expected to enter the 2.5" market, but many will concentrate on markets for drives with capacities above the range covered by this product group.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	1,180.7	729.7	359.1	154.6	56.6
All manufacturers	1,502.9	963.7	479.2	208.9	76.4

Shipments for this product group peaked in 1988, and started into a period of rapid decline in 1989. Worldwide unit shipments dropped 21% in 1989 and are expected to decline another 30.1% in 1990, to only 4.3 million drives -- a sharp comparison to the 1988 total of 7.9 million drives. Worldwide revenues are projected to decline from 1988's $2.2 billion to only $963.7 million in 1990.

The movement to higher capacities continues to come faster than anticipated, as the personal computer market transitions to more powerful processors and adopts more versatile software. The largest negative impact on revenues is the effect of reduced captive drive shipments, as IBM transitions to higher capacity 3.5" drives, plus new 2.5" models, at Fujisawa.

The share of this product group held by 3.5" drives grew slightly in 1989, to 69.4% of worldwide unit shipments. However, total 3.5" shipments were declining in 1989 and the percentage increase for 3.5" drives was attributable to the more rapid decrease in shipments of 5.25" drives. The 1990 share for 3.5" drives is expected to reach only 59.2% in 1990, as 2.5" drives reach high shipment levels.

PrairieTek started volume shipments of 2.5" drives in 1989 and was joined at year end by Conner Peripherals and JVC. Although only 24,000 2.5" drives were shipped in 1989, a surge of "notebook" computer introductions in 1990 has created a surge in shipments of 20 megabyte 2.5" drives, and 1990 worldwide unit shipments are estimated at 730,000 drives.

For years, the PC/AT standard continued to prosper without IBM, providing a strong residual market for low-end 5.25" disk drives through both clone manufacturers and the dealer aftermarket. And the many technical and legal delays faced by clone manufacturers in entering the PS/2

compatible market slowed the growth of low-end 3.5" drive shipments, helping to keep alive the market for half high 5.25" drives in this product group. About 80% of worldwide unit shipments of 5.25" drives are aftermarket products sold in the PCM/Reseller channel.

The laptop computer market has grown rapidly in the last two years, and many users have been ready to buy systems equipped with hard disk drives. But Conner Peripheral's early production capability for 1" high 3.5" models in both 20 and 40 megabyte capacities was the critical factor, and Conner captured most of the laptop market with both U.S. and Japanese system manufacturers. As noted above, the notebook computer manufacturers are turning mostly to 2.5" drives for newly developed systems.

Usage of hard disk drives with personal computers has now become standard practice in most offices, and the PC market continues to be the dominant application area for drives in this product group, accounting for 94.3% of 1989 unit shipments.

Seagate continued as the dominant leader in non-captive shipments for this product group, on the strength of its leadership in industry shipments of low-end 5.25" drives, even in the face of declining shipment levels. Seagate shipped 2,624,000 drives in 1989, of which 1,672,000 were 5.25" models, for 45.8% of the worldwide total for the product group. Miniscribe, now absorbed by Maxtor, shipped 15.2% of the total, followed by Conner Peripherals with 12.9%.

Marketing trends

The movement to drive capacities above the level included in this product group is accelerating, and it is now expected that worldwide unit

shipments will decline at an average annual rate of 51.7% during the 1991-93 period. The 1993 unit shipment total is projected at only 474,000 drives, a level approaching extinction, and representing only $76.4 million in revenue.

Small diameter drives started at 5 megabytes (formatted), then quickly upgraded to 10 megabytes, and during the last two years fixed disk drives shipped in this group have become mostly 20 megabyte models. It is clear that the typical office personal computer now uses disk drives with capacities above this product range.

Even as the total for the group declines, the product mix will continue to change:

Worldwide total Unit shipments (000)	1989	1990	1991	1992	1993
5.25" full size	51.7	53.7	10.2	--	--
	.8%	1.2%	.4%	--	--
5.25" half high	1,848.1	1,004.5	358.8	104.0	21.0
	29.6%	23.0%	14.1%	8.7%	4.4%
3.5"	4,356.1	2,599.8	1,176.0	484.0	198.0
	69.4%	59.2%	46.3%	40.8%	41.9%
2.5"	24.0	730.0	1,003.0	601.0	255.0
	.2%	16.6%	39.2%	50.5%	53.7%
	6,279.9	4,388.0	2,548.0	1,189.0	474.0

3.5" drives have held the shipment leadership in this product group only since 1988, but the current DISK/TREND projection assumes that 2.5" drives will account for slightly more than half of the group total in 1992.

Ironically, 2.5" drives in this group will be losing ground during the same period to higher capacity models in other DISK/TREND product

groups. The shipment decline for drives with less than 30 megabytes affects all disk diameters, and is driven not by form factor but by software requirements, processor capabilities and user preferences.

IBM's captive shipments of 3.5" drives with capacities below 30 megabytes have also continued to decline, as the firm emphasizes personal computers with higher level capabilities. IBM did not introduce a 2.5" drive in this capacity range for use with notebook computers, and instead confined its initial 2.5" drive product line to higher capacities.

Technical trends

The challenges of large production volume and low cost requirements are the key engineering targets for disk drives in this group. The problem is to achieve high production volumes despite use of continually higher recording densities.

Although several initially available 3.5" drives used disks with 40 millimeter inner diameters, 25 millimeter became the industry standard, to increase the recording area per disk. The result is linear densities in the 13,000 bits per inch range for 3.5" 20 megabyte drives using two disks, and up to 21,500 BPI for single disk models. 20 megabyte 2.5" drives (disks with 65 millimeter OD, 20 millimeter ID) were offered initially with two disks, but current 2.5" models in this product group all use a single disk with linear densities in the 34,000 to 40,000 range.

Two interrelated developments are increasing the cost-effectiveness of 3.5" and 2.5" drives in this group. It is cheaper to package the controller function within the disk drive, and usage of embedded controllers provides the disk drive designer with greater flexibility, since the physical characteristics of drives are masked from systems. As a result,

embedded controllers are gaining a continually higher percentage of drive shipments.

Most 3.5" floppy drives are already produced in one inch high configurations, and production of one inch high 3.5" rigid disk drives using only one disk has also reached high volume. A further reduction in box height was pioneered by Conner Peripherals with a 3/4" drive introduced in late 1989, following the lead of several Japanese floppy drive manufacturers, which are already in production with 3/4" high models. However, in view of the rapid movement to higher disk drive capacities, most of the development effort by drive manufacturers to reduce package size of 3.5" drives will probably be devoted to capacity ranges above this one.

Forecasting assumptions

1. 5.25" and 3.5" drives in this product group will continue to decline, as the market transitions to higher capacity ranges for desktop and laptop computer applications.

2. 2.5" drives in this product group will continue rapid growth in notebook computer applications until drives in the 30-60 megabyte range become available in quantity production in the first half of 1991. 2.5" drives in this group will subsequently decline.

TABLE 22

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	145.2	220.0	32.0	50.0	--	--	--	--	--	--
Other U.S. Captive	13.3	22.0	6.6	11.0	4.0	6.0	2.0	2.0	--	--
TOTAL U.S. CAPTIVE	158.5	242.0	38.6	61.0	4.0	6.0	2.0	2.0	--	--
PCM/Reseller	283.8	472.2	142.2	268.1	69.3	126.6	26.0	47.8	9.2	19.0
OEM/Integrator	170.2	466.5	117.6	400.6	47.7	226.5	18.7	104.8	6.1	37.6
TOTAL U.S. NON-CAPTIVE	454.0	938.7	259.8	668.7	117.0	353.1	44.7	152.6	15.3	56.6
TOTAL U.S. REVENUES	612.5	1,180.7	298.4	729.7	121.0	359.1	46.7	154.6	15.3	56.6
Non-U.S. Manufacturers										
Captive	9.8	131.7	--	61.0	--	25.4	--	10.2	--	4.8
PCM/Reseller	--	10.0	--	15.8	--	16.7	--	14.1	--	6.9
OEM/Integrator	29.8	180.5	21.8	157.2	14.9	78.0	7.2	30.0	1.7	8.1
TOTAL NON-U.S. REVENUES	39.6	322.2	21.8	234.0	14.9	120.1	7.2	54.3	1.7	19.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	652.1	1,502.9	320.2	963.7	135.9	479.2	53.9	208.9	17.0	76.4
OEM Average Price ($000)	.200	.215	.197	.228	.182	.186	.167	.169	.156	.152

TABLE 23

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989		Forecast							
	Shipments		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	264.0	400.0	64.0	100.0	--	--	--	--	--	--
Other U.S. Captive	10.2	16.9	6.0	10.0	4.0	6.0	2.0	2.0	--	--
TOTAL U.S. CAPTIVE	274.2	416.9	70.0	110.0	4.0	6.0	2.0	2.0	--	--
PCM/Reseller	1,593.3	2,670.8	894.3	1,684.4	444.0	803.0	171.0	311.0	63.0	130.0
OEM/Integrator	873.2	2,350.9	613.0	1,909.4	269.2	1,282.0	115.0	640.0	40.0	250.0
TOTAL U.S. NON-CAPTIVE	2,466.5	5,021.7	1,507.3	3,593.8	713.2	2,085.0	286.0	951.0	103.0	380.0
TOTAL U.S. SHIPMENTS	2,740.7	5,438.6	1,577.3	3,703.8	717.2	2,091.0	288.0	953.0	103.0	380.0
Non-U.S. Manufacturers										
Captive	10.0	138.9	--	76.0	--	38.0	--	17.0	--	8.0
PCM/Reseller	--	46.1	--	68.0	--	66.0	--	59.0	--	36.0
OEM/Integrator	128.0	656.3	96.0	540.2	75.0	353.0	40.0	160.0	10.0	50.0
TOTAL NON-U.S. SHIPMENTS	138.0	841.3	96.0	684.2	75.0	457.0	40.0	236.0	10.0	94.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,878.7	6,279.9	1,673.3	4,388.0	792.2	2,548.0	328.0	1,189.0	113.0	474.0
Total Capacity (Terabytes)	71.9	156.4	41.8	109.0	19.8	63.7	8.2	29.7	2.8	11.8
Cumulative Shipments (Units in thousands)										
IBM	2,221.4	3,244.9	2,285.4	3,344.9	2,285.4	3,344.9	2,285.4	3,344.9	2,285.4	3,344.9
Non-IBM	16,274.0	30,696.5	17,883.3	34,984.5	18,675.5	37,532.5	19,003.5	38,721.5	19,116.5	39,195.5
WORLDWIDE TOTAL	18,495.4	33,941.4	20,168.7	38,329.4	20,960.9	40,877.4	21,288.9	42,066.4	21,401.9	42,540.4

TABLE 24

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues			Forecast 1990			1991			1992			1993		
	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															
IBM Captive	--	220.0	--	--	50.0	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	22.0	--	--	11.0	--	--	6.0	--	--	2.0	--	--	--	--
PCM/Reseller	240.3	230.2	1.7	129.3	135.3	3.5	43.5	77.7	5.4	10.2	35.9	1.7	2.1	16.9	--
OEM/Integrator	45.2	414.8	6.5	20.7	216.4	163.5	6.6	68.7	151.2	1.5	19.1	84.2	--	3.8	33.8
TOTAL U.S. REVENUES	285.5	887.0	8.2	150.0	412.7	167.0	50.1	152.4	156.6	11.7	57.0	85.9	2.1	20.7	33.8
NON-U.S. MANUFACTURERS															
Captive	34.4	97.3	--	12.0	49.0	--	2.0	23.4	--	--	10.2	--	--	4.8	--
PCM/Reseller	--	10.0	--	3.0	12.8	--	6.0	10.7	--	5.6	8.5	--	1.8	5.1	--
OEM/Integrator	64.3	116.2	--	52.4	78.8	26.0	15.2	35.9	26.9	3.0	12.5	14.5	--	3.4	4.7
TOTAL NON-U.S. REVENUES	98.7	223.5	--	67.4	140.6	26.0	23.2	70.0	26.9	8.6	31.2	14.5	1.8	13.3	4.7
WORLDWIDE RECAP															
Captive	34.4	339.3	--	12.0	110.0	--	2.0	29.4	--	--	12.2	--	--	4.8	--
	-50.1%	-58.2%	--	-65.1%	-67.6%	--	-83.3%	-73.3%	--	-100.0%	-58.5%	--	--	-60.7%	--
PCM/Reseller	240.3	240.2	1.7	132.3	148.1	3.5	49.5	88.4	5.4	15.8	44.4	1.7	3.9	22.0	--
	-33.7%	+32.6%	--	-44.9%	-38.3%	+105.9%	-62.6%	-40.3%	+54.3%	-68.1%	-49.8%	-68.5%	-75.3%	-50.5%	-100.0%
OEM/Integrator	109.5	531.0	6.5	73.1	295.2	189.5	21.8	104.6	178.1	4.5	31.6	98.7	--	7.2	38.5
	-47.1%	-17.2%	--	-33.2%	-44.4%	--	-70.2%	-64.6%	-6.0%	-79.4%	-69.8%	-44.6%	-100.0%	-77.2%	-61.0%
Total Revenues	384.2	1,110.5	8.2	217.4	553.3	193.0	73.3	222.4	183.5	20.3	88.2	100.4	3.9	34.0	38.5
	-39.9%	-32.1%	--	-43.4%	-50.2%	--	-66.3%	-59.8%	-4.9%	-72.3%	-60.3%	-45.3%	-80.8%	-61.5%	-61.7%
ANNUAL SHARE, BY DIAMETER	25.7%	73.9%	.4%	22.7%	57.4%	19.9%	15.3%	46.5%	38.2%	9.7%	42.3%	48.0%	5.1%	44.6%	50.3%

TABLE 25

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments			Forecast											
				1990			1991			1992			1993		
	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															
IBM Captive	--	400.0	--	--	100.0	--	--	--	--	--	--	--	--	--	--
Other U.S. Captive	--	16.9	--	--	10.0	--	--	6.0	--	--	2.0	--	--	--	--
PCM/Reseller	1,450.9	1,214.9	5.0	833.8	840.6	10.0	290.0	495.0	18.0	70.0	235.0	6.0	15.0	115.0	--
OEM/Integrator	262.6	2,069.3	19.0	121.9	1,167.5	620.0	32.0	410.0	840.0	10.0	120.0	510.0	--	25.0	225.0
TOTAL U.S. SHIPMENTS	1,713.5	3,701.1	24.0	955.7	2,118.1	630.0	322.0	911.0	858.0	80.0	357.0	516.0	15.0	140.0	225.0
NON-U.S. MANUFACTURERS															
Captive	24.4	114.5	--	9.0	67.0	--	2.0	36.0	--	--	17.0	--	--	8.0	--
PCM/Reseller	--	46.1	--	5.0	63.0	--	12.0	54.0	--	14.0	45.0	--	6.0	30.0	--
OEM/Integrator	161.9	494.4	--	88.5	351.7	100.0	33.0	175.0	145.0	10.0	65.0	85.0	--	20.0	30.0
TOTAL NON-U.S. SHIPMENTS	186.3	655.0	--	102.5	481.7	100.0	47.0	265.0	145.0	24.0	127.0	85.0	6.0	58.0	30.0
WORLDWIDE RECAP															
Captive	24.4	531.4	--	9.0	177.0	--	2.0	42.0	--	--	19.0	--	--	8.0	--
	-53.3%	-57.9%	--	-63.1%	-66.7%	--	-77.8%	-76.3%	--	-100.0%	-54.8%	--	--	-57.9%	--
PCM/Reseller	1,450.9	1,261.0	5.0	838.8	903.6	10.0	302.0	549.0	18.0	84.0	280.0	6.0	21.0	145.0	--
	-21.6%	+64.9%	--	-42.2%	-28.3%	+100.0%	-64.0%	-39.2%	+80.0%	-72.2%	-49.0%	-66.7%	-75.0%	-48.2%	-100.0%
OEM/Integrator	424.5	2,563.7	19.0	210.4	1,519.2	720.0	65.0	585.0	985.0	20.0	185.0	595.0	--	45.0	255.0
	-56.6%	-15.6%	--	-50.4%	-40.7%	--	-69.1%	-61.5%	+36.8%	-69.2%	-68.4%	-39.6%	-100.0%	-75.7%	-57.1%
Total Shipments	1,899.8	4,356.1	24.0	1,058.2	2,599.8	730.0	369.0	1,176.0	1,003.0	104.0	484.0	601.0	21.0	198.0	255.0
	-34.1%	-14.0%	--	-44.3%	-40.3%	--	-65.1%	-54.8%	+37.4%	-71.8%	-58.8%	-40.1%	-79.8%	-59.1%	-57.6%
ANNUAL SHARE, BY DIAMETER	30.4%	69.4%	.2%	24.2%	59.2%	16.6%	14.5%	46.3%	39.2%	8.7%	40.8%	50.5%	4.4%	41.9%	53.7%
TOTAL CAPACITY (Terabytes)	42.8	92.5	.6	23.9	53.0	15.8	8.0	22.8	21.4	2.0	8.9	12.9	.4	3.5	5.6

TABLE 26

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	16.3	.4	--	--
PERSONAL COMPUTERS Business and professional, single user	5,924.5	94.3	417.1	88.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	128.7	2.0	19.0	4.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	81.6	1.3	12.8	2.7
CONSUMER AND HOBBY COMPUTERS	127.5	2.0	23.7	5.0
OTHER APPLICATIONS	--	--	1.4	.3
Total	6,279.9	99.9	474.0	100.0

TABLE 27

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 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	
Seagate Technology	966.0	560.0	--	1526.0	58.8	1672.0	952.0	--	2624.0	45.8
Miniscribe	--	430.0	--	430.0	16.6	--	870.0	--	870.0	15.2
Conner Peripherals	--	147.0	4.0	151.0	5.8	--	735.0	4.0	739.0	12.9
Western Digital	--	219.1	--	219.1	8.4	--	524.2	--	524.2	9.2
Kalok	--	79.5	--	79.5	3.1	--	159.0	--	159.0	2.8
NEC	--	--	--	--	--	86.0	61.0	--	147.0	2.6
Fuji Electric	--	--	--	--	--	--	115.0	--	115.0	2.0
Other U.S.	20.9	34.5	5.5	60.9	2.3	41.5	44.0	20.0	105.5	1.8
Other Non-U.S.	--	128.0	--	128.0	5.0	75.9	364.5	--	440.4	7.7
TOTAL	986.9	1598.1	9.5	2594.5	100.0	1875.4	3824.7	24.0	5724.1	100.0

FIXED DISK DRIVES, 30-60 MEGABYTES

1990 DISK/TREND REPORT

FIXED DISK DRIVES, 30-60 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Digirede	W525/50
DZU	SM 5509
Elebra	530
Fujitsu	M2241, M2242
Hitachi	DK511-5, DK521-5*
IBM	4956
Microlab	DFW 5053
Microscience International	HH-1050*
Miltope	RDS-5000
Mitsubishi Electric	MR535*
NEC	D5146H*
Sagem	MSA 252-50
Seagate Technology	ST4053, ST251*

3.5" disk diameter

Alps Electric	DRQ040A**
Conner Peripherals	CP3040**
Espert	PT338*
Fuji Electric	FK303-52*, FK312A-50R**
Fujitsu	M2226D2*, M2611S**
GoldStar Telecommunication	GSH-3040*
Hitachi	DK302-3*
IBM	8550-031, WDL-330P**
JVC	JD-3848H*, JD-E3848V**
Kalok	KL330*
Kyocera	KC 30B*
Maxtor	8051A/S*, 7040A/S**
Microscience International	8040**
Mitsubishi Electric	MR335*
Mitsumi Electric	HD354*
NEC	D3142*, D3735**
Plus Development	Hardcard II 40**, Passport*
Quantum	40S/AT ProDrive*
Samsung Electronics	SHD2040Z*
Seagate Technology	ST138*, ST157A*, ST351A/X**
Sony	SRD2040Z*
Teac	SD-340**
Tokico	TD3041C*
Toshiba	MK-133FA*, MK-232FB*
Western Digital	WD93044A*, WDAC140**
Y-E Data	YD-3042*, YD-3161B**
Zentek	H3040*

2.5" disk diameter

Areal Technology	MD-2050**
IBM	WDA-230**
PrairieTek	240**
Quantum	40S/AT Go.Drive**
Western Digital	WDAB130**

*Indicates drives with maximum 41.3 mm height, or less.
**Indicates drives with maximum 25.4 mm height, or less.

Drives in this capacity range are all nominally "Winchester" drives, but variations to that technology are used, including thin film disks and ferrite heads with newer "minisliders" or "microsliders." Most use rotary or linear voice coil head positioning systems, but a few use other techniques, such as stepping or torque motors.

In the last three years, numerous 3.5" drives have been introduced in this product group. Intense competition is developing at the 40 megabyte (formatted) level, which has led to a variety of attempts to reduce product costs, affecting product design.

Conner Peripheral's two platter 40 megabyte drive became the leader in this product group after its introduction in 1987, and provided the model for many later drive introductions by other firms. In 1988, Conner's single platter 1" high 40 megabyte drive took higher densities a step further, quickly became the leader for laptop portables, and served as a model for numerous competitive drives.

The first 2.5" drive at the 40 megabyte level was PrairieTek's two platter 1" high model. However, most 2.5" drives with 30 and 40 megabyte capacity now being announced in this product group use only one disk, with drive height limited to the 15-17 millimeter range. Areal Technology, a startup firm, has announced a 2.5" drive with 50 megabyte capacity, but production deliveries have not yet started. Despite the manufacturing

difficulties caused by such high areal densities, the potential cost advantages from reduced parts count and mechanical simplification will continue to stimulate further innovation.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	2,305.7	2,676.3	2,878.1	2,820.1	2,563.1
All manufacturers	3,309.2	3,731.8	4,248.8	4,493.8	4,624.7

As expected, the 30-60 megabyte product group became the industry's largest in 1989, but the amount of the increase was even larger than projected -- as shipments of 20 megabyte drives dropped off faster than projected. Worldwide shipments of 30-60 megabyte drives were 10.2 million units in 1989, up 74.8% in one year, and total revenues for the year were $3.3 million, up 51.9%.

1990 will see an estimated increase of only 22.5% in total unit shipments for the product group, and it is necessary to examine the changes in product mix for the whole story. An increase of 51.8% in 3.5" drive unit shipments is expected for this year, boosting the 3.5" total to more than 10 million drives. However, shipments of 5.25" drives are projected to be down almost 1.2 million drives, a reduction of 32.8% from the previous year.

The combination of the 3.5" form factor with capacities in the 30-40 megabyte range has proven to be a major winner. Most of this growth was driven by personal computer users' demand for more disk capacity to cope with new software programs and ever-increasing file storage requirements.

Availability of the two disk 3.5" drives with 41.3 millimeter (1.625 inch) height (30 megabytes from IBM; 40 megabytes from almost everyone else) starting in 1987 was a perfect match for the growing demand.

The subsequent introduction of single disk 3.5" drives with 25.4 millimeter (1 inch) height was again very timely. It caught the wave of hard disk upgrades to the early laptop systems, and has become another winner. U.S. drive manufacturers were the first to establish volume production capability for 1" high 3.5" drives, and their success in this segment accounts for their higher share of worldwide unit shipments in 1990, estimated at 72.3%.

IBM is expected to phase out production of 5.25" disk drives in this product group in 1990, but the firm's shipments of 30 and 40 megabyte (formatted) drives are expected to double in 1990, to 1.2 million units. 1989 production at IBM's Fujisawa factory was below the level which might have been expected due to the changeover to higher performance 1" high models using single platters.

In 1989, Seagate's share of the product group's non-captive unit shipments was 37.7%, down from the firm's 1988 share of 49.7%. Seagate increased its share of 5.25" drive shipments, with 2.5 million units, but the firm's doubling of 3.5" drive shipments was not enough to keep up with the faster growth by other manufacturers. Conner Peripheral's 1.2 million 3.5" drives earned second place with 13.2%, and Miniscribe's estimated 980,000 3.5" and 5.25" drives held third place with 10.7%.

Single user personal computer applications provided 92.1% of the worldwide market for drives in this group in 1989, and are expected to hold 90% of the 1993 market, with minor shares expected for non-office dedicated applications and consumer and hobby computers.

Marketing trends

DISK/TREND projections foresee continued growth for this product group for several years, but another surge in shipments is unlikely. The forecasted annual average increase in worldwide unit shipments in the 1991-93 period is 13.8%, with the 1993 shipment total estimated at 18.4 million drives. Total revenues are expected to grow at an average of only 7.5% per year in the same period.

The impact on revenue will be caused by changes in product mix, as smaller drives become predominant, by stronger growth for OEM drives sold at lower prices than captive drives, and as average prices suffer from the forces of intense competition. Underlying all of these changes is the continuous upward movement in the average capacity of disk drives used with personal computers, a trend which eventually will also impact this product group as average capacities continue to move up.

This product group is clearly dominated by 3.5" drives at the end of 1990, with more than 10 million 3.5" drives expected to be shipped this year, 5.25" drives dropping fast, and 2.5" drives just starting into production. However, solid growth is expected for 2.5" drives:

Worldwide total Unit shipments (000)	1989	1990	1991	1992	1993
5.25" full size	180.3	53.1	112.2	110.1	70.0
	1.8%	.3%	.8%	.7%	.4%
5.25" half high	3,424.1	2,367.9	1,438.8	737.9	250.0
	33.6%	19.1%	9.7%	4.3%	1.3%
3.5"	6,604.4	10,028.4	12,250.0	13,100.0	13,230.0
	64.6%	80.3%	82.8%	77.6%	71.9%
2.5"	.5	55.0	1,010.0	2,960.0	4,880.0
	--	.3%	6.7%	17.4%	26.4%
	10,209.3	12,504.4	14,811.0	16,908.0	18,430.0

Although most of the initial growth for 2.5" drives is in 20 megabyte models, it is expected that the momentum will shift by mid-1991 to the capacity ranges in this product group. Many drive manufacturers are expected to establish production capability by the end of the first quarter of 1991, and the appetite for higher capacities already demonstrated in the markets for desktop and laptop computers will be felt in the notebook computer market.

Also contributing to the product mix changes in this group is the continuing weakness in shipments of half high 5.25" drives. Since 1987, half high 5.25" drives from Seagate and a few other manufacturers filled most of the OEM and aftermarket demand created by the continuing momentum for shipments of PC AT clones. However, shipments of half high 5.25" drives have dipped below those of 3.5" drives in the PCM/Reseller channel, and there is a growing tendency for system manufacturers to bundle a 3.5" hard disk drive with most PC models. The movement to small footprint personal computers favors future growth for the 3.5" and smaller drives in this capacity range.

Technical trends

The technical developments that are pushing drives below 30 megabytes in capacity toward single disk configurations are having a similar impact on this product group, resulting in pressure to cut costs by reducing the parts count. Many 3.5" drives in the 40 megabyte range using single disks are now in volume production, and many more participants are to be expected during the next few years.

In addition to lower costs, higher areal density will also have the effect of speeding the transition to intelligent embedded controllers.

Higher recording densities mean higher transfer rates, and frequently will be used with multiple recording bands, each with different densities. In order to mask individual drive peculiarities, most new drives offer embedded controllers, with the choice of either SCSI or PC/AT interfaces.

Higher areal density has also made smaller box sizes practical. The first 2.5" drives in the product group have been announced, with the earlier announcement of the Areal Technology 50 megabyte drive (not yet in quantity production), now joined by 2.5" drive announcements by IBM, Quantum, Western Digital and PrairieTek, with several others expected.

Forecasting assumptions

1. IBM's production of 5.25" drives will stop in 1990, but growth for 3.5" drives will continue through 1991 before peaking. IBM will continue to rely primarily on internal manufacturing for drives in this group, but will supplement internal shortfalls with outside purchases.

2. The decline of OEM 5.25" drives will continue, replaced by the movement to 3.5" drives.

3. The volume shipments of 2.5" drives starting in 1990 will be followed by rapid growth, driven by broad acceptance of notebook computers.

TABLE 28

FIXED DISK DRIVES, 30 - 60 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989 Revenues		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	327.0	480.0	495.0	741.7	499.5	764.7	367.5	570.0	274.5	432.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	327.0	480.0	495.0	741.7	499.5	764.7	367.5	570.0	274.5	432.0
PCM/Reseller	635.9	896.0	630.9	929.1	563.4	849.1	500.1	762.6	431.5	665.3
OEM/Integrator	587.0	929.7	485.0	1,005.5	501.1	1,264.3	493.8	1,487.5	453.3	1,465.8
TOTAL U.S. NON-CAPTIVE	1,222.9	1,825.7	1,115.9	1,934.6	1,064.5	2,113.4	993.9	2,250.1	884.8	2,131.1
TOTAL U.S. REVENUES	1,549.9	2,305.7	1,610.9	2,676.3	1,564.0	2,878.1	1,361.4	2,820.1	1,159.3	2,563.1
Non-U.S. Manufacturers										
Captive	48.0	303.4	28.0	310.0	104.8	448.2	227.8	691.1	396.5	1,041.0
PCM/Reseller	47.1	79.2	46.4	79.1	40.0	71.6	39.9	75.7	43.7	90.2
OEM/Integrator	227.2	620.9	262.8	666.4	303.7	850.9	290.4	906.9	262.9	930.4
TOTAL NON-U.S. REVENUES	322.3	1,003.5	337.2	1,055.5	448.5	1,370.7	558.1	1,673.7	703.1	2,061.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,872.2	3,309.2	1,948.1	3,731.8	2,012.5	4,248.8	1,919.5	4,493.8	1,862.4	4,624.7
OEM Average Price ($000)	.283	.286	.246	.252	.235	.245	.218	.227	.200	.208

TABLE 29

FIXED DISK DRIVES, 30 - 60 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989		Forecast							
	---Shipments---		------1990-----		------1991-----		------1992-----		------1993-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	450.0	660.0	819.0	1,227.0	908.0	1,390.0	735.0	1,140.0	610.0	960.0
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	450.0	660.0	819.0	1,227.0	908.0	1,390.0	735.0	1,140.0	610.0	960.0
PCM/Reseller	2,503.5	3,536.0	2,670.0	3,925.0	2,517.0	3,795.0	2,390.0	3,645.0	2,250.0	3,470.0
OEM/Integrator	2,126.1	3,431.8	2,025.0	4,292.2	2,217.0	5,555.0	2,316.0	6,855.0	2,318.0	7,285.0
TOTAL U.S. NON-CAPTIVE	4,629.6	6,967.8	4,695.0	8,217.2	4,734.0	9,350.0	4,706.0	10,500.0	4,568.0	10,755.0
TOTAL U.S. SHIPMENTS	5,079.6	7,627.8	5,514.0	9,444.2	5,642.0	10,740.0	5,441.0	11,640.0	5,178.0	11,715.0
Non-U.S. Manufacturers										
Captive	60.0	362.2	40.0	431.1	170.0	706.0	410.0	1,228.0	790.0	2,065.0
PCM/Reseller	134.6	232.5	165.5	276.0	162.0	290.0	180.0	340.0	213.0	435.0
OEM/Integrator	747.9	1,986.8	1,009.0	2,353.1	1,208.0	3,075.0	1,285.0	3,700.0	1,260.0	4,215.0
TOTAL NON-U.S. SHIPMENTS	942.5	2,581.5	1,214.5	3,060.2	1,540.0	4,071.0	1,875.0	5,268.0	2,263.0	6,715.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6,022.1	10,209.3	6,728.5	12,504.4	7,182.0	14,811.0	7,316.0	16,908.0	7,441.0	18,430.0
Total Capacity (Terabytes)	295.8	502.7	325.9	609.5	347.4	722.7	360.3	837.0	370.3	918.9
Cumulative Shipments (Units in thousands)										
IBM	1,254.1	1,828.0	2,073.1	3,055.0	2,981.1	4,445.0	3,716.1	5,585.0	4,326.1	6,545.0
Non-IBM	12,565.9	20,661.5	18,475.4	31,938.9	24,749.4	45,359.9	31,330.4	61,127.9	38,161.4	78,597.9
WORLDWIDE TOTAL	13,820.0	22,489.5	20,548.5	34,993.9	27,730.5	49,804.9	35,046.5	66,712.9	42,487.5	85,142.9

TABLE 30

FIXED DISK DRIVES, 30 - 60 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues			Forecast											
	1990			1991			1992			1993					
	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															
IBM Captive	60.0	420.0	--	15.0	720.0	6.7	--	715.1	49.6	--	500.0	70.0	--	315.0	117.0
PCM/Reseller	600.9	295.1	--	455.8	471.0	2.3	284.1	560.4	4.6	145.1	608.5	9.0	48.4	604.3	12.6
OEM/Integrator	239.8	689.7	.2	64.0	928.2	13.3	37.1	1,052.1	175.1	19.8	1,008.3	459.4	6.0	870.2	589.6
TOTAL U.S. REVENUES	900.7	1,404.8	.2	534.8	2,119.2	22.3	321.2	2,327.6	229.3	164.9	2,116.8	538.4	54.4	1,789.5	719.2
NON-U.S. MANUFACTURERS															
Captive	27.2	276.2	--	21.1	288.9	--	10.4	371.8	66.0	4.5	417.0	269.6	--	436.0	605.0
PCM/Reseller	33.0	46.2	--	37.1	42.0	--	11.2	57.6	2.8	4.1	65.3	6.3	1.3	75.1	13.8
OEM/Integrator	56.1	564.8	--	66.8	599.6	--	106.5	723.6	20.8	88.0	745.7	73.2	49.0	746.3	135.1
TOTAL NON-U.S. REVENUES	116.3	887.2	--	125.0	930.5	--	128.1	1,153.0	89.6	96.6	1,228.0	349.1	50.3	1,257.4	753.9
WORLDWIDE RECAP															
Captive	87.2	696.2	--	36.1	1,008.9	6.7	10.4	1,086.9	115.6	4.5	917.0	339.6	--	751.0	722.0
	-60.2%	+55.6%	--	-58.6%	+44.9%	--	-71.2%	+7.7%	--	-56.7%	-15.6%	+193.8%	-100.0%	-18.1%	+112.6%
PCM/Reseller	633.9	341.3	--	492.9	513.0	2.3	295.3	618.0	7.4	149.2	673.8	15.3	49.7	679.4	26.4
	+33.6%	+176.4%	--	-22.2%	+50.3%	--	-40.1%	+20.5%	+221.7%	-49.5%	+9.0%	+106.8%	-66.7%	+.8%	+72.5%
OEM/Integrator	295.9	1,254.5	.2	130.8	1,527.8	13.3	143.6	1,775.7	195.9	107.8	1,754.0	532.6	55.0	1,616.5	724.7
	-27.5%	+147.8%	--	-55.8%	+21.8%	--	+9.8%	+16.2%	--	-24.9%	-1.2%	+171.9%	-49.0%	-7.8%	+36.1%
Total Revenues	1,017.0	2,292.0	.2	659.8	3,049.7	22.3	449.3	3,480.6	318.9	261.5	3,344.8	887.5	104.7	3,046.9	1,473.1
	-7.7%	+112.8%	--	-35.1%	+33.1%	--	-31.9%	+14.1%	--	-41.8%	-3.9%	+178.3%	-60.0%	-8.9%	+66.0%
ANNUAL SHARE, BY DIAMETER	30.8%	69.2%	--	17.7%	81.8%	.5%	10.6%	82.0%	7.4%	5.8%	74.5%	19.7%	2.3%	66.0%	31.7%

TABLE 31

FIXED DISK DRIVES, 30 - 60 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments			Forecast											
				1990			1991			1992			1993		
	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															
IBM Captive	60.0	600.0	--	15.0	1,200.0	12.0	--	1,300.0	90.0	--	1,000.0	140.0	--	700.0	260.0
PCM/Reseller	2,428.5	1,107.5	--	1,900.0	2,019.0	6.0	1,235.0	2,540.0	20.0	645.0	2,955.0	45.0	220.0	3,180.0	70.0
OEM/Integrator	874.2	2,557.1	.5	226.2	4,029.0	37.0	135.0	4,720.0	700.0	75.0	4,825.0	1,955.0	25.0	4,580.0	2,680.0
TOTAL U.S. SHIPMENTS	3,362.7	4,264.6	.5	2,141.2	7,248.0	55.0	1,370.0	8,560.0	810.0	720.0	8,780.0	2,140.0	245.0	8,460.0	3,010.0
NON-U.S. MANUFACTURERS															
Captive	14.0	348.2	--	11.7	419.4	--	6.0	590.0	110.0	3.0	735.0	490.0	--	855.0	1,210.0
PCM/Reseller	93.2	139.3	--	120.5	155.5	--	40.0	240.0	10.0	15.0	300.0	25.0	5.0	370.0	60.0
OEM/Integrator	134.5	1,852.3	--	147.6	2,205.5	--	135.0	2,860.0	80.0	110.0	3,285.0	305.0	70.0	3,545.0	600.0
TOTAL NON-U.S. SHIPMENTS	241.7	2,339.8	--	279.8	2,780.4	--	181.0	3,690.0	200.0	128.0	4,320.0	820.0	75.0	4,770.0	1,870.0
WORLDWIDE RECAP															
Captive	74.0	948.2	--	26.7	1,619.4	12.0	6.0	1,890.0	200.0	3.0	1,735.0	630.0	--	1,555.0	1,470.0
	-60.0%	+92.4%	--	-63.9%	+70.8%	--	-77.5%	+16.7%	--	-50.0%	-8.2%	+215.0%	-100.0%	-10.4%	+133.3%
PCM/Reseller	2,521.7	1,246.8	--	2,020.5	2,174.5	6.0	1,275.0	2,780.0	30.0	660.0	3,255.0	70.0	225.0	3,550.0	130.0
	+28.8%	+241.8%	--	-19.9%	+74.4%	--	-36.9%	+27.8%	+400.0%	-48.2%	+17.1%	+133.3%	-65.9%	+9.1%	+85.7%
OEM/Integrator	1,008.7	4,409.4	.5	373.8	6,234.5	37.0	270.0	7,580.0	780.0	185.0	8,110.0	2,260.0	95.0	8,125.0	3,280.0
	-20.5%	+180.8%	--	-62.9%	+41.4%	--	-27.8%	+21.6%	--	-31.5%	+7.0%	+189.7%	-48.6%	+.2%	+45.1%
Total Shipments	3,604.4	6,604.4	.5	2,421.0	10,028.4	55.0	1,551.0	12,250.0	1,010.0	848.0	13,100.0	2,960.0	320.0	13,230.0	4,880.0
	+5.6%	+172.0%	--	-32.8%	+51.8%	--	-35.9%	+22.2%	--	-45.3%	+6.9%	+193.1%	-62.3%	+1.0%	+64.9%
ANNUAL SHARE, BY DIAMETER	35.4%	64.6%	--	19.4%	80.3%	.3%	10.5%	82.8%	6.7%	5.0%	77.6%	17.4%	1.7%	71.9%	26.4%
TOTAL CAPACITY (Terabytes)	168.3	205.4	--	107.1	346.8	2.6	68.5	411.1	39.6	36.0	432.0	105.6	12.3	423.0	147.9

TABLE 32

FIXED DISK DRIVES, 30 - 60 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	317.5	3.1	276.5	1.5
PERSONAL COMPUTERS Business and professional, single user	9,398.7	92.1	16,586.9	90.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	245.0	2.4	239.6	1.3
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	215.4	2.1	737.2	4.0
CONSUMER AND HOBBY COMPUTERS	32.7	.3	552.9	3.0
OTHER APPLICATIONS	--	--	36.9	.2
Total	10,209.3	100.0	18,430.0	100.0

TABLE 33

FIXED DISK DRIVES, 30 - 60 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 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	
Seagate Technology	1814.0	665.0	--	2479.0	45.0	2570.0	897.0	--	3467.0	37.7
Conner Peripherals	--	719.0	--	719.0	13.0	--	1216.0	--	1216.0	13.2
Miniscribe	470.0	170.0	--	640.0	11.6	620.0	360.0	--	980.0	10.7
Western Digital	--	263.6	--	263.6	4.8	--	603.8	--	603.8	6.6
NEC	--	50.0	--	50.0	.9	28.0	546.1	--	574.1	6.2
Quantum	--	427.5	--	427.5	7.8	--	501.8	--	501.8	5.4
Sony	--	399.0	--	399.0	7.2	--	415.0	--	415.0	4.5
Fujitsu	1.3	17.5	--	18.8	.3	2.5	266.1	--	268.6	2.9
Toshiba	--	80.0	--	80.0	1.5	--	188.0	--	188.0	2.0
Mitsubishi Electric	121.0	--	--	121.0	2.2	187.0	--	--	187.0	2.0
Other U.S.	56.5	44.0	--	100.5	1.8	112.7	86.0	.5	199.2	2.3
Other Non-U.S.	.5	213.2	--	213.7	3.9	10.2	576.4	--	586.6	6.5
TOTAL	2463.3	3048.8	--	5512.1	100.0	3530.4	5656.2	.5	9187.1	100.0

FIXED DISK DRIVES, 60-100 MEGABYTES

1990 DISK/TREND REPORT

FIXED DISK DRIVES, 60-100 MEGABYTES

Coverage

Examples of disk drives in this group include:

8" disk diameter

Hitachi	DK812S-8
Sequel	7050, 803

5.25" disk diameter

Digirede	W525/85
Elebra	W580
Fujitsu	M2243B, M2243T*
Hewlett-Packard	7957B
Hitachi	DK511-8, DK512-8
Hyosung	HC 8085
IBM	4956
Maxtor	XT-1085
Microlab	DFW 5096
Micropolis	1335
Microscience International	HH-1090*
Seagate Technology	ST277N*, ST4096, ST279R*
Toshiba	MK-56FB

3.5" disk diameter

Conner Peripherals	CP-3184*
Espert	PT376R*
IBM	8550-061, WDA-380*
JVC	JD-E3896V**
Kalok	KL386*
Maxtor	7080A/S**
Mitsubishi Electric	MR335R*
Mitsumi Electric	HD309AA*
Plus Development	Hardcard II 80*
Quantum	80S/AT ProDrive*, 80S/AT Gem*
Prologica	W320B
Rodime	RO3085A*, RO3071S**
Seagate Technology	ST1096N*, ST3096A**
Teac	SD-380**
Tokico	TD3081C*
Y-E Data	YD-3082*
Zentek	H3060A*

2.5" disk diameter

IBM	WDA-260**
Quantum	80S/AT Go.Drive**
Western Digital	WDAH260**

*Indicates drives with maximum 41.3 mm height, or less.
**Indicates drives with maximum 25.4 mm height, or less.

Significant shipments in this product group got under way in 1981 with early entrants such as the 8" Priam and Fujitsu drives, which developed quick acceptance of the 8" form factor at this capacity level, and rapidly displaced earlier 14" drives.

During recent years, however, even more substantial displacement, this time of 8" models, followed the 1984 arrival of 85 megabyte 5.25" drives. By providing a major reduction in price and making possible the addition of higher disk capacities to desktop workstations, 85 megabyte 5.25" drives became one of the industry's classic success stories, later followed by successful half high versions.

1988 saw the start of production shipments for 3.5" drives by many additional companies, plus several of the existing 5.25" drive producers, and they have quickly risen in shipments to provide more than half of this product group's total. The majority of the 3.5" drives are targeted at personal computer applications, with embedded controllers compatible with IBM PC/AT standards, as well as SCSI, commonly offered.

Three companies have recently announced 2.5" drives in this capacity range, and more are expected by the end of 1990. Most will be limited to a box height of 19 millimeters or less, and volume production is expected in the first half of 1991.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	1,578.1	1,619.4	1,673.9	1,638.8	1,486.5
All manufacturers	1,733.8	1,778.2	1,975.3	2,099.8	2,095.1

Worldwide unit shipments totaled 2.2 million for disk drives in the 60-100 megabyte range in 1989, up 36.8%, with a further increase of 52.9% expected in 1990, bringing the year's shipments to 3.4 million drives.

The increases in total revenues, however, have been more modest, with negative impacts from product mix changes, as older 5.25" drives are replaced by 3.5" drives at lower prices, and as competition intensifies between producers of non-captive 3.5" drives. Worldwide revenues increased only 8.9% in 1989, and the forecast for this year is up only 2.6%.

Current major shipment growth is being produced by U.S. manufacturers of non-captive 3.5" drives. While 5.25" drive sales to PC manufacturers are being rapidly replaced by 3.5" drives, including new 1" high models, shipment growth for 3.5" drives has been even faster in the PCM/Reseller channel. Strong demand has emerged for easy-to-install drives which enable the aftermarket to offer replacement and upgrade products in both older systems and newly installed systems. The current 3.5" drives, with embedded PC/AT and SCSI controllers, make that possible.

The personal computer market continues to absorb an increasing share of worldwide production 60-100 megabyte drives, taking 85% of 1989's shipments, as the minicomputer and technical workstation markets moved to higher capacity drives. This trend is continuing, with personal computers expected to account for 87.9% of 1993 shipments.

Seagate's shipments of non-captive drives in the 60-100 megabyte range more than doubled in 1989, boosted by aftermarket growth and the Imprimis acquisition. Seagate held 38.7% of 1989 worldwide non-captive unit shipments with 553,000 drives, mostly 5.25" models. Quantum was a strong second with 23.2%, mostly 3.5" drives.

Marketing trends

Despite a few years of excellent growth in unit shipments, most system manufacturers, with the notable exception of Apple Computer, have elected to skip over this capacity group for upgraded personal computer models, in favor of drives in the 100-120 megabyte range. We expect this to continue, and annual 1991-93 unit shipment increases averaging only 21.2% are forecasted, with 1993 shipments placed at 6.1 million drives.

Worldwide total Unit shipments (000)	1989	1990	1991	1992	1993
8"	2.6	.8	.5	--	--
	.1%	--	--	--	--
5.25" full size	660.8	380.6	200.0	87.0	25.0
	28.9%	10.9%	4.3%	1.6%	.4%
5.25" half high	384.2	346.5	300.0	225.0	120.0
	16.8%	9.9%	6.5%	4.0%	1.9%
3.5"	1,236.5	2,760.0	3,900.0	4,618.0	4,795.0
	54.1%	79.0%	84.2%	82.5%	77.7%
2.5"	--	4.0	230.0	670.0	1,230.0
	--	.1%	5.0%	12.0%	19.9%
	2,284.1	3,491.9	4,630.5	5,600.0	6,170.0

No revenue growth is expected by the end of that period, as 3.5" drive shipments increase only slightly and 2.5" drives at lower prices grow to almost 20% of the total shipments for the product group.

Technical trends

Technology employed for drives in this product group has been derived mostly from programs developed for the groups above and below it in capacity. The extensive development of 3.5" drives with capacities above 100 megabytes has resulted in achievement of high areal densities, now employed with drives in this group, using heads, disks and other components made available through the pioneering at higher capacities. The packaging techniques developed for 2.5" drives and 1" high 3.5" drives with lower capacities is also being adapted to this product group, taking advantage of the availability of miniaturized drive motors, head positioning mechanisms and electronic components.

Interfaces offered on future 3.5" drives in this group will also probably follow the patterns established on lower capacity drives. Because of the higher areal densities employed, embedded controllers are used with most new drives, with most drive manufacturers offering an optional choice of the PC/AT or SCSI controllers compatible with popular personal computers.

Forecasting assumptions

1. IBM's production of 5.25" drives will stop in 1990, while 3.5" shipments will continue slow growth. IBM will rely mostly on internal manufacturing for drives in this group, but may supplement internal shortfalls with outside purchases.

2. Growth for OEM 5.25" drives has ended, limited by movement to higher capacities, and by a movement to 3.5" drives.

3. Availability of non-captive 2.5" and 3.5" drives will be adequate to satisfy growing demand.

TABLE 34

FIXED DISK DRIVES, 60 - 100 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	667.0	962.0	529.1	770.8	501.0	748.0	492.0	745.0	452.0	696.0
Other U.S. Captive	21.2	54.0	1.7	5.3	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	688.2	1,016.0	530.8	776.1	501.0	748.0	492.0	745.0	452.0	696.0
PCM/Reseller	171.0	237.9	298.6	413.4	303.6	426.4	273.9	383.3	213.4	303.2
OEM/Integrator	255.5	324.2	327.2	429.9	346.8	499.5	296.1	510.5	218.4	487.3
TOTAL U.S. NON-CAPTIVE	426.5	562.1	625.8	843.3	650.4	925.9	570.0	893.8	431.8	790.5
TOTAL U.S. REVENUES	1,114.7	1,578.1	1,156.6	1,619.4	1,151.4	1,673.9	1,062.0	1,638.8	883.8	1,486.5
Non-U.S. Manufacturers										
Captive	--	46.1	--	46.0	9.0	63.8	30.8	133.1	59.8	239.1
PCM/Reseller	10.6	11.9	7.6	11.2	18.2	23.2	30.8	39.4	37.0	50.0
OEM/Integrator	30.0	97.7	23.5	101.6	150.7	214.4	201.1	288.5	217.1	319.5
TOTAL NON-U.S. REVENUES	40.6	155.7	31.1	158.8	177.9	301.4	262.7	461.0	313.9	608.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,155.3	1,733.8	1,187.7	1,778.2	1,329.3	1,975.3	1,324.7	2,099.8	1,197.7	2,095.1
OEM Average Price ($000)	.473	.494	.331	.354	.310	.312	.274	.275	.244	.249

TABLE 35

FIXED DISK DRIVES, 60 - 100 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989		Forecast							
	Shipments		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	570.0	820.0	573.0	834.0	630.0	940.0	710.0	1,075.0	760.0	1,170.0
Other U.S. Captive	7.3	18.6	.7	2.2	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	577.3	838.6	573.7	836.2	630.0	940.0	710.0	1,075.0	760.0	1,170.0
PCM/Reseller	397.7	553.2	793.0	1,106.0	890.0	1,265.0	925.0	1,300.0	835.0	1,190.0
OEM/Integrator	541.1	687.0	991.6	1,284.1	1,175.0	1,690.5	1,132.0	1,930.0	943.0	2,015.0
TOTAL U.S. NON-CAPTIVE	938.8	1,240.2	1,784.6	2,390.1	2,065.0	2,955.5	2,057.0	3,230.0	1,778.0	3,205.0
TOTAL U.S. SHIPMENTS	1,516.1	2,078.8	2,358.3	3,226.3	2,695.0	3,895.5	2,767.0	4,305.0	2,538.0	4,375.0
Non-U.S. Manufacturers										
Captive	--	14.8	--	20.3	12.0	70.0	45.0	187.0	95.0	380.0
PCM/Reseller	20.6	22.8	22.9	28.2	55.0	70.0	102.0	130.0	138.0	185.0
OEM/Integrator	62.2	167.7	69.4	217.1	430.0	595.0	681.0	978.0	840.0	1,230.0
TOTAL NON-U.S. SHIPMENTS	82.8	205.3	92.3	265.6	497.0	735.0	828.0	1,295.0	1,073.0	1,795.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,598.9	2,284.1	2,450.6	3,491.9	3,192.0	4,630.5	3,595.0	5,600.0	3,611.0	6,170.0
Total Capacity (Terabytes)	138.3	196.9	220.2	312.6	286.8	415.0	332.6	518.4	341.0	583.2
Cumulative Shipments (Units in thousands)										
IBM	1,321.1	1,896.0	1,894.1	2,730.0	2,524.1	3,670.0	3,234.1	4,745.0	3,994.1	5,915.0
Non-IBM	3,296.1	4,802.1	5,173.7	7,460.0	7,735.7	11,150.5	10,620.7	15,675.5	13,471.7	20,675.5
WORLDWIDE TOTAL	4,617.2	6,698.1	7,067.8	10,190.0	10,259.8	14,820.5	13,854.8	20,420.5	17,465.8	26,590.5

TABLE 36

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues			Forecast													
				1990				1991				1992			1993		
	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	192.0	770.0	--	48.0	720.0	2.8	--	--	720.0	28.0	--	700.0	45.0	--	630.0	66.0
Other U.S. Captive	--	54.0	--	--	5.3	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	201.1	36.8	--	175.0	238.4	--	--	120.6	305.8	--	72.7	306.2	4.4	32.6	259.4	11.2
OEM/Integrator	6.6	162.3	155.3	2.1	82.3	345.5	--	1.3	54.1	396.3	47.8	30.0	353.6	126.9	11.3	270.7	205.3
TOTAL U.S. REVENUES	6.6	609.4	962.1	2.1	310.6	1,303.9	2.8	1.3	174.7	1,422.1	75.8	102.7	1,359.8	176.3	43.9	1,160.1	282.5
NON-U.S. MANUFACTURERS																	
Captive	--	46.1	--	--	30.0	16.0	--	--	15.0	48.8	--	6.0	94.5	32.6	--	143.1	96.0
PCM/Reseller	--	4.4	7.5	--	2.3	8.9	--	--	--	23.2	--	--	37.9	1.5	--	44.2	5.8
OEM/Integrator	--	38.1	59.6	--	25.0	76.6	--	--	13.0	194.0	7.4	--	265.3	23.2	--	283.8	35.7
TOTAL NON-U.S. REVENUES	--	88.6	67.1	--	57.3	101.5	--	--	28.0	266.0	7.4	6.0	397.7	57.3	--	471.1	137.5
WORLDWIDE RECAP																	
Captive	--	292.1	770.0	--	83.3	736.0	2.8	--	15.0	768.8	28.0	6.0	794.5	77.6	--	773.1	162.0
	-100.0%	-5.0%	+51.0%	--	-71.5%	-4.4%	--	--	-82.0%	+4.5%	+900.0%	-60.0%	+3.3%	+177.1%	-100.0%	-2.7%	+108.8%
PCM/Reseller	--	205.5	44.3	--	177.3	247.3	--	--	120.6	329.0	--	72.7	344.1	5.9	32.6	303.6	17.0
	--	-20.0%	+735.8%	--	-13.7%	+458.2%	--	--	-32.0%	+33.0%	--	-39.7%	+4.6%	--	-55.2%	-11.8%	+188.1%
OEM/Integrator	6.6	200.4	214.9	2.1	107.3	422.1	--	1.3	67.1	590.3	55.2	30.0	618.9	150.1	11.3	554.5	241.0
	-35.9%	-40.1%	+838.4%	-68.2%	-46.5%	+96.4%	--	-38.1%	-37.5%	+39.8%	--	-55.3%	+4.8%	+171.9%	-62.3%	-10.4%	+60.6%
Total Revenues	6.6	698.0	1,029.2	2.1	367.9	1,405.4	2.8	1.3	202.7	1,688.1	83.2	108.7	1,757.5	233.6	43.9	1,631.2	420.0
	-95.7%	-22.4%	+91.2%	-68.2%	-47.3%	+36.6%	--	-38.1%	-44.9%	+20.1%	--	-46.4%	+4.1%	+180.8%	-59.6%	-7.2%	+79.8%
ANNUAL SHARE, BY DIAMETER	.4%	40.4%	59.2%	.1%	20.8%	79.0%	.1%	.1%	10.3%	85.6%	4.0%	5.2%	83.8%	11.0%	2.1%	78.0%	19.9%

TABLE 37

FIXED DISK DRIVES, 60 - 100 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments			Forecast													
				1990				1991				1992			1993		
	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	--	120.0	700.0	--	30.0	800.0	4.0	--	--	900.0	40.0	--	1,000.0	75.0	--	1,050.0	120.0
Other U.S. Captive	--	18.6	--	--	2.2	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	485.7	67.5	--	465.0	641.0	--	--	345.0	920.0	--	225.0	1,060.0	15.0	110.0	1,040.0	40.0
OEM/Integrator	2.6	355.4	329.0	.8	200.3	1,083.0	--	.5	140.0	1,385.0	165.0	85.0	1,400.0	445.0	35.0	1,220.0	760.0
TOTAL U.S. SHIPMENTS	2.6	979.7	1,096.5	.8	697.5	2,524.0	4.0	.5	485.0	3,205.0	205.0	310.0	3,460.0	535.0	145.0	3,310.0	920.0
NON-U.S. MANUFACTURERS																	
Captive	--	14.8	--	--	9.3	11.0	--	--	5.0	65.0	--	2.0	135.0	50.0	--	220.0	160.0
PCM/Reseller	--	6.5	16.3	--	1.2	27.0	--	--	--	70.0	--	--	125.0	5.0	--	165.0	20.0
OEM/Integrator	--	44.0	123.7	--	19.1	198.0	--	--	10.0	560.0	25.0	--	898.0	80.0	--	1,100.0	130.0
TOTAL NON-U.S. SHIPMENTS	--	65.3	140.0	--	29.6	236.0	--	--	15.0	695.0	25.0	2.0	1,158.0	135.0	--	1,485.0	310.0
WORLDWIDE RECAP																	
Captive	--	153.4	700.0	--	41.5	811.0	4.0	--	5.0	965.0	40.0	2.0	1,135.0	125.0	--	1,270.0	280.0
	-100.0%	-3.8%	+75.0%	--	-72.9%	+15.9%	--	--	-88.0%	+19.0%	+900.0%	-60.0%	+17.6%	+212.5%	-100.0%	+11.9%	+124.0%
PCM/Reseller	--	492.2	83.8	--	466.2	668.0	--	--	345.0	990.0	--	225.0	1,185.0	20.0	110.0	1,205.0	60.0
	--	+3.8%	+909.6%	--	-5.3%	+697.1%	--	--	-26.0%	+48.2%	--	-34.8%	+19.7%	--	-51.1%	+1.7%	+200.0%
OEM/Integrator	2.6	399.4	452.7	.8	219.4	1,281.0	--	.5	150.0	1,945.0	190.0	85.0	2,298.0	525.0	35.0	2,320.0	890.0
	-45.8%	-28.7%	+977.9%	-69.2%	-45.1%	+183.0%	--	-37.5%	-31.6%	+51.8%	--	-43.3%	+18.1%	+176.3%	-58.8%	+1.0%	+69.5%
Total Shipments	2.6	1,045.0	1,236.5	.8	727.1	2,760.0	4.0	.5	500.0	3,900.0	230.0	312.0	4,618.0	670.0	145.0	4,795.0	1,230.0
	-89.6%	-12.5%	+174.6%	-69.2%	-30.4%	+123.2%	--	-37.5%	-31.2%	+41.3%	--	-37.6%	+18.4%	+191.3%	-53.5%	+3.8%	+83.6%
ANNUAL SHARE, BY DIAMETER	.1%	45.9%	54.0%	--	20.9%	79.0%	--	--	10.8%	84.3%	4.9%	5.6%	82.6%	11.8%	2.4%	77.8%	19.8%
TOTAL CAPACITY (Terabytes)	.2	88.7	89.2	.1	64.7	222.6	.3	--	42.7	283.8	18.9	27.0	318.7	49.8	12.5	314.4	85.7

TABLE 38

FIXED DISK DRIVES, 60 - 100 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	134.8	5.9	185.1	3.0
PERSONAL COMPUTERS Business and professional, single user	1,942.3	85.0	5,423.4	87.9
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	111.5	4.9	228.3	3.7
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	90.9	4.0	246.8	4.0
CONSUMER AND HOBBY COMPUTERS	4.6	.2	80.2	1.3
OTHER APPLICATIONS	--	--	6.2	.1
Total	2,284.1	100.0	6,170.0	100.0

TABLE 39

FIXED DISK DRIVES, 60 - 100 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 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	--	341.0	15.0	356.0	34.8	--	532.0	21.0	553.0	38.7
Quantum	--	18.0	288.9	306.9	30.0	--	18.0	314.5	332.5	23.2
Micropolis	--	85.8	--	85.8	8.4	--	95.8	--	95.8	6.7
Microscience	--	37.9	.5	38.4	3.8	--	75.7	1.0	76.7	5.4
Miniscribe	--	54.0	--	54.0	5.3	--	60.0	--	60.0	4.2
Conner Peripherals	--	--	60.0	60.0	5.9	--	--	60.0	60.0	4.2
Rodime	--	2.7	45.1	47.8	4.7	--	3.8	55.0	58.8	4.1
Tokico	--	--	--	--	--	--	--	45.0	45.0	3.1
Other U.S.	.3	37.4	--	37.7	3.7	2.6	59.6	--	62.2	4.4
Other Non-U.S.	--	16.5	18.5	35.0	3.4	--	46.7	40.0	86.7	6.0
TOTAL	.3	593.3	428.0	1021.6	100.0	2.6	891.6	536.5	1430.7	100.0

FIXED DISK DRIVES, 100-300 MEGABYTES

1990 DISK/TREND REPORT

FIXED DISK DRIVES, 100-300 MEGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

IBM	4967-2CX, 5360-BXX

8" disk diameter

Fujitsu	M2322
Hitachi	DK812S-12, DK814S-17
IBM	9332-200
Mitsubishi Electric	M4870F
Northern Telecom	8208X, 8210X
Sequel	806
Toshiba	MK186FB

5.25" disk diameter

Atasi Technology	519
Digirede	W525/190
Edisa	ED 71204
Digital Equipment	RF30*
Fujitsu	M2245E, M2243R*
Hewlett-Packard	97532E, 97533E
Hitachi	DK512-17, DK522C-10*
Hyosung	HC8170E
IBM	8580-111, 671-284
Magtron	4170*
Maxtor	XT-1140, XT-2190
Micropolis	1355, 1674-7*
Microscience International	HH-1120*, HH-3120*
Miltope	RDS-1720
NEC	D5655*, D5852
Sagem	MSA 252-100
Seagate Technology	ST4144A, ST2106N*
Toshiba	MK-156FB

3.5" disk diameter

Alps Electric	DRR100C**
Brand Technology	BT9170*
Cardiff Peripherals	F-3194-S*
Conner Peripherals	CP-3100*, CP-3200*, CP-30100**
Fuji Electric	FK313S-130R*, FK314S-90R**
Fujitsu	M2614S*
Hewlett-Packard	C2233S/A*
IBM	8570-121, WD-3158*, WD-3160*

3.5" disk diameter (continued)

Kyocera	KC 120DA*
Maxtor	LXT-100S*, LXT-200S*
Microscience International	5100*
Mitsubishi Electric	MR3314S*
NEC	D3661*, D3755**
Quantum	210S/A ProDrive*, 160S/A Gem**
Rodime	RO3259AP*
Seagate Technology	ST1144N*, ST1186N*
Tokico	TD3135A*
Toshiba	MK-234FB*
Western Digital	WDAP4200*
Y-E Data	YD-3084B*, YD-3162B**
Zentek	H3100A*

*Indicates drives with maximum 41.3 mm height, or less.
**Indicates drives with maximum 25.4 mm height, or less.

Previously the exclusive domain of 14" drives, the 1980's have seen numerous introductions of drives using smaller diameter disks in this group. A parade of 8" drives was launched at the beginning of the decade, followed by numerous 5.25" drives in the middle of the decade -- and now by a wave of 3.5" drives since 1987.

These, as well as the older 14" drives, all use variations of Winchester technology. Disks used with the 14" and 8" drives are oxide coated, but disks used on the 5.25" and 3.5" drives are mostly plated or sputtered.

Heads are usually ferrite types on the 14" and 8" drives, and also on a majority of the smaller drives, usually "mini" types patterned after the 3370 slider. There is limited usage of thin film heads, except for 5.25" and 3.5" drives employing higher areal densities.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	1,584.0	2,367.9	3,355.6	3,975.6	4,250.3
All manufacturers	2,229.3	3,226.1	4,519.2	5,554.8	6,131.3

This product group has been impacted more than any other by the rapid growth of the market for 386-based personal computers and the more sophisticated software which has become available for use with these systems. 1989's 51.6% growth in worldwide unit shipments is being followed by an even sharper 123.6% estimated increase in 1990, bringing the shipment total for the year to 3.9 million drives.

3.5" drives are currently providing all of the growth for 100-300 megabyte drives. After the first year of high volume shipments in 1988, 3.5" drive shipments increased 276.5% in 1989, and another 232.5% increase is projected for 1990. 3.5" drives are expected to provide 83.3% of this year's unit shipments, driven by large increases by IBM and in non-captive drives produced by both U.S. and non-U.S. drive manufacturers.

As recently as 1985, 5.25" drives provided only 16.6% of the unit shipments for this product group. Only two years later, 83.1% of the group's unit shipments were 5.25" drives, and in 1988 5.25" drives still held 72.5% of the total. However, in 1989 the share for 5.25" fell to 43.0%, and was down to 16.5% for 1990.

Most non-captive shipments are currently still going to system manufacturers, but growth in aftermarket sales through PCM/reseller channels is now starting to develop, led by the newer 3.5" drives. The leading application for drives in this group has become the personal computer

market, which captured 59% of worldwide unit shipments in 1989, with growth to 69.3% projected for 1993. Minicomputers and multiuser micros, which previously was the dominant application, was down to 23.7% in 1989, with non-office systems and workstations limited to 10.4%.

Conner Peripherals captured the leadership in non-captive drive shipments in 1989 with 362,000 3.5" drives, for 29.0% of the worldwide market. Seagate held 23.3%, mostly with 5.25" drives.

Marketing trends

A high growth rate through 1993 is forecasted for this product group, with average annual increases in unit shipments of 37.2% expected for the 1991-93 period. As usual in the disk drive business, revenue increases will follow a lower trajectory, as non-captive distribution predominates and prices decline.

Worldwide total Unit shipments (000)	1989	1990	1991	1992	1993
14"	4.6	--	--	--	--
	.3%	--	--	--	--
8"	14.1	8.3	2.0	--	--
	.8%	.2%	--	--	--
5.25" full size	482.7	348.4	182.0	93.0	37.0
	27.1%	8.7%	3.0%	1.1%	.4%
5.25" half high	283.1	309.4	309.0	246.0	158.0
	15.9%	7.8%	5.0%	2.9%	1.5%
3.5"	998.9	3,321.5	5,628.0	8,015.0	9,545.0
	55.9%	83.3%	91.4%	94.5%	94.2%
2.5"	--	--	40.0	140.0	400.0
	--	--	.6%	1.5%	3.9%
	1,783.4	3,987.6	6,161.0	8,494.0	10,140.0

By 1993, 3.5" drive shipments are expected to reach 9.5 million drives, representing 94.2% of worldwide unit shipments for all drives in this product group. A few hundred thousand 5.25" drives will probably still be in production, mostly half high models, but by that year the movement to smaller disk diameters will again be under way. We expect IBM to make the first shipments of 2.5" drives with capacities over 100 megabytes, starting in 1991 and followed by numerous independent drive manufacturers.

The big growth for 5.25" drives in the 100-300 megabyte range was fueled by demand for technical workstations and minicomputers, but the even larger future market for 3.5" drives is built upon the personal computer market, which is rapidly upgrading to more capable processors, being used for applications which need more data storage.

Although significant usage of 3.5" drives in this product group with technical workstations started in 1989, sharp growth in shipments of personal computers using 80386 processors has been the main stimulus for growth. Since most of the new personal computers introduced in the last three years have used 3.5" floppies and hard disk drives, the PC industry's product planners have preferred to use that form factor for increased disk storage as their systems migrate to better processors and as more versatile software becomes available.

Half high 5.25" drives have maintained more momentum than expected, but shipments finally peaked in 1990. Half high drives were a major business success for Imprimis, but other manufacturers of high-end 5.25" drives which eventually chose to offer half high models arrived in the market too late -- the movement to the 3.5" form factor was already under way.

Underlying the rapid decline in full size 5.25" drives is the movement by the minicomputer and technical workstation markets to higher capacity 5.25" models, above this product group. Half high 5.25" drives are acceptable for many workstation applications, but 3.5" drives are rapidly becoming the choice for low-end workstations. With 200 megabyte 3.5" drives now in production from multiple vendors, further penetration of the workstation market is inevitable.

Technical trends

This product group continues to make severe demands on the key components used in achieving the high recording densities necessary to produce 5.25" and 3.5" drives in the 100-300 megabyte range. Most of the 5.25" drives and all of the 3.5" drives with capacities over 100 megabytes now offered use thin film disks, to make possible high areal densities.

The high capacity 3.5" drives now being developed throughout the world by disk drive manufacturers present some of the most demanding design challenges facing the industry. Not only are areal densities very high, but packaging requirements are severe, involving drive heights approaching 3/4", new head suspensions, embedded controllers, and very fast actuators.

Areal Technology created great interest in the industry by announcing a single disk 3.5" drive offering 100 megabytes (formatted) capacity, the most technically ambitious undertaking among the new products, operating at 57,000 BPI (2,7 RLL) and 1,720 TPI. The drive wasn't delivered, and the project has been dropped following a company reorganization, but it won't be the last to set similar targets. Whether other drives to be

offered in the near future use a single disk, such as Areal attempted, or use two or more disks to achieve the same capacity, there will be a market for 1" high 3.5" drives in the 100 megabyte range with 386-based laptop computers as users' appetites for storage continue to grow.

It is not yet clear which interfaces will prevail with 3.5" drives in this range. But there are design advantages in masking a file organization optimized for high density behind an intelligent interface, so PC/AT and SCSI and embedded controllers compatible with specific personal computers will probably continue to predominate.

Forecasting assumptions

1. Growth in IBM's shipments of 3.5" drives in this group will continue to increase, with 2.5" drives to be added in 1991.
2. 3.5" drives will continue to dominate non-captive drive shipments due to their wide acceptance in the high-end personal computer market.
3. 2.5" drives for other captive and non-captive applications will be in volume production by 1992.

TABLE 40

FIXED DISK DRIVES, 100 - 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989 Revenues		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	556.4	762.1	676.7	958.1	1,170.0	1,664.0	1,338.0	1,968.0	1,482.8	2,205.5
Other U.S. Captive	69.2	161.7	68.3	149.1	113.9	230.5	120.0	237.0	123.6	233.2
TOTAL U.S. CAPTIVE	625.6	923.8	745.0	1,107.2	1,283.9	1,894.5	1,458.0	2,205.0	1,606.4	2,438.7
PCM/Reseller	69.8	93.7	200.4	269.1	334.3	431.3	440.9	589.7	494.8	661.8
OEM/Integrator	441.5	566.5	749.1	991.6	670.4	1,029.8	890.8	1,180.9	859.6	1,149.8
TOTAL U.S. NON-CAPTIVE	511.3	660.2	949.5	1,260.7	1,004.7	1,461.1	1,331.7	1,770.6	1,354.4	1,811.6
TOTAL U.S. REVENUES	1,136.9	1,584.0	1,694.5	2,367.9	2,288.6	3,355.6	2,789.7	3,975.6	2,960.8	4,250.3
Non-U.S. Manufacturers										
Captive	60.4	430.7	56.3	433.6	62.9	422.7	74.4	520.0	103.8	658.1
PCM/Reseller	14.9	17.7	25.1	34.3	125.0	143.7	230.4	272.7	303.8	380.3
OEM/Integrator	42.1	196.9	86.6	390.3	144.1	597.2	188.0	786.5	212.6	842.6
TOTAL NON-U.S. REVENUES	117.4	645.3	168.0	858.2	332.0	1,163.6	492.8	1,579.2	620.2	1,881.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,254.3	2,229.3	1,862.5	3,226.1	2,620.6	4,519.2	3,282.5	5,554.8	3,581.0	6,131.3
OEM Average Price ($000)	.659	.683	.505	.517	.475	.467	.414	.426	.380	.389

TABLE 41

FIXED DISK DRIVES, 100 - 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989		Forecast							
	Shipments		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	283.4	383.7	443.5	624.0	900.0	1,280.0	1,115.0	1,640.0	1,348.0	2,005.0
Other U.S. Captive	18.3	42.2	17.0	37.0	38.0	75.0	50.0	96.0	69.0	128.0
TOTAL U.S. CAPTIVE	301.7	425.9	460.5	661.0	938.0	1,355.0	1,165.0	1,736.0	1,417.0	2,133.0
PCM/Reseller	83.9	110.5	339.7	452.7	665.0	855.0	980.0	1,310.0	1,240.0	1,655.0
OEM/Integrator	687.7	880.4	1,493.9	1,963.1	1,430.5	2,275.5	2,190.0	2,875.0	2,300.0	3,052.0
TOTAL U.S. NON-CAPTIVE	771.6	990.9	1,833.6	2,415.8	2,095.5	3,130.5	3,170.0	4,185.0	3,540.0	4,707.0
TOTAL U.S. SHIPMENTS	1,073.3	1,416.8	2,294.1	3,076.8	3,033.5	4,485.5	4,335.0	5,921.0	4,957.0	6,840.0
Non-U.S. Manufacturers										
Captive	14.5	107.5	14.7	140.9	24.0	177.2	38.0	259.0	61.0	386.0
PCM/Reseller	18.7	21.6	48.4	61.3	255.0	293.0	480.0	568.0	675.0	845.0
OEM/Integrator	45.9	237.5	160.6	708.6	285.3	1,205.3	416.0	1,746.0	523.0	2,069.0
TOTAL NON-U.S. SHIPMENTS	79.1	366.6	223.7	910.8	564.3	1,675.5	934.0	2,573.0	1,259.0	3,300.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,152.4	1,783.4	2,517.8	3,987.6	3,597.8	6,161.0	5,269.0	8,494.0	6,216.0	10,140.0
Total Capacity (Terabytes)	180.4	277.4	397.5	619.4	543.4	912.6	866.7	1,386.1	1,123.2	1,819.8
Cumulative Shipments (Units in thousands)										
IBM	571.8	769.5	1,015.3	1,393.5	1,915.3	2,673.5	3,030.3	4,313.5	4,378.3	6,318.5
Non-IBM	2,159.0	3,434.1	4,233.3	6,797.7	6,931.1	11,678.7	11,085.1	18,532.7	15,953.1	26,667.7
WORLDWIDE TOTAL	2,730.8	4,203.6	5,248.6	8,191.2	8,846.4	14,352.2	14,115.4	22,846.2	20,331.4	32,986.2

TABLE 42

FIXED DISK DRIVES, 100 - 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues				Forecast												
					1990			1991				1992			1993		
	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	35.1	17.0	200.0	510.0	34.1	96.0	828.0	--	--	1,612.0	52.0	--	1,860.0	108.0	--	2,040.5	165.0
Other U.S. Captive	--	--	161.7	--	--	149.1	--	--	178.0	52.5	--	139.5	97.5	--	79.2	154.0	--
PCM/Reseller	--	--	79.0	14.7	--	109.8	159.3	--	106.5	324.8	--	83.7	506.0	--	60.0	599.9	1.9
OEM/Integrator	8.1	4.0	306.2	248.2	2.3	192.3	797.0	1.3	132.3	896.2	--	73.6	1,099.4	7.9	31.4	1,074.0	44.4
TOTAL U.S. REVENUES	43.2	21.0	746.9	772.9	36.4	547.2	1,784.3	1.3	416.8	2,885.5	52.0	296.8	3,562.9	115.9	170.6	3,868.4	211.3
NON-U.S. MANUFACTURERS																	
Captive	--	58.4	281.1	91.2	29.0	206.1	198.5	13.2	107.1	302.4	--	77.5	427.5	15.0	34.1	561.0	63.0
PCM/Reseller	--	--	1.7	16.0	--	10.6	23.7	--	4.0	139.7	--	1.5	271.2	--	--	380.3	--
OEM/Integrator	--	12.9	92.1	91.9	2.2	66.4	321.7	.6	39.6	557.0	--	20.3	758.3	7.9	7.0	805.6	30.0
TOTAL NON-U.S. REVENUES	--	71.3	374.9	199.1	31.2	283.1	543.9	13.8	150.7	999.1	--	99.3	1,457.0	22.9	41.1	1,746.9	93.0
WORLDWIDE RECAP																	
Captive	35.1	75.4	642.8	601.2	63.1	451.2	1,026.5	13.2	285.1	1,966.9	52.0	217.0	2,385.0	123.0	113.3	2,755.5	228.0
	-83.3%	-70.4%	+42.4%	+111.9%	-16.3%	-29.8%	+70.7%	-79.1%	-36.8%	+91.6%	--	-23.9%	+21.3%	+136.5%	-47.8%	+15.5%	+85.4%
PCM/Reseller	--	--	80.7	30.7	--	120.4	183.0	--	110.5	464.5	--	85.2	777.2	--	60.0	980.2	1.9
	--	--	-27.1%	+230.1%	--	+49.2%	+496.1%	--	-8.2%	+153.8%	--	-22.9%	+67.3%	--	-29.6%	+26.1%	--
OEM/Integrator	8.1	16.9	398.3	340.1	4.5	258.7	1,118.7	1.9	171.9	1,453.2	--	93.9	1,857.7	15.8	38.4	1,879.6	74.4
	-59.9%	-53.4%	-30.1%	+300.6%	-73.4%	-35.0%	+228.9%	-57.8%	-33.6%	+29.9%	--	-45.4%	+27.8%	--	-59.1%	+1.2%	+370.9%
Total Revenues	43.2	92.3	1,121.8	972.0	67.6	830.3	2,328.2	15.1	567.5	3,884.6	52.0	396.1	5,019.9	138.8	211.7	5,615.3	304.3
	-81.2%	-68.3%	.9%	+157.2%	-26.8%	-26.0%	+139.5%	-77.7%	-31.7%	+66.8%	--	-30.2%	+29.2%	+166.9%	-46.6%	+11.9%	+119.2%
ANNUAL SHARE, BY DIAMETER	1.9%	4.1%	50.4%	43.6%	2.1%	25.8%	72.1%	.3%	12.6%	86.1%	1.0%	7.1%	90.5%	2.4%	3.5%	91.7%	4.8%

Note: 8 inch totals include 9 inch drives.

TABLE 43

FIXED DISK DRIVES, 100 - 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments				Forecast											
	1990			1991				1992			1993		
	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS																	
IBM Captive	2.0	1.7	80.0	300.0	4.0	40.0	580.0	--	--	1,240.0	40.0	--	1,550.0	90.0	--	1,855.0	150.0
Other U.S. Captive	--	--	42.2	--	--	37.0	--	--	40.0	35.0	--	31.0	65.0	--	18.0	110.0	--
PCM/Reseller	--	--	87.0	23.5	--	152.7	300.0	--	160.0	695.0	--	135.0	1,175.0	--	100.0	1,550.0	5.0
OEM/Integrator	2.6	1.6	382.1	494.1	.9	267.2	1,695.0	.5	195.0	2,080.0	--	115.0	2,740.0	20.0	52.0	2,880.0	120.0
TOTAL U.S. SHIPMENTS	4.6	3.3	591.3	817.6	4.9	496.9	2,575.0	.5	395.0	4,050.0	40.0	281.0	5,530.0	110.0	170.0	6,395.0	275.0
NON-U.S. MANUFACTURERS																	
Captive	--	5.1	70.0	32.4	2.4	59.0	79.5	1.2	32.0	144.0	--	24.0	225.0	10.0	11.0	330.0	45.0
PCM/Reseller	--	--	1.8	19.8	--	14.3	47.0	--	8.0	285.0	--	3.0	565.0	--	--	845.0	--
OEM/Integrator	--	5.7	102.7	129.1	1.0	87.6	620.0	.3	56.0	1,149.0	--	31.0	1,695.0	20.0	14.0	1,975.0	80.0
TOTAL NON-U.S. SHIPMENTS	--	10.8	174.5	181.3	3.4	160.9	746.5	1.5	96.0	1,578.0	--	58.0	2,485.0	30.0	25.0	3,150.0	125.0
WORLDWIDE RECAP																	
Captive	2.0	6.8	192.2	332.4	6.4	136.0	659.5	1.2	72.0	1,419.0	40.0	55.0	1,840.0	100.0	29.0	2,295.0	195.0
	-83.3%	-73.5%	+50.5%	+114.6%	-5.9%	-29.2%	+98.4%	-81.3%	-47.1%	+115.2%	--	-23.6%	+29.7%	+150.0%	-47.3%	+24.7%	+95.0%
PCM/Reseller	--	--	88.8	43.3	--	167.0	347.0	--	168.0	980.0	--	138.0	1,740.0	--	100.0	2,395.0	5.0
	--	--	-22.2%	+230.5%	--	+88.1%	+701.4%	--	+.6%	+182.4%	--	-17.9%	+77.6%	--	-27.5%	+37.6%	--
OEM/Integrator	2.6	7.3	484.8	623.2	1.9	354.8	2,315.0	.8	251.0	3,229.0	--	146.0	4,435.0	40.0	66.0	4,855.0	200.0
	-58.7%	-53.5%	-20.4%	+540.5%	-74.0%	-26.8%	+271.5%	-57.9%	-29.3%	+39.5%	--	-41.8%	+37.3%	--	-54.8%	+9.5%	+400.0%
Total Shipments	4.6	14.1	765.8	998.9	8.3	657.8	3,321.5	2.0	491.0	5,628.0	40.0	339.0	8,015.0	140.0	195.0	9,545.0	400.0
	-74.9%	-65.9%	-10.0%	+276.5%	-41.1%	-14.1%	+232.5%	-75.9%	-25.4%	+69.4%	--	-31.0%	+42.4%	+250.0%	-42.5%	+19.1%	+185.7%
ANNUAL SHARE, BY DIAMETER	.3%	.8%	43.0%	55.9%	.2%	16.5%	83.3%	--	8.0%	91.4%	.6%	4.0%	94.5%	1.5%	1.9%	94.2%	3.9%
TOTAL CAPACITY (Terabytes)	.9	.7	97.2	122.6	1.1	81.6	400.8	.1	70.3	611.1	5.7	50.4	924.3	15.6	30.6	1,166.3	38.8

Note: 8 inch totals include 9 inch drives.

TABLE 44

FIXED DISK DRIVES, 100 - 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	422.3	23.7	1,622.4	16.0
PERSONAL COMPUTERS Business and professional, single user	1,052.3	59.0	7,027.1	69.3
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	115.6	6.5	152.1	1.5
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	186.5	10.4	1,318.2	13.0
CONSUMER AND HOBBY COMPUTERS	5.5	.3	10.1	.1
OTHER APPLICATIONS	1.2	.1	10.1	.1
Total	1,783.4	100.1	10,140.0	100.0

TABLE 45

FIXED DISK DRIVES, 100 - 300 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
Conner Peripherals	--	--	--	290.0	290.0	34.7	--	--	--	362.0	362.0	29.0
Seagate Technology	--	--	133.0	55.0	188.0	22.5	--	--	231.0	60.0	291.0	23.3
Maxtor	--	--	83.2	11.5	94.7	11.3	--	--	102.1	14.3	116.4	9.3
Micropolis	--	--	97.9	--	97.9	11.7	--	--	109.4	--	109.4	8.8
Fujitsu	--	2.0	8.5	10.1	20.6	2.5	--	3.8	23.6	70.8	98.2	7.9
Quantum	--	--	--	79.1	79.1	9.5	--	--	--	81.1	81.1	6.5
Other U.S.	2.6	1.2	18.0	.1	21.9	2.5	2.6	1.6	26.6	.2	31.0	2.4
Other Non-U.S.	--	1.2	9.6	33.2	44.0	5.3	--	1.9	80.9	78.1	160.9	12.8
TOTAL	2.6	4.4	350.2	479.0	836.2	100.0	2.6	7.3	573.6	666.5	1250.0	100.0

Note: 8 inch totals include 9 inch drives.

FIXED DISK DRIVES, 300-500 MEGABYTES

1990 DISK/TREND REPORT

FIXED DISK DRIVES, 300-500 MEGABYTES

Coverage

Examples of disk drives in this group include:

14" disk diameter

DZU	EC 5063
IBM	5360-BXA, 4967-3CA

10.5" disk diameter

Fujitsu	M2350A, F6421

9" disk diameter

Seagate Technology	ST6344J

8" disk diameter

Cerplex	C2400
Fujitsu	M2333K
Hitachi	DK-814S-34
IBM	9332-400, 678-400
Mitsubishi Electric	MR4875
Northern Telecom	8308, 8212X
Seagate Technology	ST8368
Sequel	807
Toshiba	MK-286FC

5.25" disk diameter

Atasi Technology	638, 738
Digirede	W525S/410
Digital Equipment	RA70, RF71
Edisa	ED 71408
Fujitsu	M2249E/S
Hewlett-Packard	97536E/S, 97544P
Hitachi	DK514-38
IBM	8580-311, 671-387
Maxtor	XT-4380E/S, XT-8380E/S
Micropolis	1558-15, 1664-7*
Miltope	RDS-3800
NEC	D5662
Seagate Technology	ST4385N, ST2383N*
Toshiba	MK-355FD

3.5" disk diameter

Cardiff Peripherals	F3380E*
Hewlett-Packard	C2235S*
IBM	0661-371*, 0661-467*
Maxtor	LXT-340*
Orca Technology	Shrike-400*
Quantum	330S/AT ProDrive*
Rodime	RO3414T*
Seagate Technology	ST1480A/N*

*Indicates drives with maximum 41.3 mm height, or less.

The original disk drives in this group were patterned after IBM's 3350 -- typically 317.5 megabyte floor-standing drives intended for use with mainframes.

The later 14" drives were rack-mounted 14" drives introduced for both captive (IBM, DEC, Data General) and OEM (Century, Fujitsu) markets -- with only a few still in production. Led by the successful Fujitsu 10.5" Eagle, other small drives included several 9" models by Control Data, followed by numerous 8" drives.

A wave of 380 megabyte 5.25" drives, following the lead of Maxtor, has provided major shipments for many producers during the last several years, with fourteen companies active, at various times, in the market. In 1989, IBM became the first company to announce and ship 3.5" drives in this capacity range, but numerous other drive manufacturers have also announced 3.5" drives in 1990.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	1,681.8	2,513.0	2,687.4	2,773.7	2,709.6
All manufacturers	2,296.8	3,029.3	3,170.0	3,221.8	3,147.0

Overall unit shipments for 300-500 megabyte drives are on a relentless growth pattern, but total revenues have had their ups and downs, due to the continuing product mix transition to physically smaller disk drives, which affects all distribution channels -- IBM, other captive, PCM/Reseller and OEM/Integrator.

Worldwide unit shipments grew 53.2% in 1989, and another 40.3% increase is expected in 1990. However, total revenues for 1989 were down 4.5%, while expected to recover this year with a gain of 31.9%. 1989 total revenue was hurt by rapid shipment declines in 14" and 8/9" drives, offset by growing 5.25" shipments at lower prices. 1990 total revenue is receiving a boost from surging IBM shipments of new 3.5" drives.

After many competitors expressed initial skepticism regarding the Maxtor 380 megabyte 5.25" drive, which was first shipped in 1984, thirteen firms had started production by 1988 -- and a playing field that was initially too empty had become overcrowded, despite a 700% shipment increase in 1988.

The momentum continued for another year, and shipments of 5.25" drives more than doubled in 1989, to 756,400 units. But in 1990 the effects of competition from 3.5" drives and the migration to higher capacities for 5.25" drives are being felt, and the 5.25" increase this year is estimated at only 9.5%. It is believed that 1990 will be the peak year for 5.25" drives in this group.

IBM still has a major impact on this product group. Although the company's shipments of 14" and 8" drives are expected to stop this year, production of the IBM "Lee" 5.25" drive, with formatted capacity of 315 megabytes, is continuing after its 1989 peak and isn't expected to end until next year. But IBM's emphasis has shifted to the 320 megabyte

"Lightning" 3.5" drive, first offered in mid-1989 to distributors, and added as a standard drive on several major IBM systems in the Spring of 1990.

The Lightning introduction represented an interesting change in IBM sales strategy for the non-captive market. After unsuccessful attempts to sell earlier disk drives produced by IBM's Low End Storage Products operation to major system manufacturers on an OEM basis, a different sales program has been established for the Lightning. The drive was offered for resale through Western Digital on an OEM basis and through WD's distributors, through System Industries with DEC compatible subsystems, and through CMS Enhancements for the PC aftermarket.

Although IBM enjoyed a full year head start in shipments of 3.5" drives in the 300-500 megabyte range, they will soon have lots of company in the marketplace. 3.5" drives in this capacity range have been announced by eight drive manufacturers, and more are expected soon.

Minicomputer and multiuser micro applications, including network file servers, continued to lead with 41.0% of all unit shipments for the product group in 1989, and further growth to 55.0% in 1993 is expected. Technical workstations will also secure a growing share, but the share for mainframes and superminis will drop as older drives are discontinued.

The lead in non-captive shipments for 1989 was held by Seagate, as a result of its acquisition of Imprimis, the previous year's leader. Seagate captured 29.5% of total worldwide non-captive shipments, a total of 190,000 drives, mostly "Wren" 5.25" models, plus a smaller number of 9" "FSD" and 8" "Sabre" drives. Maxtor was second with 22.9%, and Micropolis placed third with 21.0%, all 5.25" drives from both companies.

Marketing trends

The 14" and 8/9" drives which provided two thirds of this group's revenue in 1988 are now approaching end of life, and both types are expected to be out of production by the end of 1992. The victory for 5.25" drives is temporary, however, and 5.25" shipments are expected to decline starting in 1991. By 1993 5.25" drives are expected to account for only 20.6% of worldwide shipments, with 3.5" drives holding the balance.

One result of these product mix changes will be lower average prices, holding down revenue increases for the group to an annual average barely over 1% for the 1991-93 time period, and revenue is projected to be down slightly in 1993. Revenue growth is hurt by migration of 5.25" drive capacities to higher levels, above this product group. Ironically, it is also hurt by rapid growth within the 300-500 megabyte range of demand for 3.5" drives for personal computer applications, bringing even higher levels of price competition.

With its head start in production of high capacity 3.5" drives, IBM's shipments are expected to reach peak at 375,000 units in 1992. Despite early emphasis on resale channels, it is believed that IBM's captive requirements for high-end personal computers, office systems and technical workstations will predominate. The quantity of Lightning drives needed for IBM's own systems would probably be even larger, except for diversion of some of the demand to higher capacity versions planned for next year.

Technical trends

Packaging for smaller form factors and refinements in performance will continue to receive priority in development activities for this product group. Little engineering effort is being devoted to 8" and 9"

drives in the 300-500 megabyte range -- while intense activity is under way on smaller drives.

Maxtor was the lonely pioneer in 5.25" drives in the 300-500 megabyte range. The firm's successful production of such drives inspired a dozen competitors to take on the twin challenges of fitting enough disks into the standard 5.25" form factor and finding ways to improve head positioning time below the sub-20 millisecond average required to be competitive. Only two companies, Seagate and Micropolis, produce 5.25" half high 380 megabyte drives, using the same areal density now being employed with 770 megabyte 5.25" drives. The significant costs for tooling and the declining 5.25" market will limit participation in the half high field to firms which already have products.

While many manufacturers are still sweating out the design and manufacturing startup problems associated with 3.5" drives at the 200 megabyte level, most have had to divert engineering talent to the 400 megabyte range, utilizing techniques such as higher areal density, zoned recording and closer packaging of disks.

The demand for more capacity in small spaces will continue. Expect to see extensive use of MIG and thin film heads, sputtered disks using thinner substrates, advanced encoding methods, intelligent interfaces, and extensive use of VLSI in drive electronics. IBM's Lightning drive is still unmatched in usage of 8 disks in the standard 41.3 millimeter height for 3.5" drives, an impressive design made possible by reducing the normal 50 mil disk substrate thickness to only 31.5 mils, which is now a de facto standard.

In 1987, limited availability of thin film heads for 5.25" drives in this group caused severe problems for several companies, and head vendors

sharply expanded production capacity. That shortage also inspired most drive manufacturers to substitute MIG heads in many drive designs as a competitive alternative. However, in 1990 extremely rapid shipment growth and the continuing movement to higher areal densities have again made availability of high performance heads a key issue for those drive manufacturers on a fast growth curve. Manufacturers of both thin film and MIG heads are scrambling to install additional production capacity and to improve yields in existing facilities.

Forecasting assumptions

1. Total shipments of 14", 9" and 8" drives will continue to decline, and shipments of 5.25" drives will decline starting in 1991.

2. Sustained growth for technical workstations, LANs, office systems and specialized systems will create significant growth for both captive and non-captive 3.5" drives.

TABLE 46

FIXED DISK DRIVES, 300 - 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989 Revenues		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	493.1	668.5	1,133.2	1,441.5	1,090.5	1,457.5	1,053.0	1,462.5	988.0	1,406.0
Other U.S. Captive	163.5	294.6	191.5	358.5	169.0	364.0	136.6	300.8	137.0	260.4
TOTAL U.S. CAPTIVE	656.6	963.1	1,324.7	1,800.0	1,259.5	1,821.5	1,189.6	1,763.3	1,125.0	1,666.4
PCM/Reseller	130.1	151.4	81.8	100.8	114.4	133.5	171.5	193.7	231.8	273.6
OEM/Integrator	435.7	567.3	470.1	612.2	572.1	732.4	638.2	816.7	585.6	769.6
TOTAL U.S. NON-CAPTIVE	565.8	718.7	551.9	713.0	686.5	865.9	809.7	1,010.4	817.4	1,043.2
TOTAL U.S. REVENUES	1,222.4	1,681.8	1,876.6	2,513.0	1,946.0	2,687.4	1,999.3	2,773.7	1,942.4	2,709.6
Non-U.S. Manufacturers										
Captive	26.5	439.5	28.2	362.2	26.2	301.5	27.8	268.3	28.0	221.0
PCM/Reseller	.6	1.4	--	.8	7.7	33.5	6.8	42.3	16.0	60.0
OEM/Integrator	59.0	174.1	39.0	153.3	32.4	147.6	38.9	137.5	44.6	156.4
TOTAL NON-U.S. REVENUES	86.1	615.0	67.2	516.3	66.3	482.6	73.5	448.1	88.6	437.4
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,308.5	2,296.8	1,943.8	3,029.3	2,012.3	3,170.0	2,072.8	3,221.8	2,031.0	3,147.0
OEM Average Price ($000)	1.3	1.4	1.1	1.1	.9	1.0	.8	.9	.8	.8

TABLE 47

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989		Forecast							
	Shipments		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	81.3	107.0	265.6	334.0	273.0	365.0	270.0	375.0	260.0	370.0
Other U.S. Captive	25.4	44.9	34.2	61.4	35.0	75.0	31.0	68.0	35.0	66.0
TOTAL U.S. CAPTIVE	106.7	151.9	299.8	395.4	308.0	440.0	301.0	443.0	295.0	436.0
PCM/Reseller	107.7	124.7	72.1	88.3	125.0	145.0	210.0	237.0	305.0	360.0
OEM/Integrator	343.6	437.6	429.9	555.0	599.0	761.0	726.0	922.0	723.0	944.0
TOTAL U.S. NON-CAPTIVE	451.3	562.3	502.0	643.3	724.0	906.0	936.0	1,159.0	1,028.0	1,304.0
TOTAL U.S. SHIPMENTS	558.0	714.2	801.8	1,038.7	1,032.0	1,346.0	1,237.0	1,602.0	1,323.0	1,740.0
Non-U.S. Manufacturers										
Captive	3.5	47.1	4.3	49.4	4.2	47.7	6.0	51.1	7.0	52.0
PCM/Reseller	.3	.7	--	.1	4.0	19.0	8.0	40.0	20.0	75.0
OEM/Integrator	29.0	80.7	26.8	94.2	29.1	112.0	41.0	136.9	52.0	183.0
TOTAL NON-U.S. SHIPMENTS	32.8	128.5	31.1	143.7	37.3	178.7	55.0	228.0	79.0	310.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	590.8	842.7	832.9	1,182.4	1,069.3	1,524.7	1,292.0	1,830.0	1,402.0	2,050.0
Total Capacity (Terabytes)	226.2	322.5	316.7	450.5	414.5	590.2	506.8	716.9	554.6	810.5
Cumulative Shipments (Units in thousands)										
IBM	314.0	464.8	579.6	798.8	852.6	1,163.8	1,122.6	1,538.8	1,382.6	1,908.8
Non-IBM	1,235.2	1,922.2	1,802.5	2,770.6	2,598.8	3,930.3	3,620.8	5,385.3	4,762.8	7,065.3
WORLDWIDE TOTAL	1,549.2	2,387.0	2,382.1	3,569.4	3,451.4	5,094.1	4,743.4	6,924.1	6,145.4	8,974.1

TABLE 48

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues				Forecast 1990				1991				1992				1993	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																		
IBM Captive	34.0	202.5	432.0	--	17.0	96.0	160.0	1,168.5	--	--	17.5	1,440.0	--	--	--	1,462.5	--	1,406.0
Other U.S. Captive	29.7	3.2	261.7	--	10.0	--	348.5	--	--	--	254.8	109.2	--	--	156.8	144.0	55.2	205.2
PCM/Reseller	--	2.5	139.3	9.6	--	--	69.9	30.9	--	--	51.8	81.7	--	--	11.4	182.3	--	273.6
OEM/Integrator	2.5	64.5	500.3	--	--	32.5	573.5	6.2	--	16.2	541.9	174.3	--	5.2	476.3	335.2	330.1	439.5
TOTAL U.S. REVENUES	66.2	272.7	1,333.3	9.6	27.0	128.5	1,151.9	1,205.6	--	16.2	866.0	1,805.2	--	5.2	644.5	2,124.0	385.3	2,324.3
NON-U.S. MANUFACTURERS																		
Captive	6.6	215.0	217.9	--	6.6	92.2	263.4	--	4.2	52.5	208.8	36.0	2.0	28.0	137.5	100.8	53.0	168.0
PCM/Reseller	--	--	1.4	--	--	--	.8	--	--	--	20.0	13.5	--	--	10.0	32.3	--	60.0
OEM/Integrator	45.1	51.7	77.3	--	28.0	20.5	104.8	--	24.0	8.1	84.0	31.5	9.5	--	58.3	69.7	42.0	114.4
TOTAL NON-U.S. REVENUES	51.7	266.7	296.6	--	34.6	112.7	369.0	--	28.2	60.6	312.8	81.0	11.5	28.0	205.8	202.8	95.0	342.4
WORLDWIDE RECAP																		
Captive	70.3	420.7	911.6	--	33.6	188.2	771.9	1,168.5	4.2	52.5	481.1	1,585.2	2.0	28.0	294.3	1,707.3	108.2	1,779.2
	-81.2%	-44.4%	+116.1%	--	-52.2%	-55.3%	-15.3%	--	-87.5%	-72.1%	-37.7%	+35.7%	-52.4%	-46.7%	-38.8%	+7.7%	-63.2%	+4.2%
PCM/Reseller	--	2.5	140.7	9.6	--	--	70.7	30.9	--	--	71.8	95.2	--	--	21.4	214.6	--	333.6
	--	--	+161.5%	--	--	-100.0%	-49.8%	+221.9%	--	--	+1.6%	+208.1%	--	--	-70.2%	+125.4%	-100.0%	+55.5%
OEM/Integrator	47.6	116.2	577.6	--	28.0	53.0	678.3	6.2	24.0	24.3	625.9	205.8	9.5	5.2	534.6	404.9	372.1	553.9
	-72.7%	-55.9%	+60.2%	--	-41.2%	-54.4%	+17.4%	--	-14.3%	-54.2%	-7.7%	--	-60.4%	-78.6%	-14.6%	+96.7%	-30.4%	+36.8%
Total Revenues	117.9	539.4	1,629.9	9.6	61.6	241.2	1,520.9	1,205.6	28.2	76.8	1,178.8	1,886.2	11.5	33.2	850.3	2,326.8	480.3	2,666.7
	-78.5%	-47.1%	+94.9%	--	-47.8%	-55.3%	-6.7%	--	-54.2%	-68.2%	-22.5%	+56.5%	-59.2%	-56.8%	-27.9%	+23.4%	-43.5%	+14.6%
ANNUAL SHARE, BY DIAMETER	5.1%	23.6%	71.0%	.3%	2.0%	8.0%	50.3%	39.7%	.9%	2.4%	37.3%	59.4%	.4%	1.0%	26.5%	72.1%	15.3%	84.7%

Note: 14 inch totals include 10.5 inch drives.
8 inch totals include 9 inch drives.

TABLE 49

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments				Forecast													
					1990				1991				1992				1993	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	5.25"	3.5"
U.S. MANUFACTURERS																		
IBM Captive	2.0	15.0	90.0	--	1.0	8.0	40.0	285.0	--	--	5.0	360.0	--	--	--	375.0	--	370.0
Other U.S. Captive	1.5	.3	43.1	--	.4	--	61.0	--	--	--	49.0	26.0	--	--	32.0	36.0	12.0	54.0
PCM/Reseller	--	.5	116.2	8.0	--	--	62.7	25.6	--	--	50.0	95.0	--	--	12.0	225.0	--	360.0
OEM/Integrator	.5	21.7	415.4	--	--	11.6	538.0	5.4	--	6.0	550.0	205.0	--	2.0	501.0	419.0	358.0	586.0
TOTAL U.S. SHIPMENTS	4.0	37.5	664.7	8.0	1.4	19.6	701.7	316.0	--	6.0	654.0	686.0	--	2.0	545.0	1,055.0	370.0	1,370.0
NON-U.S. MANUFACTURERS																		
Captive	.3	13.5	33.3	--	.3	5.8	43.3	--	.2	3.5	36.0	8.0	.1	2.0	25.0	24.0	10.0	42.0
PCM/Reseller	--	--	.7	--	--	--	.1	--	--	--	4.0	15.0	--	--	2.0	38.0	--	75.0
OEM/Integrator	5.7	17.3	57.7	--	4.0	7.3	82.9	--	4.0	3.0	70.0	35.0	1.9	--	53.0	82.0	40.0	143.0
TOTAL NON-U.S. SHIPMENTS	6.0	30.8	91.7	--	4.3	13.1	126.3	--	4.2	6.5	110.0	58.0	2.0	2.0	80.0	144.0	50.0	260.0
WORLDWIDE RECAP																		
Captive	3.8	28.8	166.4	--	1.7	13.8	144.3	285.0	.2	3.5	90.0	394.0	.1	2.0	57.0	435.0	22.0	466.0
	-82.6%	-45.2%	+115.5%	--	-55.3%	-52.1%	-13.3%	--	-88.2%	-74.6%	-37.6%	+38.2%	-50.0%	-42.9%	-36.7%	+10.4%	-61.4%	+7.1%
PCM/Reseller	--	.5	116.9	8.0	--	--	62.8	25.6	--	--	54.0	110.0	--	--	14.0	263.0	--	435.0
	--	--	+212.6%	--	--	-100.0%	-46.3%	+220.0%	--	--	-14.0%	+329.7%	--	--	-74.1%	+139.1%	-100.0%	+65.4%
OEM/Integrator	6.2	39.0	473.1	--	4.0	18.9	620.9	5.4	4.0	9.0	620.0	240.0	1.9	2.0	554.0	501.0	398.0	729.0
	-69.3%	-56.5%	+88.3%	--	-35.5%	-51.5%	+31.2%	--	--	-52.4%	--	--	-52.5%	-77.8%	-10.6%	+108.8%	-28.2%	+45.5%
Total Shipments	10.0	68.3	756.4	8.0	5.7	32.7	828.0	316.0	4.2	12.5	764.0	744.0	2.0	4.0	625.0	1,199.0	420.0	1,630.0
	-76.2%	-52.0%	+106.7%	--	-43.0%	-52.1%	+9.5%	--	-26.3%	-61.8%	-7.7%	+135.4%	-52.4%	-68.0%	-18.2%	+61.2%	-32.8%	+35.9%
ANNUAL SHARE, BY DIAMETER	1.2%	8.1%	89.9%	.8%	.5%	2.8%	70.1%	26.6%	.3%	.8%	50.2%	48.7%	.1%	.2%	34.3%	65.4%	20.6%	79.4%
TOTAL CAPACITY (Terabytes)	1.7	14.9	253.7	3.0	.6	7.9	269.4	117.7	--	2.2	252.8	265.6	--	.7	211.2	414.5	143.9	542.3

Note: 14 inch totals include 10.5 inch drives.
8 inch totals include 9 inch drives.

TABLE 50

FIXED DISK DRIVES, 300 - 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

	1989 Estimate		1993 Projection	
APPLICATION	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	73.7	8.7	41.0	2.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	345.9	41.0	1,127.5	55.0
PERSONAL COMPUTERS Business and professional, single user	158.8	18.8	451.0	22.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	127.4	15.2	61.5	3.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	136.3	16.2	369.0	18.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.6	.1	--	--
Total	842.7	99.9	2,050.0	100.0

TABLE 51

FIXED DISK DRIVES, 300 - 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	14"	8"	5.25"	3.5"	Total		14"	8"	5.25"	3.5"	Total	
Seagate Technology	--	13.8	120.0	--	133.8	27.8	--	19.0	171.0	--	190.0	29.5
Maxtor	--	--	112.9	--	112.9	23.5	--	--	147.5	--	147.5	22.9
Micropolis	--	--	126.8	--	126.8	26.4	--	--	135.0	--	135.0	21.0
Miniscribe	--	--	52.0	--	52.0	10.8	--	--	58.0	--	58.0	9.0
Fujitsu	.1	11.0	8.3	--	19.4	4.0	1.7	16.3	29.9	--	47.9	7.4
Other U.S.	.3	1.4	16.1	8.0	25.8	5.4	.5	3.2	20.1	8.0	31.8	4.9
Other Non-U.S.	--	1.0	8.9	--	9.9	2.1	4.0	1.0	28.5	--	33.5	5.3
TOTAL	.4	27.2	445.0	8.0	480.6	100.0	6.2	39.5	590.0	8.0	643.7	100.0

Note: 14 inch totals include 10.5 inch drives.
Note: 8 inch totals include 9 inch drives.

FIXED DISK DRIVES 500 MEGABYTES-1 GIGABYTE

1990 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

Alpha Data	Atlas 520
Digital Equipment	RA82
Hitachi	DKU-97S, DKU-85I-D14

10.5" disk diameter

Fujitsu	F6425, M2361A

9" disk diameter

Elebra	W950
Hitachi	DK815-5
Mitsubishi Electric	E1880B
NEC	D2366, N7759
Seagate Technology	ST6515

8" disk diameter

Cerplex	C2600, DS2800
Fujitsu	M2344K/KS
Hewlett-Packard	7937S
IBM	9332-600
Northern Telecom	8312, 8412
Seagate Technology	ST8500, ST8851
Toshiba	MK-288FC, 388FA

5.25" disk diameter

Digirede	W525S/760
Digital Equipment	RF31, RF71
Edisa	ED 71793
Fujitsu	M2263E
Hewlett-Packard	97548P
Hitachi	DK711S-60D, DK515-78
IBM	0681-500, 9336-10
Maxtor	XT-8760E/S, P1-08S
Micropolis	1568-15
Microscience International	FH-2777
NEC	D5682
Orca Technology	Falcon-E/S
Seagate Technology	ST2502N*, ST4766N
Toshiba	MK-358FA

3.5" disk diameter

Maxtor LXT-535*

*Indicates drives with maximum 41.3 mm height, or less.

Until recent years, disk drives in this group consisted mostly of PCM, IBM and other captive floor-standing 14" drives intended for use with mainframe systems.

Control Data's 9" FSD was the pioneer product among drives with disk diameters less than 10.5", but in the mid-1980s several 8" drives with capacities above 500 megabytes entered the market.

Maxtor's introduction of a 768 megabyte 5.25" drive precipitated a flurry of announcements from many of the same companies already competing for the 380 megabyte 5.25" market. Maxtor is also the first company to announce a 3.5" drive in this product group, with first deliveries scheduled for early 1991.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	1,861.4	1,475.7	1,517.6	1,694.3	2,166.8
All manufacturers	2,696.0	2,481.6	2,553.3	2,811.0	3,250.6

On the face of it, total revenues for this product group were declining in 1989 and 1990, but the appearance of decline was actually caused by our reclassification of two drives to another product group. Disk drives are assigned to DISK/TREND product groups on the basis of unformatted capacity. This year we discovered that the IBM 9335 14" drive actually had an unformatted capacity well over 1 gigabyte, so it was moved to that

product group, as was the basic model of the IBM 9336 5.25", with similar capacity, when it was announced this year.

When the 9335 is eliminated from the data for this product group, 1989 total revenues were up 14.6%, and worldwide unit shipments were up 37.6%. The 8.0% estimated revenue drop in 1990 is the direct result of declining shipments for older 8" and 14" drives by U.S manufacturers of captive disk drives.

As in lower capacity product groups, the product mix in the 500 megabyte - 1 gigabyte range is changing rapidly. Shipments for 14" drives peaked in 1988, and 8/9" drives peaked in 1989. In 1989, 8/9" drives led the group with 49.4% of worldwide unit shipments, but were down to an estimated 21.1% in 1990. 5.25" drives are expected to provide 75.9% of 1990's overall unit shipment total, and 74.6% of worldwide non-captive revenues.

After the reclassification of IBM drives mentioned above, mainframe and supermini applications held 35.7% of 1989 shipments, but are projected at only 21.0% in 1993. Minicomputers/multiuser micro/file server applications held 36.3% of 1989 shipments, with a climb to 59% in 1993 expected.

Seagate, having acquired the Imprimis products, held 37.4% of worldwide non-captive shipments in 1989, with 81,300 units, a mixture of 9", 8" and 5.25" drives. Maxtor rose to 25.5% by leading in the 760 megabyte 5.25" market, and Fujitsu retained 18.0%, with its broad line of 10.5", 8" and 5.25" drives.

Marketing trends

Continuing gains in worldwide unit shipment totals are projected for this group through 1993, averaging 26.6% per year. Of course, the

movement to smaller disk drives at lower prices will dampen the growth in revenue for all distribution channels, with the overall gain per year expected to average only 9.5% in the 1991-93 period.

Extensive design-in of 760 megabyte 5.25" drives by system manufacturers has been under way since 1989, which has resulted in the rapid growth for 5.25" drives in 1990 and 1991. The already large shipments of 5.25" OEM/Integrator drives are now being supplemented by new captive drives. However, growth in 5.25" shipments is expected to slow to a crawl after 1991 and peak in 1992, impacted by the same 3.5" form factor which has taken over so much of the shipments for lower capacity drives.

The first 3.5" drive in this capacity range has been introduced by Maxtor for delivery in early 1991, and IBM is expected to announce in the near future a higher capacity version (code-named "Comet") of the "Lightning" (320 megabytes formatted) and "Turbo" (400 megabytes formatted) 3.5" drives. By 1993, 3.5" drives are projected to capture 51.1% of worldwide unit shipments for this product group, diverting much of the growth which otherwise would have gone to 5.25" models.

Although there is considerable speculation regarding the possibility of providing serious competition to IBM in the plug compatible market for mainframe drives through use of multiple spindle arrays of small diameter drives, the actual intentions of IBM's competitors in the PCM market toward this approach are not yet clear, and no provision for such programs are included in this year's DISK/TREND Report. If these programs materialize soon, the potential effect would be the diversion of shipments to this product group from the product group for drives over 1 gigabyte, in the form of enhanced shipments of small drives.

Technical trends

It is believed that the technical developments in this product group during the next few years will consist primarily of performance refinements and capacity improvements to drives already introduced. The basic problem in reducing the physical size of high capacity drives, notably to the 3.5" form factor, has already been accomplished by several drive manufacturers -- with more VLSI, thinner disks, higher density heads and more advanced motors.

The next steps for small drives in this group are expected to be mostly evolutionary. Average head positioning times of 11-14 milliseconds for 3.5" drives in this group will be improved even further. And motor speed for 3.5" drives, now up to 4,300 RPM in the IBM series of 3.5" drives, will go substantially higher.

Forecasting assumptions

1. IBM will stop production of 8" drives in this product group in 1991, and will start shipments of 3.5" drives in the same year.
2. Volume production of 3.5" drives by other manufacturers will start in 1991.

TABLE 52

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	495.0	825.0	375.0	675.0	514.6	805.0	577.5	825.0	825.0	1,250.0
Other U.S. Captive	346.7	682.8	158.6	312.0	101.0	171.5	150.0	288.0	186.0	372.0
TOTAL U.S. CAPTIVE	841.7	1,507.8	533.6	987.0	615.6	976.5	727.5	1,113.0	1,011.0	1,622.0
PCM/Reseller	34.9	42.8	38.0	53.2	60.3	79.5	79.8	107.4	82.6	114.7
OEM/Integrator	246.1	310.8	353.6	435.5	384.9	461.6	392.4	473.9	346.7	430.1
TOTAL U.S. NON-CAPTIVE	281.0	353.6	391.6	488.7	445.2	541.1	472.2	581.3	429.3	544.8
TOTAL U.S. REVENUES	1,122.7	1,861.4	925.2	1,475.7	1,060.8	1,517.6	1,199.7	1,694.3	1,440.3	2,166.8
Non-U.S. Manufacturers										
Captive	3.0	632.0	19.0	789.8	1.6	838.0	14.0	912.0	30.0	888.0
PCM/Reseller	.4	.4	4.2	4.2	5.3	8.6	17.9	25.2	19.6	28.4
OEM/Integrator	100.2	202.2	99.5	211.9	84.3	189.1	60.1	179.5	64.0	167.4
TOTAL NON-U.S. REVENUES	103.6	834.6	122.7	1,005.9	91.2	1,035.7	92.0	1,116.7	113.6	1,083.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,226.3	2,696.0	1,047.9	2,481.6	1,152.0	2,553.3	1,291.7	2,811.0	1,553.9	3,250.6
OEM Average Price ($000)	2.3	2.5	1.6	1.7	1.3	1.4	1.2	1.2	1.0	1.0

TABLE 53

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989 Shipments		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	30.0	50.0	25.0	45.0	68.0	100.0	105.0	150.0	165.0	250.0
Other U.S. Captive	21.8	44.7	21.1	41.3	23.0	39.5	35.0	67.0	50.0	100.0
TOTAL U.S. CAPTIVE	51.8	94.7	46.1	86.3	91.0	139.5	140.0	217.0	215.0	350.0
PCM/Reseller	15.4	18.7	21.0	29.0	39.0	51.0	56.0	75.0	66.0	92.0
OEM/Integrator	110.4	135.6	229.4	278.3	290.0	347.0	329.0	397.0	320.0	398.0
TOTAL U.S. NON-CAPTIVE	125.8	154.3	250.4	307.3	329.0	398.0	385.0	472.0	386.0	490.0
TOTAL U.S. SHIPMENTS	177.6	249.0	296.5	393.6	420.0	537.5	525.0	689.0	601.0	840.0
Non-U.S. Manufacturers										
Captive	.2	32.5	1.2	44.8	.1	53.0	2.0	72.0	5.0	88.0
PCM/Reseller	.1	.1	2.2	2.2	3.1	5.1	12.0	17.0	15.0	22.0
OEM/Integrator	36.3	63.1	50.0	101.7	48.0	112.0	47.0	132.0	57.0	150.0
TOTAL NON-U.S. SHIPMENTS	36.6	95.7	53.4	148.7	51.2	170.1	61.0	221.0	77.0	260.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	214.2	344.7	349.9	542.3	471.2	707.6	586.0	910.0	678.0	1,100.0
Total Capacity (Terabytes)	156.3	249.5	259.8	400.6	340.9	513.8	420.9	655.4	495.2	804.1
Cumulative Shipments (Units in thousands)										
IBM	163.6	331.2	188.6	376.2	256.6	476.2	361.6	626.2	526.6	876.2
Non-IBM	552.9	982.3	877.8	1,479.6	1,281.0	2,087.2	1,762.0	2,847.2	2,275.0	3,697.2
WORLDWIDE TOTAL	716.5	1,313.5	1,066.4	1,855.8	1,537.6	2,563.4	2,123.6	3,473.4	2,801.6	4,573.4

TABLE 54

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues			Forecast													
				1990			1991				1992				1993		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	--	825.0	--	--	675.0	--	--	355.0	--	450.0	--	--	--	825.0	--	--	1,250.0
Other U.S. Captive	296.8	386.0	--	70.0	102.8	139.2	19.5	--	152.0	--	--	--	188.0	100.0	--	196.0	176.0
PCM/Reseller	--	2.6	40.2	--	--	53.2	--	--	70.4	9.1	--	--	87.0	20.4	--	72.9	41.8
OEM/Integrator	--	133.0	177.8	--	77.1	358.4	--	29.7	413.9	18.0	--	12.8	419.3	41.8	--	314.5	115.6
TOTAL U.S. REVENUES	296.8	1,346.6	218.0	70.0	854.9	550.8	19.5	384.7	636.3	477.1	--	12.8	694.3	987.2	--	583.4	1,583.4
NON-U.S. MANUFACTURERS																	
Captive	232.2	394.4	5.4	202.0	283.8	304.0	152.0	176.0	510.0	--	108.0	90.0	588.0	126.0	36.0	624.0	228.0
PCM/Reseller	--	.4	--	--	.8	3.4	--	.4	8.2	--	--	--	18.7	6.5	--	14.0	14.4
OEM/Integrator	32.6	136.1	33.5	22.6	78.5	110.8	10.0	49.5	129.6	--	9.0	15.0	132.5	23.0	--	104.4	63.0
TOTAL NON-U.S. REVENUES	264.8	530.9	38.9	224.6	363.1	418.2	162.0	225.9	647.8	--	117.0	105.0	739.2	155.5	36.0	742.4	305.4
WORLDWIDE RECAP																	
Captive	529.0	1,605.4	5.4	272.0	1,061.6	443.2	171.5	531.0	662.0	450.0	108.0	90.0	776.0	1,051.0	36.0	820.0	1,654.0
	-74.8%	+91.6%	--	-48.6%	-33.9%	--	-36.9%	-50.0%	+49.4%	--	-37.0%	-83.1%	+17.2%	+133.6%	-66.7%	+5.7%	+57.4%
PCM/Reseller	--	3.0	40.2	--	.8	56.6	--	.4	78.6	9.1	--	--	105.7	26.9	--	86.9	56.2
	--	-69.4%	+408.9%	--	-73.3%	+40.8%	--	-50.0%	+38.9%	--	--	-100.0%	+34.5%	+195.6%	--	-17.8%	+108.9%
OEM/Integrator	32.6	269.1	211.3	22.6	155.6	469.2	10.0	79.2	543.5	18.0	9.0	27.8	551.8	64.8	--	418.9	178.6
	-65.4%	-41.0%	+523.3%	-30.7%	-42.2%	+122.1%	-55.8%	-49.1%	+15.8%	--	-10.0%	-64.9%	+1.5%	+260.0%	-100.0%	-24.1%	+175.6%
Total Revenues	561.6	1,877.5	256.9	294.6	1,218.0	969.0	181.5	610.6	1,284.1	477.1	117.0	117.8	1,433.5	1,142.7	36.0	1,325.8	1,888.8
	-74.4%	+44.0%	+514.6%	-47.5%	-35.1%	+277.2%	-38.4%	-49.9%	+32.5%	--	-35.5%	-80.7%	+11.6%	+139.5%	-69.2%	-7.5%	+65.3%
ANNUAL SHARE, BY DIAMETER	20.9%	69.6%	9.5%	11.9%	49.2%	38.9%	7.1%	24.0%	50.3%	18.6%	4.2%	4.2%	51.1%	40.5%	1.1%	40.9%	58.0%

Note: 14 inch totals include 10.5 inch drives.
8 inch totals include 9 inch drives.

TABLE 55

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments			Forecast													
				1990			1991				1992				1993		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	5.25"	3.5"
U.S. MANUFACTURERS																	
IBM Captive	--	50.0	--	--	45.0	--	--	25.0	--	75.0	--	--	--	150.0	--	--	250.0
Other U.S. Captive	19.2	25.5	--	5.0	7.3	29.0	1.5	--	38.0	--	--	--	47.0	20.0	--	56.0	44.0
PCM/Reseller	--	.7	18.0	--	--	29.0	--	--	44.0	7.0	--	--	58.0	17.0	--	54.0	38.0
OEM/Integrator	--	34.5	101.1	--	22.3	256.0	--	9.0	323.0	15.0	--	4.0	355.0	38.0	--	280.0	118.0
TOTAL U.S. SHIPMENTS	19.2	110.7	119.1	5.0	74.6	314.0	1.5	34.0	405.0	97.0	--	4.0	460.0	225.0	--	390.0	450.0
NON-U.S. MANUFACTURERS																	
Captive	11.4	20.8	.3	10.0	15.8	19.0	8.0	11.0	34.0	--	6.0	6.0	42.0	18.0	2.0	48.0	38.0
PCM/Reseller	--	.1	--	--	.2	2.0	--	.1	5.0	--	--	--	12.0	5.0	--	10.0	12.0
OEM/Integrator	1.6	38.5	23.0	1.3	23.4	77.0	1.0	15.0	96.0	--	1.0	5.0	106.0	20.0	--	87.0	63.0
TOTAL NON-U.S. SHIPMENTS	13.0	59.4	23.3	11.3	39.4	98.0	9.0	26.1	135.0	--	7.0	11.0	160.0	43.0	2.0	145.0	113.0
WORLDWIDE RECAP																	
Captive	30.6	96.3	.3	15.0	68.1	48.0	9.5	36.0	72.0	75.0	6.0	6.0	89.0	188.0	2.0	104.0	332.0
	-71.3%	+89.9%	--	-51.0%	-29.3%	--	-36.7%	-47.1%	+50.0%	--	-36.8%	-83.3%	+23.6%	+150.7%	-66.7%	+16.9%	+76.6%
PCM/Reseller	--	.8	18.0	--	.2	31.0	--	.1	49.0	7.0	--	--	70.0	22.0	--	64.0	50.0
	--	-57.9%	+462.5%	--	-75.0%	+72.2%	--	-50.0%	+58.1%	--	--	-100.0%	+42.9%	+214.3%	--	-8.6%	+127.3%
OEM/Integrator	1.6	73.0	124.1	1.3	45.7	333.0	1.0	24.0	419.0	15.0	1.0	9.0	461.0	58.0	--	367.0	181.0
	-89.0%	-35.0%	+773.9%	-18.7%	-37.4%	+168.3%	-23.1%	-47.5%	+25.8%	--	--	-62.5%	+10.0%	+286.7%	-100.0%	-20.4%	+212.1%
Total Shipments	32.2	170.1	142.4	16.3	114.0	412.0	10.5	60.1	540.0	97.0	7.0	15.0	620.0	268.0	2.0	535.0	563.0
	-73.4%	+3.2%	+718.4%	-49.4%	-33.0%	+189.3%	-35.6%	-47.3%	+31.1%	--	-33.3%	-75.0%	+14.8%	+176.3%	-71.4%	-13.7%	+110.1%
ANNUAL SHARE, BY DIAMETER	9.3%	49.4%	41.3%	3.0%	21.1%	75.9%	1.5%	8.5%	76.4%	13.6%	.8%	1.6%	68.2%	29.4%	.2%	48.7%	51.1%
TOTAL CAPACITY (Terabytes)	16.4	74.7	90.0	4.3	51.3	234.5	1.3	24.0	303.0	57.4	--	2.8	342.4	145.5	--	288.4	325.0

Note: 14 inch totals include 10.5 inch drives.
8 inch totals include 9 inch drives.

TABLE 56

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	122.9	35.7	231.0	21.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	125.2	36.3	649.0	59.0
PERSONAL COMPUTERS Business and professional, single user	10.4	3.0	66.0	6.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	15.1	4.4	33.0	3.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	71.1	20.6	121.0	11.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	344.7	100.0	1,100.0	100.0

TABLE 57

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
Seagate Technology	--	24.6	35.6	60.2	37.1	--	34.3	47.0	81.3	37.4
Maxtor	--	--	50.1	50.1	30.9	--	--	55.5	55.5	25.5
Fujitsu	--	14.0	6.6	20.6	12.7	1.6	25.5	12.0	39.1	18.0
Other U.S.	--	.9	14.6	15.5	9.6	--	.9	16.6	17.5	8.0
Other Non-U.S.	--	9.1	6.7	15.8	9.7	--	13.1	11.0	24.1	11.1
TOTAL	--	48.6	113.6	162.2	100.0	1.6	73.8	142.1	217.5	100.0

Note: 14 inch totals include 10.5 inch drives.
Note: 8 inch totals include 9 inch drives.

FIXED DISK DRIVES, OVER 1 GIGABYTE

1990 DISK/TREND REPORT

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

14" disk diameter

Hitachi	DKU-85I, DKU-98I
Ibis	2812
IBM	3380-J, 3380-K, 9335
Storage Technology	8380-BP4, 8380F

10.8" disk diameter

IBM	3390-1/2

10.5" disk diameter

Fujitsu	F6425M4, F6425H

9.5" disk diameter

Hitachi	DKU-86I, H-6587

9" disk diameter

Digital Equipment	RA90, RA92
Hitachi	DK815-10
NEC	D2367, D2377

8" disk diameter

Fujitsu	M2392K
Northern Telecom	8514
Seagate Technology	ST81236, ST82500

5.25" disk diameter

Fujitsu	M2266
Hewlett-Packard	97560E
Hitachi	DK516C-16
IBM	0681-1000, 9336-20
Maxtor	P1-13E, P2-21S
Micropolis	1518-15
Microscience International	FH-31200
NEC	D5892
Seagate Technology	ST41600N, ST41201

IBM's 3380 series of high-end mainframe disk drives was the core of this product group during most of the 1980s. The original 3380 was first shipped in 4th quarter of 1981, after an extremely expensive (to IBM) delay of over a year from the announced delivery schedule. The double density 3380E arrived in July, 1985, and the triple density 3380K in October, 1987, marking the first time that IBM has offered two mid-life enhancements in a disk drive model series.

The other 14", 10.5", and 9.5" drives in this group are intended for mainframe and supermini applications similar to IBM's, and most use technology similar to IBM's 3380 drives, relying on oxide coated disks and thin film heads. The exceptions are a few drives using ferrite heads, plus the Ibis drives now at end of life, which use plated disks and offer 12 megabyte/second transfer rates for supercomputer and high-end imaging applications through parallel transfer electronics.

The 8" and 9" drives now offer capacities over 3 gigabytes, and are used typically in small mainframe, supermini and imaging applications. Some are also finding their way into mainframe PCM applications, with Fujitsu 8" drives now included in a plug compatible 3380 equivalent subsystem.

5.25" drives have become the most numerous models in the above list, even though shipments just got started in 1989. Most 5.25" drives in the group follow the physical packaging of the original Maxtor 5.25" drive configuration, with 8 disks in a 3.25" high drive. However, IBM's "Redwing" drives use 12 disks, although maintaining the same drive height.

Plug compatible drives sold by major mainframe PCM vendors such as Amdahl, National Advanced Systems, Comparex and Memorex Telex have been included in the product specification section, in the interest of clarity.

Currently, Fujitsu makes the drives sold by Amdahl, while Hitachi makes the drives sold by National Advanced Systems and Comparex. Drives currently offered in the plug compatible market by Memorex Telex are made by Unisys, Fujitsu and Northern Telecom.

Market status

DISK/TREND estimate of total market size:

Worldwide sales ($M)	1989	1990	1991	1992	1993
U.S. manufacturers	6,887.4	8,366.2	9,618.2	9,736.6	10,503.3
All manufacturers	8,735.0	10,387.6	11,655.2	11,646.1	12,376.3

As the result of reclassifying the IBM 9335 to this product group, since its unformatted capacity is actually over 1 gigabyte, it is difficult to make a direct year-to-year comparison of some data from this group with last year's DISK/TREND Report. However, with the reclassification of the 9335 taken into account, the product group was up 19.2% in total worldwide revenues, and also grew 30.9% in unit shipments of all types of drives.

Overall unit shipment growth is expected to increase another 47.3% in 1990, to 469,200 drives, based on 42.8% growth in 8/9" drive shipments and the start of volume production shipments for 5.25" drives. The spurt in 5.25" drive shipments is being generated by IBM's usage of its new "Redwing" drive on workstations, office computers and mainframes, plus the first year of real shipments for several independent drive manufacturers selling to OEM/Integrator customers.

The big money in this product group comes from IBM drives sold to mainframe users -- currently over $5 billion per year. With the introduc-

tion last November of the 3390, IBM signaled the end of the ten year life of the 3380, by far the most important revenue producer in the 34 year history of IBM's disk drive business.

IBM 1990 captive shipments for 3380K are estimated to be only half of the 1989 level, down to 32,000 spindles. IBM 3390 captive shipments for the year are estimated at 68,000 spindles. 1990 is a growth year for the plug compatible distribution channel for 3380K equivalent drives, but shipments of PCM single and double capacity models are now at very low levels. The independents are projected to ship 24,300 3380K equivalent spindles this year.

Fujitsu captured the highest 1989 total for non-captive unit shipments, with 35,000 units, the majority 8" models signaling Fujitsu's major role in the 8" OEM/Integrator market. Hitachi was second with 22.7%, mostly representing 9/9.5" drives, and Seagate held third with 19.8%, mostly 8" drives.

Marketing trends

It's a tough life for those companies which choose to compete with IBM in the market for disk drives used with IBM mainframes. That's been true for twenty years, and the degree of difficulty is increasing, considering the rapidity of new model introductions and the higher level of investment required for each generation.

We currently assume the introduction of a 1991 mid-life kicker for the 3390, with 50% more capacity, and most important, an improvement in price per megabyte. The pricing improvement will probably be about 22% compared to today's 3390 model 2, and about 33% compared to the 3380K.

This is the level required to motivate the majority of IBM's mainframe customers to migrate to the new drive, and which will be required by mid-1991 to maintain reasonable sales momentum for the 3390 family.

Based on the above assumptions, DISK/TREND forecasts show a complete replacement of the current 3390 by the enhanced model during 1992. However, these shipments alone would not be sufficient to maintain the expected annual increases in disk storage for mainframe applications, and the forecasts also assume the long-delayed introduction of the 5.25" Sutter drive. The Sutter, with an even lower price per megabyte, is expected to find a large market with IBM's mainframe customers who don't think they need much more performance, but who cherish a strong belief that they need a much better price from IBM.

Most of the existing plug compatible drive participants should be able to match the impressive IBM improvements mentioned above, but they will probably do it in a variety of creative ways. Most have offered drives equivalent to the 3380K with disks smaller than 14", and they will match the 3390 with disks smaller than 10.8".

If the 5.25" Sutter appears as envisioned, development of an equivalent drive may be even more attainable, since there will be many other high capacity 5.25" drives available. The greater problem may well be found in controller electronics and firmware, as the logical complexity grows and as IBM has more possibilities to bury subtleties in the logic of system managed storage.

OEM drives have become a major part of the industry's shipments in this product group during the past two years, and their role will become larger. OEM shipments of 8"-9" drives are not expected to peak during the 1991-94 period. But the 5.25" drives introduced in 1989 and going into

volume production this year are destined to overtake all other drive form factors in this group, and are expected to provide over 80% of 1993's unit shipments of non-captive drives.

Technical trends

The technology employed in IBM's 3390 "Soquel" drive was substantially what the industry expected -- 10.8" oxide coated disks, inductive thin film heads, 62 megabits/square inch (2,235 TPI, 27,940 BPI using 1,7 RLL), and 4,260 RPM.

What will happen next? The timing and sequence of events may vary greatly, but it appears that IBM is working on a mid-life kicker for the 3390, as well as proceeding with development of the 5.25" "Sutter" drive. Business strategy may well control which program gets the nod first, rather than technical considerations.

The purpose of the enhanced 3390 will be to improve IBM's return on the basic investment in development and production equipment for the program and to provide the lower price per megabyte that the majority of current 3380K users will demand before migrating to the 3390 family. It is believed that the next 3390 version will offer 50% more capacity, achieved through high track density, and that IBM will try to put it in production in 1991.

The 5.25" Sutter had been scheduled for introduction this year, but has been delayed until next year if current plans stay on track. The Sutter has been planned to achieve the transfer rates required for mainframe channels, by employing high linear density and a 5,400 RPM motor. The capacity utilized in the final version of this drive will probably

depend on when it is finally introduced, as will the question of whether array subsystem versions will also be available at time of introduction. If the introduction is in 1991, we currently assume 1.8 gigabyte capacity per spindle.

Forecasting assumptions

1. IBM will ship both an enhanced version of the 3390 and the 5.25" Sutter drive in 1991. Last shipments of 3380 and 9335 drives will occur in 1991.

2. PCM vendors will match IBM's 3390 starting in 1991, and will match new IBM drives expected in 1991 starting in 1992.

3. Shipments of 5.25" drives in OEM/Integrator markets will grow rapidly in the 1990-93 period.

TABLE 58

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1989 Revenues		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3,361.7	5,567.8	4,497.1	6,798.8	4,978.5	7,667.0	4,716.8	7,625.1	5,040.0	8,375.0
Other U.S. Captive	547.0	865.5	603.0	1,078.8	691.0	1,282.0	700.8	1,300.8	605.5	1,143.0
TOTAL U.S. CAPTIVE	3,908.7	6,433.3	5,100.1	7,877.6	5,669.5	8,949.0	5,417.6	8,925.9	5,645.5	9,518.0
PCM/Reseller	116.1	187.2	88.1	118.7	121.9	168.1	74.0	102.6	49.6	67.2
OEM/Integrator	147.6	266.9	247.3	369.9	339.5	501.1	465.4	708.1	584.3	918.1
TOTAL U.S. NON-CAPTIVE	263.7	454.1	335.4	488.6	461.4	669.2	539.4	810.7	633.9	985.3
TOTAL U.S. REVENUES	4,172.4	6,887.4	5,435.5	8,366.2	6,130.9	9,618.2	5,957.0	9,736.6	6,279.4	10,503.3
Non-U.S. Manufacturers										
Captive	1.7	838.8	1.7	1,004.3	--	899.0	--	645.0	--	419.0
PCM/Reseller	263.6	590.5	292.7	646.2	414.0	773.2	515.4	893.0	634.0	1,090.0
OEM/Integrator	215.4	418.3	177.1	370.9	211.8	364.8	232.8	371.5	217.6	364.0
TOTAL NON-U.S. REVENUES	480.7	1,847.6	471.5	2,021.4	625.8	2,037.0	748.2	1,909.5	851.6	1,873.0
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	4,653.1	8,735.0	5,907.0	10,387.6	6,756.7	11,655.2	6,705.2	11,646.1	7,131.0	12,376.3
OEM Average Price ($000)	6.0	8.5	3.8	4.9	3.1	3.6	2.4	2.7	1.9	2.1

TABLE 59

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1989 Shipments		Forecast 1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	82.0	141.0	130.0	198.5	167.5	257.0	189.0	300.0	238.0	395.0
Other U.S. Captive	20.3	32.0	24.9	44.5	43.0	83.0	51.0	100.0	54.0	109.0
TOTAL U.S. CAPTIVE	102.3	173.0	154.9	243.0	210.5	340.0	240.0	400.0	292.0	504.0
PCM/Reseller	9.6	13.2	9.8	11.6	22.0	26.5	23.4	32.0	31.0	42.0
OEM/Integrator	18.7	23.7	71.8	83.7	122.0	153.3	205.9	274.5	309.1	442.0
TOTAL U.S. NON-CAPTIVE	28.3	36.9	81.6	95.3	144.0	179.8	229.3	306.5	340.1	484.0
TOTAL U.S. SHIPMENTS	130.6	209.9	236.5	338.3	354.5	519.8	469.3	706.5	632.1	988.0
Non-U.S. Manufacturers										
Captive	.1	31.1	.1	41.2	--	39.0	--	30.0	--	21.0
PCM/Reseller	8.8	20.9	10.9	24.5	15.0	28.0	28.6	49.0	40.0	70.0
OEM/Integrator	41.1	56.7	38.3	65.2	55.0	87.0	76.0	123.0	94.0	157.0
TOTAL NON-U.S. SHIPMENTS	50.0	108.7	49.3	130.9	70.0	154.0	104.6	202.0	134.0	248.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	180.6	318.6	285.8	469.2	424.5	673.8	573.9	908.5	766.1	1,236.0
Total Capacity (Terabytes)	411.0	723.2	625.5	1,017.7	886.6	1,421.7	1,211.8	1,957.4	1,615.2	2,635.1
Cumulative Shipments (Units in thousands)										
IBM	376.0	639.3	506.0	837.8	673.5	1,094.8	862.5	1,394.8	1,100.5	1,789.8
Non-IBM	211.4	452.1	367.2	722.8	624.2	1,139.6	1,009.1	1,748.1	1,537.2	2,589.1
WORLDWIDE TOTAL	587.4	1,091.4	873.2	1,560.6	1,297.7	2,234.4	1,871.6	3,142.9	2,637.7	4,378.9

TABLE 60

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1989 Revenues			Forecast											
	1990			1991			1992			1993		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS															
IBM Captive	5,567.8	--	--	5,954.0	--	844.8	5,522.0	--	2,145.0	4,160.0	--	3,465.1	3,500.0	--	4,875.0
Other U.S. Captive	156.0	709.5	--	46.2	1,032.0	.6	--	1,122.0	160.0	--	1,080.0	220.8	--	855.0	288.0
PCM/Reseller	162.6	24.6	--	94.8	20.4	3.5	121.5	10.5	36.1	50.0	3.3	49.3	--	--	67.2
OEM/Integrator	187.6	76.8	2.5	157.6	138.3	74.0	161.1	176.8	163.2	185.9	178.2	344.0	195.1	138.0	585.0
TOTAL U.S. REVENUES	6,074.0	810.9	2.5	6,252.6	1,190.7	922.9	5,804.6	1,309.3	2,504.3	4,395.9	1,261.5	4,079.2	3,695.1	993.0	5,815.2
NON-U.S. MANUFACTURERS															
Captive	546.0	292.8	--	540.0	464.3	--	416.0	483.0	--	225.0	420.0	--	96.0	323.0	--
PCM/Reseller	138.3	452.2	--	123.2	523.0	--	140.4	632.8	--	72.0	546.0	275.0	--	690.0	400.0
OEM/Integrator	144.6	273.7	--	75.1	280.2	15.6	38.0	273.6	53.2	--	261.0	110.5	--	188.0	176.0
TOTAL NON-U.S. REVENUES	828.9	1,018.7	--	738.3	1,267.5	15.6	594.4	1,389.4	53.2	297.0	1,227.0	385.5	96.0	1,201.0	576.0
WORLDWIDE RECAP															
Captive	6,269.8	1,002.3	--	6,540.2	1,496.3	845.4	5,938.0	1,605.0	2,305.0	4,385.0	1,500.0	3,685.9	3,596.0	1,178.0	5,163.0
	+36.5%	+631.6%	--	+4.3%	+49.3%	--	-9.2%	+7.3%	+172.7%	-26.2%	-6.5%	+59.9%	-18.0%	-21.5%	+40.1%
PCM/Reseller	300.9	476.8	--	218.0	543.4	3.5	261.9	643.3	36.1	122.0	549.3	324.3	--	690.0	467.2
	-57.4%	+223.3%	--	-27.6%	+14.0%	--	+20.1%	+18.4%	+931.4%	-53.4%	-14.6%	+798.3%	-100.0%	+25.6%	+44.1%
OEM/Integrator	332.2	350.5	2.5	232.7	418.5	89.6	199.1	450.4	216.4	185.9	439.2	454.5	195.1	326.0	761.0
	-13.4%	+100.1%	--	-30.0%	+19.4%	--	-14.4%	+7.6%	+141.5%	-6.6%	-2.5%	+110.0%	+4.9%	-25.8%	+67.4%
Total Revenues	6,902.9	1,829.6	2.5	6,990.9	2,458.2	938.5	6,399.0	2,698.7	2,557.5	4,692.9	2,488.5	4,464.7	3,791.1	2,194.0	6,391.2
	+21.5%	+298.0%	--	+1.3%	+34.4%	--	-8.5%	+9.8%	+172.5%	-26.7%	-7.8%	+74.6%	-19.2%	-11.8%	+43.1%
ANNUAL SHARE, BY DIAMETER	79.1%	20.9%	--	67.4%	23.7%	8.9%	55.0%	23.2%	21.8%	40.4%	21.4%	38.2%	30.7%	17.7%	51.6%

Note: 14 inch totals include 10.5 inch drives.
8 inch totals include 9 and 9.5 inch drives.

TABLE 61

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1989 Shipments			Forecast											
				1990			1991			1992			1993		
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
U.S. MANUFACTURERS															
IBM Captive	141.0	--	--	150.5	--	48.0	127.0	--	130.0	80.0	--	220.0	70.0	--	325.0
Other U.S. Captive	4.7	27.3	--	1.4	43.0	.1	--	51.0	32.0	--	54.0	46.0	--	45.0	64.0
PCM/Reseller	8.1	5.1	--	4.7	5.5	1.4	4.5	3.0	19.0	2.0	1.0	29.0	--	--	42.0
OEM/Integrator	6.6	16.0	1.1	5.2	39.5	39.0	5.3	52.0	96.0	5.5	54.0	215.0	6.0	46.0	390.0
TOTAL U.S. SHIPMENTS	160.4	48.4	1.1	161.8	88.0	88.5	136.8	106.0	277.0	87.5	109.0	510.0	76.0	91.0	821.0
NON-U.S. MANUFACTURERS															
Captive	18.2	12.9	--	20.0	21.2	--	16.0	23.0	--	9.0	21.0	--	4.0	17.0	--
PCM/Reseller	4.4	16.5	--	4.4	20.1	--	5.4	22.6	--	3.0	21.0	25.0	--	30.0	40.0
OEM/Integrator	5.6	51.1	--	3.6	54.8	6.8	2.0	57.0	28.0	--	58.0	65.0	--	47.0	110.0
TOTAL NON-U.S. SHIPMENTS	28.2	80.5	--	28.0	96.1	6.8	23.4	102.6	28.0	12.0	100.0	90.0	4.0	94.0	150.0
WORLDWIDE RECAP															
Captive	163.9	40.2	--	171.9	64.2	48.1	143.0	74.0	162.0	89.0	75.0	266.0	74.0	62.0	389.0
	+57.9%	+658.5%	--	+4.9%	+59.7%	--	-16.8%	+15.3%	+236.8%	-37.8%	+1.4%	+64.2%	-16.9%	-17.3%	+46.2%
PCM/Reseller	12.5	21.6	--	9.1	25.6	1.4	9.9	25.6	19.0	5.0	22.0	54.0	--	30.0	82.0
	-60.3%	+242.9%	--	-27.2%	+18.5%	--	+8.8%	--	--	-49.5%	-14.1%	+184.2%	-100.0%	+36.4%	+51.9%
OEM/Integrator	12.2	67.1	1.1	8.8	94.3	45.8	7.3	109.0	124.0	5.5	112.0	280.0	6.0	93.0	500.0
	-19.7%	+137.1%	--	-27.9%	+40.5%	--	-17.0%	+15.6%	+170.7%	-24.7%	+2.8%	+125.8%	+9.1%	-17.0%	+78.6%
Total Shipments	188.6	128.9	1.1	189.8	184.1	95.3	160.2	208.6	305.0	99.5	209.0	600.0	80.0	185.0	971.0
	+25.3%	+223.1%	--	+.6%	+42.8%	--	-15.6%	+13.3%	+220.0%	-37.9%	+.2%	+96.7%	-19.6%	-11.5%	+61.8%
ANNUAL SHARE, BY DIAMETER	59.3%	40.5%	.2%	40.6%	39.2%	20.2%	23.9%	31.0%	45.1%	11.0%	23.1%	65.9%	6.5%	15.0%	78.5%
TOTAL CAPACITY (Terabytes)	465.3	69.6	1.3	525.8	144.9	106.1	603.9	153.1	372.9	580.9	174.3	806.1	508.4	159.2	1,406.9

Note: 14 inch totals include 10.5 inch drives.
8 inch totals include 9 and 9.5 inch drives.

TABLE 62

WORLDWIDE SHIPMENTS OF IBM CAPTIVE AND PCM FIXED DISK DRIVES

PRODUCT MIX ANALYSIS

	DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)									
	1989		FORECAST							
	Shipments		1990		1991		1992		1993	
	US	WW	US	WW	US	WW	US	WW	US	WW
IBM 9335 (856 MB)	28.0	55.0	23.0	45.0	10.0	20.0	--	--	--	--
IBM 9336 (857 MB)	--	--	36.0	48.0	60.0	85.0	75.0	110.0	80.0	125.0
3380J Type (1260 MB)										
IBM	6.5	11.0	3.0	5.5	--	--	--	--	--	--
PCM*	1.8	6.8	.9	3.1	.3	1.5	--	--	--	--
TOTAL	8.3	17.8	3.9	8.6	.3	1.5	--	--	--	--
3380E Type (2520 MB)										
IBM	--	--	--	--	--	--	--	--	--	--
PCM*	3.5	6.9	1.1	1.7	--	--	--	--	--	--
TOTAL	3.5	6.9	1.1	1.7	--	--	--	--	--	--
3380K Type (3780 MB)										
IBM	42.0	67.0	20.0	32.0	6.5	11.0	--	--	--	--
PCM*	8.9	16.7	12.0	24.3	9.5	19.0	2.0	5.0	--	--
TOTAL	50.9	83.7	32.0	56.3	16.0	30.0	2.0	5.0	--	--
3390 type (3780 MB)										
IBM	5.5	8.0	48.0	68.0	58.0	86.0	--	--	--	--
PCM*	--	--	--	--	8.5	12.0	9.0	15.0	2.0	4.0
TOTAL	5.5	8.0	48.0	68.0	66.5	98.0	9.0	15.0	2.0	4.0
Not yet announced										
IBM 3390 x 1.5 (5670 MB)	--	--	--	--	6.0	10.0	48.0	80.0	42.0	70.0
PCM* 3390 x 1.5 (5670 MB)	--	--	--	--	--	--	4.0	6.0	16.0	26.0
TOTAL 3390 x 1.5	--	--	--	--	6.0	10.0	52.0	86.0	58.0	96.0
IBM 5.25 INCH (1800 MB)	--	--	--	--	27.0	45.0	66.0	110.0	116.0	200.0
PCM* 5.25 INCH (1800 MB)	--	--	--	--	--	--	15.0	25.0	22.0	40.0
TOTAL 5.25 INCH	--	--	--	--	27.0	45.0	81.0	135.0	138.0	240.0
TOTAL SPINDLES	96.2	171.4	144.0	227.6	185.8	289.5	219.0	351.0	278.0	465.0
TOTAL FORMATTED CAPACITY (Terabytes)		433.5 +13%		564.6 +30%		713.4 +26%		900.5 +26%		1,098.6 +24%

* PCM 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.

TABLE 63

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1989 Estimate Units (000)	1989 Estimate %	1993 Projection Units (000)	1993 Projection %
MAINFRAME/SUPERMINI General purpose	244.9	76.9	815.7	66.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	68.6	21.5	346.1	28.0
PERSONAL COMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	--	--	--	--
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	5.0	1.6	74.2	6.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	318.6	100.0	1,236.0	100.0

TABLE 64

FIXED DISK DRIVES, MORE THAN 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Non-Captive Disk Drives

	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
Fujitsu	2.5	24.0	--	26.5	33.9	8.6	26.4	--	35.0	30.6
Hitachi	--	10.8	--	10.8	13.8	1.4	24.6	--	26.0	22.7
Seagate Technology	1.0	19.2	.9	21.1	27.0	1.0	20.7	1.0	22.7	19.8
NEC	--	12.0	--	12.0	15.3	--	16.0	--	16.0	14.0
Other U.S.	6.7	.4	.1	7.2	9.2	13.7	.4	.1	14.2	12.4
Other Non-U.S.	--	.6	--	.6	.8	--	.6	--	.6	.5
TOTAL	10.2	67.0	1.0	78.2	100.0	24.7	88.7	1.1	114.5	100.0

Note: 14 inch totals include 10.5 inch drives.
Note: 8 inch totals include 9 and 9.5 inch drives.

RIGID DISK DRIVE SPECIFICATIONS

1990 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. Not listed in most cases are captive drives which are similar to OEM/Integrator models made by the same manufacturer. For most plug compatible drives used with mainframes, drives made by one manufacturer and resold by another firm have been included for identification purposes.

Generic type

Where applicable, model numbers of IBM or other manufacturers are used to describe various characteristics of drives and media, since these designations are well-known throughout the industry. However, such usage of a specific model number is not meant to imply interchangeability, due to variations in media, recording formats and interfaces.

Interfaces

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

OEM prices

Previous editions of the DISK/TREND Report included information in the specifications section on the OEM/Integrator price for drives sold in the United States at the 100 unit level, or for larger quantities in some cases. Starting with this year's edition of the report, price information for individual products is no longer included, because of the rapid changes involved and the lack of actual selling activity at the low quantity level for which prices were provided.

Capacities

Capacities are listed as "U" for unformatted or "F" for formatted. In general, unformatted capacities are shown for OEM/Integrator and PCM/Reseller drives without embedded controllers, and formatted capacities are given for captive drives and non-captive drives with embedded controllers, such as SCSI or PC/AT. Unformatted capacity is used to determine the appropriate DISK/TREND product group for each drive.

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.

1990 DISK/TREND product groups for rigid magnetic disk drives

Removable magnetic media:	1.	Disk cartridge drives
	2.	Disk pack drives
Fixed magnetic media:	3.	Fixed disk drives, less than 30 megabytes
	4.	Fixed disk drives, 30-60 megabytes
	5.	Fixed disk drives, 60-100 megabytes
	6.	Fixed disk drives, 100-300 megabytes
	7.	Fixed disk drives, 300-500 megabytes
	8.	Fixed disk drives, 500 MB-1 gigabyte
	9.	Fixed disk drives, more than 1 gigabyte

MANUFACTURER	ALPHA DATA	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	Atlas 520	DRP020A	DRP020D	DRP020L	DRP020Q
DISK/TREND GROUP	8	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	MIG	MIG	MIG
Interface	ESMD	Alps	SCSI	Alps	SASI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 520	U: 25.6	F: 21.4	U: 25.6	F: 22.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 20,832	F: 17,408	U: 20,832	F: 18,432
Data surfaces per spindle	7.6	2	2	2	2
Heads per data surface	10	1	1	1	1
Tracks per surface	2250	615	615	615	615
Track density (TPI)	1000	880	880	880	880
Maximum linear density (BPI)	11700	27022 BPI 18015 FCI	27022 BPI 18015 FCI	27022 BPI 18015 FCI	28823 BPI 19216 FCI
Recording code	MFM	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	2640	2640	2640	2640
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Servo type	Dedicated Surf.	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	18	75 (including settling)	75 (including settling)	60 (including settling)	75 (including settling)
Average rotational delay (msec)	8.3	11.4	11.4	11.4	11.4
Average access time (msec)	26.3	86.4	86.4	71.4	86.4
Data transfer rate (KBytes/sec)	1800	937.5	1429	937.5	625.5
FIRST CUSTOMER SHIPMENT	2Q86	1987	1987	1988	1988
COMMENTS	8 parallel channel version available	25.4 mm high	30 mm high	25.4 mm high	30 mm high

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRIVE	DRQ040A	DRQ040D	DRR040C	DRR040D	DRR100C
DISK/TREND GROUP	4	4	4	4	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	Alps	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2	F: 42.8	F: 42.8	F: 45.34	F: 105.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 17,408	F: 17,920	F: 17,920	F: 17,920
Data surfaces per spindle	4	4	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	1195	1265	1465
Track density (TPI)	880	880	1400	1740	1740
Maximum linear density (BPI)	27022 BPI 18015 FCI	27022 BPI 18015 FCI	33343 BPI 22229 FCI	33343 BPI 22229 FCI	33343 BPI 22229 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	2640	2640	3205	3205	3205
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Embedded	Embedded	Embedded
Average positioning time (msec)	45 (including settling)	45 (including settling)	19	19	19
Average rotational delay (msec)	11.4	11.4	9.4	9.4	9.4
Average access time (msec)	56.4	56.4	28.4	28.4	28.4
Data transfer rate (KBytes/sec)	937.5	1667	750	2000	750
FIRST CUSTOMER SHIPMENT	1988	1988	4Q89	1990	1Q90
COMMENTS	25.4 mm high	30 mm high	20.8 mm high	20.8 mm high	25.4 mm high

MANUFACTURER	ALPS ELECTRIC	AMDAHL	AMDAHL	AREAL TECHNOLOGY	ATASI TECHNOLOGY
DRIVE	DRR100D	6380-AJ4 6380-BJ4	6380-AK4 6380-BK4	MD-2050	519
DISK/TREND GROUP	6	8	9	4	6
MARKET	OEM	PCM	PCM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	65 mm OD 20 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Sputtered	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	Thin Film	Ferrite
Interface	SCSI	IBM	IBM	SCSI, PC AT	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105.0	F: 630	F: 1,890	F: 50.2	U: 191.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 47,476	F: 47,476	F: 30,720	U: 10,416
Data surfaces per spindle	4	8	16	2	15
Heads per data surface	1	2	2	1	1
Tracks per surface	1465	1770	2656	819	1224
Track density (TPI)	1740	1350	1350	1931	1070
Maximum linear density (BPI)	33343 BPI 22229 FCI	21300 BPI 15975 FCI	24440 BPI 18330 FCI	57000 BPI 38000 FCI	10924
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3205	3620	3620	1600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	19	12	16	29	22
Average rotational delay (msec)	9.4	8.3	8.3	18.75	8.3
Average access time (msec)	28.4	20.3	24.3	47.75	30.3
Data transfer rate (KBytes/sec)	2000	3000	3000	937.5	625
FIRST CUSTOMER SHIPMENT	1990	1Q89	1Q89	2Q90	1Q86
COMMENTS	25.4 mm high	PCM 3380J Drive has 4 spindles	PCM 3380K Drive has 4 spindles	17 mm high	

MANUFACTURER	ATASI TECHNOLOGY	ATASI TECHNOLOGY	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES
DRIVE	638	738	BT9170A	BT9170E	BT9170S
DISK/TREND GROUP	7	7	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	ESDI	SCSI	PC AT	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 382.7	F: 353.5	F: 150	U: 170	F: 150
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 19,456	F: 18,432	U: 20,850	F: 18,432
Data surfaces per spindle	15	15	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1225	1225	1166	1166	1166
Track density (TPI)	1070	1070	1328	1328	1328
Maximum linear density (BPI)	21848 BPI 14565 FCI	21848 BPI 14565 FCI	29700 BPI 19800 FCI	29700 BPI 19800 FCI	29700 BPI 19800 FCI
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	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	18	16.5	16.5	16.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	24.8	24.8	24.8
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	3Q86	4Q86	8/90	8/90	8/90
COMMENTS			41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	BRAND TECHNOLOGIES	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS
DRIVE	BT9220A	BT9220E	BT9220S	F3160-E	F3192-S,A
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	ESDI	SCSI	ESDI	SCSI, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 200	U: 226	F: 200	U: 160	F: 167
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 20,850	F: 18,432	U: 29,070	*
Data surfaces per spindle	9	9	9	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1208	1208	1208	1828	1828
Track density (TPI)	1376	1376	1376	2053	2053
Maximum linear density (BPI)	29700 BPI 19800 FCI	29700 BPI 19800 FCI	29700 BPI 19800 FCI	41725 BPI 27817 FCI	41725 BPI 27817 FCI
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	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16.5	16.5	16.5	12	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	24.8	24.8	20.3	20.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1750	Up to 8000
FIRST CUSTOMER SHIPMENT	8/90	8/90	8/90	--	--
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high *Varies by zone

MANUFACTURER	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CERPLEX TECHNOLOGIES
DRIVE	F3267-E	F3320-S,A	F3480-E	F3575-S,A	7110
DISK/TREND GROUP	6	6	7	7	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	8" Cartridge
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	MIG	MIG	MIG	Ferrite
Interface	ESDI	SCSI, PC AT	ESDI	SCSI, PC AT	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 367	F: 279	U: 480	F: 502	U: 26.9
REMOVABLE	--	--	--	--	U: 26.9
Capacity per track (Bytes)	U: 29,070	*	U: 29,070	*	U: 20,928
Data surfaces per spindle	5	5	9	9	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1828	1828	1828	1828	644
Track density (TPI)	2053	2053	2053	2053	555
Maximum linear density (BPI)	41725 BPI 27817 FCI	41725 BPI 27817 FCI	41725 BPI 27817 FCI	41725 BPI 27817 FCI	10986 BPI 7324 FCI
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	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	12	12	12	12	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	20.3	20.3	20.3	20.3	33.3
Data transfer rate (KBytes/sec)	1750	Up to 8000	1750	Up to 1500	1229
FIRST CUSTOMER SHIPMENT	--	--	--	--	1Q83
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high *Varies by zone	

MANUFACTURER	CERPLEX TECHNOLOGIES	CERPLEX TECHNOLOGIES	CERPLEX TECHNOLOGIES	CERPLEX TECHNOLOGIES	CERPLEX TECHNOLOGIES
DRIVE	7130	PhD	C2400	C2600	DS2800
DISK/TREND GROUP	1	1	7	8	8
MARKET	OEM	PCM	OEM	OEM	PCM
MEDIA: Generic type	8" Cartridge	8" Cartridge	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SMD, SCSI	SCSI, PC	SMD	Modified SMD	SDI (DEC)
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 80.9	U: 80.9	U: 344	U: 613	F: 625
REMOVABLE	U: 26.9	U: 26.9	--	--	--
Capacity per track (Bytes)	U: 20,928	U: 20,928	U: 20,160	U: 30,240	F: 31,990
Data surfaces per spindle	8	8	24	12	16
Heads per data surface	1	1	1	1	1
Tracks per surface	644	644	711	1690	1221
Track density (TPI)	555	555	1143	1143	1087
Maximum linear density (BPI)	10986 BPI 7324 FCI	10986 BPI 7324 FCI	12783 BPI 8522 FCI	19200 BPI 12800 FCI	19739 BPI 13159 FCI
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	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	25	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	1229	1229	1209	1813	2400
FIRST CUSTOMER SHIPMENT	1/86	1/86	3Q85	3Q85	1Q88
COMMENTS					RA82 compatible DEC market

MANUFACTURER	COMPAREX	COMPAREX	COMPAREX	COMPAREX	COMPAREX
DRIVE	6480AJ 6480BJ	6480D 6481D	6480AE 6480BE	6480AK 6480BK	6485 6486
DISK/TREND GROUP	8	8	9	9	9
MARKET	PCM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	14"	9.5"	9.5"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 630	F: 630	F: 1,260	F: 1,890	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	8	10	8	8	12
Heads per data surface	2	2	2	4	2
Tracks per surface	1327.5	1327.5	2655	2655	2212.5
Track density (TPI)	*	*	*	*	*
Maximum linear density (BPI)	*	*	*	*	*
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	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	15	13	12.5	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	19.3	23.3	21.3	20.8	25.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	1988	1986	1988	1988	1986
COMMENTS	PCM 3380J Drive has 2 or 4 spindles *Not announced	PCM 3380D Drive has 4 spindles *Not announced	PCM 3380E Drive has 2 or 4 spindles *Not announced	PCM 3380K Drive has 2 or 4 spindles *Not announced	PCM 3380E Drive has 4 spindles *Not announced

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-2020	CP-2024	CP-3020	CP-3024	CP-4024
DISK/TREND GROUP	3 •	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Thin Film
Interface	SCSI	PC AT/XT	SCSI	PC AT	PC AT/XT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.4	F: 21.4	F: 21.0	F: 21.5	F: 21.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 16,896	F: 16,896	F: 17,408
Data surfaces per spindle	2	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	653	653	622	636	620
Track density (TPI)	1700	1700	1150	1150	1150
Maximum linear density (BPI)	34000 BPI 22666 FCI	34000 BPI 22666 FCI	21379 BPI 14253 FCI	21379 BPI 14253 FCI	23148 BPI 15432 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3433	3433	3575	3575	2913
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)	23	23	27	27	29
Average rotational delay (msec)	8.7	8.7	8.4	8.4	10.3
Average access time (msec)	31.7	31.7	35.4	35.4	39.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1125
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	2Q88	2Q88	4Q89
COMMENTS	17.5 mm high	17.5 mm high	25.4 mm high	25.4 mm high	19.8 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-3040	CP-3044	CP-4044	CP-3180	CP-3184
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film, MIG	Thin Film, MIG	MIG	Ferrite	Ferrite
Interface	SCSI	PC AT	PC AT/XT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.65	F: 42.65	F: 42.6	F: 84.3	F: 84.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,480	F: 20,480	F: 19,456	F: 16,896	F: 16,896
Data surfaces per spindle	2	2	2	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1047	1047	1095	833	833
Track density (TPI)	1400	1400	1400	1150	1150
Maximum linear density (BPI)	30871 BPI 20581 FCI	30871 BPI 20581 FCI	32729 BPI 21919 FCI	24437 BPI 16291 FCI	24437 BPI 16291 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3557	3557	2904	3575	3575
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	25	25	29	25	25
Average rotational delay (msec)	8.4	8.4	10.3	8.4	8.4
Average access time (msec)	33.4	33.4	39.3	33.4	33.4
Data transfer rate (KBytes/sec)	1500	1500	1250	1250	1250
FIRST CUSTOMER SHIPMENT	4Q88	4Q88	4Q89		
COMMENTS	25.4 mm high	25.4 mm high	19.8 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-30100	CP-30104	CP-30109	CP-3100	CP-3104
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Ferrite	Ferrite
Interface	SCSI	PC AT/XT, EISA	MCA	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 120	F: 120	F: 120	F: 104.9	F: 104.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,968	F: 19,968	F: 19,968	F: 16,896	F: 16,896
Data surfaces per spindle	4	4	4	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1522	1522	1522	776	776
Track density (TPI)	1850	1850	1850	1150	1150
Maximum linear density (BPI)	35600 BPI 23733 FCI	35600 BPI 23733 FCI	35600 BPI 23733 FCI	23441 BPI 15627 FCI	23441 BPI 15627 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3399	3399	3399	3575	3575
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	19	19	25	25
Average rotational delay (msec)	8.8	8.8	8.8	8.4	8.4
Average access time (msec)	27.8	27.8	27.8	33.4	33.4
Data transfer rate (KBytes/sec)	1500	1500	1500	1250	1250
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	1Q90	4Q87	4Q87
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	CP-3114	CP-3200F	CP-3204	CP-3204F	CP-3209F
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI	PC AT	PC AT	MCI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 112	F: 212.6	F: 209.7	F: 212.6	F: 212.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 19,456	F: 19,456	F: 19,456	F: 19,456
Data surfaces per spindle	8	8	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	833	1348	1348	1348	1348
Track density (TPI)	1150	1700	1700	1700	1700
Maximum linear density (BPI)	23441 BPI 15627 FCI	31800 BPI 21200 FCI	31800 BPI 21200 FCI	31800 BPI 21200 FCI	31800 BPI 21200 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3575	3485	3600	3485	3485
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	25	16	19	16	16
Average rotational delay (msec)	8.4	8.6	8.3	8.6	8.6
Average access time (msec)	33.4	24.6	27.3	24.6	24.6
Data transfer rate (KBytes/sec)	1250	1500	1500	1500	1500
FIRST CUSTOMER SHIPMENT	1988	4Q89	2Q89	4Q89	4Q89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	DIGIREDE	DIGIREDE	DIGIREDE	DIGIREDE	DIGIREDE
DRIVE	W525/50	W525/85	W525/140	W525/190	W525R/125
DISK/TREND GROUP	4	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 50	U: 85.3	U: 140.2	U: 191.2	U: 127.99
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 15,624
Data surfaces per spindle	5	9	11	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1224	1224	1024
Track density (TPI)	1022	1022	1022	1022	1070
Maximum linear density (BPI)	9934	11555	11555	11555	14901 BPI 9934 FCI
Recording code	MFM	MFM	MFM	MFM	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)	27	28	30	30	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	36.3	38.3	38.3	36.3
Data transfer rate (KBytes/sec)	625	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	1987	1987	1987	1987	1989
COMMENTS					For use with RLL controller

MANUFACTURER	DIGIREDE	DIGIREDE	DIGIREDE	DIGIREDE	DIGIREDE
DRIVE	W525R/240	W525E/380	W525E/410	W525S/410	W525E/760
DISK/TREND GROUP	6	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ST412	ESDI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 239.98	U: 382.0	U: 410.1	F: 360.97	U: 768.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624	U: 20,808	U: 31,410	F: 27,648	U: 31,410
Data surfaces per spindle	15	15	8	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1224	1632	1632	1632
Track density (TPI)	1070	1022	1376	1376	1376
Maximum linear density (BPI)	14901 BPI 9934 FCI	20975 BPI 13980 FCI	31596 BPI 21064 FCI	31596 BPI 21064 FCI	31596 BPI 21064 FCI
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)	28	18	14.5	14.5	16.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	26.3	22.8	22.8	24.8
Data transfer rate (KBytes/sec)	937.5	1250	1875	1875	1875
FIRST CUSTOMER SHIPMENT	1989	1988	1990	1990	1990
COMMENTS	For use with RLL controller				

MANUFACTURER	DIGIREDE	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE	W525S/760	RF30	RA70	RA82	RF31
DISK/TREND GROUP	8	6	7	8	8
MARKET	OEM	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	DEC	DEC	DEC	DEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 676.8	U: 200 F: 150	U: 350 F: 280	U: 855 F: 622	U: 508 F: 381
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	F: 25,000	F: 17,408	F: 29,184	F: 25,600
Data surfaces per spindle	15	6	11	8	8
Heads per data surface	1	1	1	2	1
Tracks per surface	1632	1331	1507	2846	1861
Track density (TPI)	1376	1355	1355	1063	1875
Maximum linear density (BPI)	31596 BPI 21064 FCI	22784 BPI 15189 FCI	22437 BPI 14958 FCI	12545 BPI 8363 FCI	30520 BPI 22890 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	4000	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	16.5	21.0	19.5	20	16
Average rotational delay (msec)	8.3	8.3	7.5	8.3	8.3
Average access time (msec)	24.8	29.3	27.0	28.3	24.3
Data transfer rate (KBytes/sec)	1875	1500	1450	2400	2000
FIRST CUSTOMER SHIPMENT	1990	10/88	4/88	4Q87	6/90
COMMENTS		41.3 mm high		SA482 consists of 4 spindles up to 2,448 MB	

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES	DMA TECHNOLOGIES
DRIVE	RF71	RA90	RA92	360	370
DISK/TREND GROUP	8	9	9	1	1
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	--	--
Nominal disk diameter	130 mm OD 40 mm ID	9"	9"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Ferrite	Ferrite
Interface	DEC	DEC	DEC	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 532 F: 400	U: 1,607 F: 1,216	U: 1,987 F: 1,506	--	--
REMOVABLE	--	--	--	U: 12.75	U: 25.0
Capacity per track (Bytes)	F: 25,000	F: 35,328	F: 35,328	U: 10,416	U: 10,416
Data surfaces per spindle	8	13	13	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1331	2649	3099	612	1224
Track density (TPI)	1355	1750	2045	612	1222
Maximum linear density (BPI)	22784 BPI 15189 FCI	22839 BPI 15226 FCI	22839 BPI 15226 FCI	10894	10894
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	MFM	MFM
Rotational speed (RPM)	3600	3600	3400	3473	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Open Loop	Open Loop
Average positioning time (msec)	21.0	17.5	16	98 (including settling)	85 (including settling)
Average rotational delay (msec)	8.3	8.3	8.8	8.6	8.6
Average access time (msec)	29.3	27	24.8	106.6	93.6
Data transfer rate (KBytes/sec)	1500	2800	2800	625	625
FIRST CUSTOMER SHIPMENT		8/88	3/90	5/84	5/88
COMMENTS		SA600 consists of 4 or 8 spindles, up to 9,728 MB	SA800 consists of up to 16 spindles (in 2 cabinets),up to 24,096 MB	41.3 mm high	41.3 mm high

MANUFACTURER	DMA TECHNOLOGIES	DZU	DZU	DZU	DZU
DRIVE	371	ISOT 5502C	SM 5509	CM 5515	CM 5511
DISK/TREND GROUP	1	4	4	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	--	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	SMD	
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 50.88	U: 44.84	U: 160	U: 315.2
REMOVABLE	F: 21.2	--	--	--	--
Capacity per track (Bytes)	F: 8,704	U: 10,416	U: 10,416	U: 20,160	U: 20,160
Data surfaces per spindle	2	5	7	5	10
Heads per data surface	1	1	1	2	2/1
Tracks per surface	1224	977	615	1646	1646
Track density (TPI)	1222	625	625	635	635
Maximum linear density (BPI)	10894	9617	9617	6350	6350
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	3473	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	85 (including settling)	40	45	30	30
Average rotational delay (msec)	8.6	8.3	8.3	8.3	8.3
Average access time (msec)	93.6	48.3	53.3	38.3	38.3
Data transfer rate (KBytes/sec)	625	625	625	1209	1209
FIRST CUSTOMER SHIPMENT	5/88	1989		1989	1989
COMMENTS	41.3 mm high				

MANUFACTURER	DZU	DZU	DZU	EDISA INFORMATICA	EDISA INFORMATICA
DRIVE	EC 5063	EC 5063 C	EC 5065	ED 71204	ED 71408
DISK/TREND GROUP	7	7	8	6	7
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface		SMD		SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 317	U: 337.7	F: 635	F: 162	F: 323
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	U: 20,160	F:	F: 16,384	F: 16,384
Data surfaces per spindle	15	15	15	6	12
Heads per data surface	2	2	2	1	1
Tracks per surface	1122	1120	2242	1643	1643
Track density (TPI)	475	475	960	1590	1590
Maximum linear density (BPI)	6248	6248	6248	20745 BPI 13830 FCI	20745 BPI 13830 FCI
Recording code	MFM	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3348	3348
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	25	22	25	17.5	17.5
Average rotational delay (msec)	8.3	8.3	8.3	8.96	8.96
Average access time (msec)	33.3	30.3	33.3	26.46	26.46
Data transfer rate (KBytes/sec)	1198	1209	1198	1500	1500
FIRST CUSTOMER SHIPMENT	1985	1989	1989	2Q90	2Q90
COMMENTS					

MANUFACTURER	EDISA INFORMATICA	ELEBRA	ELEBRA	ELEBRA	ELEBRA
DRIVE	ED 71793	W320	W530	W540	W560
DISK/TREND GROUP	8	3	4	4	5
MARKET	Captive, OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 664	U: 25	U: 30	U: 48	U: 67
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,672	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	16	4	3	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1447	612	925	925	925
Track density (TPI)	1667	600	960	960	960
Maximum linear density (BPI)	30552 BPI 20368 FCI	18800	9274	9274	9274
Recording code	2,7 RLL	MFM	MFM	MFM	MFM
Rotational speed (RPM)	4002	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16.5	65	28	28	28
Average rotational delay (msec)	7.49	8.3	8.3	8.3	8.3
Average access time (msec)	23.99	73.3	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	1500	625	625	625	625
FIRST CUSTOMER SHIPMENT	2Q91	1Q89	2Q85	2Q85	2Q85
COMMENTS		Usable with RLL controller	Usable with RLL controller	Usable with RLL controller	Usable with RLL controller

MANUFACTURER	ELEBRA	ELEBRA	ESPERT	ESPERT	ESPERT
DRIVE	W580	W950	EP-340A	PT338	PT351
DISK/TREND GROUP	5	8	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	230 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Ferrite	Ferrite	Ferrite
Interface	ST412	Modified SMD	PC AT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 86	U: 516	F: 41.5	U: 38.4	U: 51.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 30,240	F: 13,312	U: 10,416	U: 10,416
Data surfaces per spindle	9	12	3	6	6
Heads per data surface	1	2	1	1	1
Tracks per surface	925	1422	1040	615	820
Track density (TPI)	960	960	1200	983	983
Maximum linear density (BPI)	9274	15159 BPI 10106 FCI	21122 BPI 14082 FCI	12218	14479
Recording code	MFM	2,7 RLL	2,7 RLL	MFM	MFM
Rotational speed (RPM)	3600	3600	3600	3428	3428
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, DC Motor	Linear, DC Motor
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	28	18	25	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.75	8.75
Average access time (msec)	36.3	26.3	33.3	43.75	43.75
Data transfer rate (KBytes/sec)	625	1825	4000 max.	625	625
FIRST CUSTOMER SHIPMENT	2Q85	1986	1990	1988	9/87
COMMENTS	Usable with RLL controller	Similar to Seagate FSD	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	ESPERT	ESPERT	FLEXDISK	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	PT357R	PT376R	FX 325	FK309-26	FK309S-26R
DISK/TREND GROUP	4	5	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 57.6*	U: 76.8*	U: 25.62	U: 25.6	F: 22.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 15,624*	U: 10,416	U: 10,416	F: 9,216
Data surfaces per spindle	6	6	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	820	615	615	615
Track density (TPI)	983	983	850	753	880
Maximum linear density (BPI)	18327 BPI 12218 FCI	21719 BPI 14479 FCI		15600	14200 BPI 9466 FCI
Recording code	2,7 RLL*	2,7 RLL*	MFM	MFM	2,7 RLL
Rotational speed (RPM)	3428	3428	3600	3350	3350
PERFORMANCE					
Actuator type	Linear, DC Motor	Linear, DC Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Servo type	Embedded	Embedded	Open Loop	Embedded	Embedded
Average positioning time (msec)	35 (including settling)	35 (including settling)	48	65 (including settling)	47 (including settling)
Average rotational delay (msec)	8.75	8.75	8.3	8.96	8.95
Average access time (msec)	43.75	43.75	56.3	73.96	55.95
Data transfer rate (KBytes/sec)	937.5*	937.5*	625	625	645
FIRST CUSTOMER SHIPMENT	3Q86	3Q87	3/90	4/87	
COMMENTS	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	Usable with RLL controller	41.3 mm high	41.3 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK309X-26	FK311-26	FK311A-26R	FK303-52	FK309-39R
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC XT	ST412	PC AT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.4	U: 25.6	F: 21.4	U: 51.2	U: 38.4*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	U: 10,416	F: 17,408	U: 10,416	U: 15,624*
Data surfaces per spindle	4	4	2	8	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	615
Track density (TPI)	753	910	910	753	753
Maximum linear density (BPI)	15600 BPI 10400 FCI	15200	26600 BPI 17733 FCI	15600	23400 BPI 15600 FCI
Recording code	2,7 RLL	MFM	2,7 RLL	MFM	2,7 RLL*
Rotational speed (RPM)	3350	3050	3050	3350	3350
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	65 (including settling)	60 (including settling)	28 (including settling)	40 (including settling)	65 (including settling)
Average rotational delay (msec)	8.95	9.84	9.84	8.96	8.96
Average access time (msec)	73.95	69.84	37.84	48.96	73.96
Data transfer rate (KBytes/sec)	645	625	1093	625	937.5*
FIRST CUSTOMER SHIPMENT		1/89	2/89	8/87	4/87
COMMENTS	41.3 mm high	25.4 mm high	30 mm high	41.3 mm high	41.3 mm high *With RLL controller

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK309S-50R	FK311A-50R	FK311S-50R	FK312A-53R	FK312S-53R
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	SASI, SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.5	F: 42.8	F: 41.6	F: 42.8	F: 40.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 17,408	F: 16,896	F: 17,408	F: 15,360
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	628	615	652
Track density (TPI)	880	910	910	1053	1053
Maximum linear density (BPI)	25600 BPI 17066 FCI	26600 BPI 17733 FCI	27900 BPI 18600 FCI	27000 BPI 18000 FCI	27000 BPI 18000 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3150	3050	3050	3051	3051
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	47 (including settling)	28	30	28	28
Average rotational delay (msec)	9.52	9.84	9.84	9.83	9.83
Average access time (msec)	56.52	37.84	39.84	37.83	37.83
Data transfer rate (KBytes/sec)	1093	1093	1152	1041	1041
FIRST CUSTOMER SHIPMENT		4Q89	4Q89	4/89	2/89
COMMENTS	41.3 mm high	30 mm high	30 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJITSU	FUJITSU	FUJITSU
DRIVE	FK313S-130R	FK314S-90R	M2225AD	M2225D2	M2235AS
DISK/TREND GROUP	6	6	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	MIG	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 102.7	F: 91.4	U: 25.62	U: 25.62	U: 26.66
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 15,360	F: 20,400	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	4	4	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	840	1116	615	615	320
Track density (TPI)	1053	1400	846	834	300
Maximum linear density (BPI)	27000 BPI 18000 FCI	34000 BPI 25500 FCI	13330	14845	10200
Recording code	2,7 RLL	1,7 RLL	MFM	MFM	MFM
Rotational speed (RPM)	3051	3540	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Encoder Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	19	25	85 (including settling)	35	83 (including settling)
Average rotational delay (msec)	9.83	8.5	8.3	8.3	8.3
Average access time (msec)	28.83	33.5	93.3	43.3	91.3
Data transfer rate (KBytes/sec)	1041	1500	625	625	625
FIRST CUSTOMER SHIPMENT	3Q90	4Q90	4Q86	2Q87	10/83
COMMENTS	41.3 mm high	25.4 mm high	41.3 mm high	41.3 mm high	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2226D2	M2227D2	M2241AS2 M2241B	M2242AS2 M2242B	M2611S/SA/SB
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412, SA4000	ST412, SA4000	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.43	U: 51.24	U: 31.4	U: 54.9	F: 45.07
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	F: 17,408
Data surfaces per spindle	6	8	4	7	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	754	754	1334
Track density (TPI)	834	834	760	760	1681
Maximum linear density (BPI)	14845	14845	10200	10200	29571 BPI 22178 FCI
Recording code	MFM	MFM	MFM	MFM	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3490
PERFORMANCE					
Actuator type	Rotary, Encoder Motor	Rotary, Encoder Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	35	35	30	30	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.6
Average access time (msec)	43.3	43.3	38.3	38.3	33.6
Data transfer rate (KBytes/sec)	625	625	625	625	1250
FIRST CUSTOMER SHIPMENT	1Q87	1Q87	5/84	5/84	4Q88
COMMENTS	41.3 mm high	41.3 mm high			25.4 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2611T	M2243AS2 M2243B	M2243T	M2244C/E	M2244S/SA/SB
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	Captive, OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412, SA4000	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 45.07	U: 86.3	U: 86.4	U: 85.8	F: 63
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	U: 10,416	U: 10,416	U: 20,864	F: 16,640
Data surfaces per spindle	2	11	7	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1334	754	1185	823	823
Track density (TPI)	1681	760	1226	850	850
Maximum linear density (BPI)	29571 BPI 22178 FCI	10200	10200	20400 BPI 13600 FCI	20400 BPI 13600 FCI
Recording code	1,7 RLL	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3490	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	30	25	25	25
Average rotational delay (msec)	8.6	8.3	8.3	8.3	8.3
Average access time (msec)	33.6	38.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	7400	625	625	1250	1500/2500
FIRST CUSTOMER SHIPMENT	3Q89	5/84	3Q87	3Q85	2Q87
COMMENTS	25.4 mm high		41.3 mm high		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2243R	M2245C/E	M2245S/SA/SB	M2246C/E	M2246S/SA/SB
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 129.6*	U: 120.2	F: 89.7	U: 171.7	F: 130.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 20,864	F: 16,640	U: 20,864	F: 16,640
Data surfaces per spindle	7	7	7	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	1185	823	823	823	823
Track density (TPI)	1226	850	850	850	850
Maximum linear density (BPI)	15300 BPI 10200 FCI	20400 BPI 13600 FCI	20400 BPI 13600 FCI	20400 BPI 13600 FCI	20400 BPI 13600 FCI
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)	25	25	25	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	937.5*	1250	1500/2500	1250	1500/2500
FIRST CUSTOMER SHIPMENT	3Q87	3Q85	2Q87	3Q85	2Q87
COMMENTS	41.3 mm high *With RLL controller				

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2247E	M2247S/SA/SB	M2248E	M2248S/SA/SB	M2322K
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 181.5	F: 137.9	U: 285.3	F: 220.5	U: 168.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	U: 20,864	F: 16,640	U: 20,480
Data surfaces per spindle	7	7	11	11	10
Heads per data surface	1	1	1	1	1
Tracks per surface	1243	1243	1243	1243	823
Track density (TPI)	1267	1267	1267	1267	683
Maximum linear density (BPI)	19295 BPI 14471 FCI	19295 BPI 14471 FCI	19295 BPI 14471 FCI	19295 BPI 14471 FCI	9867
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
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)	18	18	18	18	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	26.3	26.3	28.3
Data transfer rate (KBytes/sec)	1250	1500/2500	1250	1500/2500	1229
FIRST CUSTOMER SHIPMENT	3Q87	1Q88	3Q87	1Q88	11/83
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2331K	M2612S/SA/SB	M2612T	M2613S/SA/SB	M2613T
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 168.5	F: 90.84	F: 90.15	F: 136.6	F: 135.23
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	F: 17,408	F: 16,896	F: 17,408	F: 16,896
Data surfaces per spindle	5	4	4	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1334	1334	1334	1334
Track density (TPI)	683	1681	1681	1681	1681
Maximum linear density (BPI)	19734 BPI 13156 FCI	29571 BPI 22178 FCI	29571 BPI 22178 FCI	29571 BPI 22178 FCI	29571 BPI 22178 FCI
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3490	3490	3490	3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	20	25	25	25	25
Average rotational delay (msec)	8.3	8.6	8.6	8.6	8.6
Average access time (msec)	28.3	33.6	33.6	33.6	33.6
Data transfer rate (KBytes/sec)	2458	1500/2500	7400	1500/2500	7400
FIRST CUSTOMER SHIPMENT	11/84	4Q88	3Q89	4Q88	3Q89
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2614S/SA/SB	M2614T	F6421	M2249E	M2249S/SA/SB
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.5" OD 4.0" ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	Fujitsu	ESDI	SCSI
CAPACITY/RECORDING DENSITY			1.607 or 1.144 MB Fixed Head Option		
Total capacity (Mbytes) FIXED	F: 182.36	F: 180.31	F: 446/317.5	U: 389	F: 303.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 16,896	F: 26,793/ 19,069	U: 20,864	F: 16,640
Data surfaces per spindle	8	8	10	15	15
Heads per data surface	1	1	2	1	1
Tracks per surface	1334	1334	1680	1243	1243
Track density (TPI)	1681	1681	880	1267	1267
Maximum linear density (BPI)	29571 BPI 22178 FCI	29571 BPI 22178 FCI	12790	19295 BPI 14471 FCI	19295 BPI 14471 FCI
Recording code	1,7 RLL	1,7 RLL	MFM	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	3490	3961	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)	25	25	18	18	18
Average rotational delay (msec)	8.6	8.6	7.5	8.3	8.3
Average access time (msec)	33.6	33.6	25.5	26.3	26.3
Data transfer rate (KBytes/sec)	1500/2500	7400	1859	1250	1500/2500
FIRST CUSTOMER SHIPMENT	4Q88	3Q89	3Q81	3Q87	1Q88
COMMENTS	41.3 mm high	41.3 mm high	Drive has 4 spindles		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2261E	M2261H/HA/HB M2261S/SA/SB	M2333K/KS	M2343K/KS	M2350A
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	Modified SMD	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 415.1	F: 357*	U: 337.1	U: 383.38	U: 473.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,296	F: 27,136	U: 40,960	U: 40,960	U: 28,160
Data surfaces per spindle	8	8	10	7.5	10
Heads per data surface	1	1	1	2/1	2
Tracks per surface	1658	1658	823	1248	1682
Track density (TPI)	1712	1712	683	846	880
Maximum linear density (BPI)	28816 BPI 21612 FCI	28816 BPI 21612 FCI	19734 BPI 13156 FCI	20767 BPI 13844 FCI	12790
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3961
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	20	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.5
Average access time (msec)	24.3	24.3	28.3	24.3	25.5
Data transfer rate (KBytes/sec)	1875	1750/4000	2458	2458	1859/7436/9295
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	11/84	4Q87	2/84
COMMENTS		*512 byte sector			Parallel data transfer, 4 or 5 channels

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2351A	F6423B	F6425G	F6425K4/L4	M2262E
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Fujitsu	Fujitsu	Fujitsu	ESDI
CAPACITY/RECORDING DENSITY	1.69 MB Fixed Head Option				
Total capacity (Mbytes) FIXED	U: 474.2	F: 630.0	F: 630.0	F: 630.0	U: 570.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 28,160	F: 47,476	F: 47,476	F: 47,476	U: 31,296
Data surfaces per spindle	10	8	8	8	11
Heads per data surface	2	2	2	2	1
Tracks per surface	1684	988	1770	1770	1658
Track density (TPI)	880	1193	1350	905	1712
Maximum linear density (BPI)	12790	23260 BPI 17445 FCI	21300 BPI 15975 FCI	24420 BPI 16280 FCI	28816 BPI 21612 FCI
Recording code	MFM	1,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3961	3620	3620	3620	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)	18	13	12	15	16
Average rotational delay (msec)	7.5	8.3	8.3	8.3	8.3
Average access time (msec)	25.5	21.3	20.3	23.3	24.3
Data transfer rate (KBytes/sec)	1859	3000	3000	3000	1875
FIRST CUSTOMER SHIPMENT	3/82	8/88	12/88	3Q86	2Q88
COMMENTS		Drive has 4 spindles	Drive has 4 spindles	Drive has 4 spindles	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2262H/HA/HB M2262S/SA/SB	M2263E	M2263H/HA/HB M2263S/SA/SB	M2344K/KS	M2360A
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	Mod. SMD, SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 442.0*	U: 778.3	F: 672*	U: 690.1	U: 689.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	U: 31,296	F: 27,136	U: 40,960	U: 40,960
Data surfaces per spindle	11	15	15	13.5	10
Heads per data surface	1	1	1	2/1	2
Tracks per surface	1658	1658	1658	1248	1684
Track density (TPI)	1712	1712	1712	846	880
Maximum linear density (BPI)	28816 BPI 21612 FCI	28816 BPI 21612 FCI	28816 BPI 21612 FCI	20767 BPI 13844 FCI	18620 BPI 12413 FCI
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3673
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	16	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.17
Average access time (msec)	24.3	24.3	24.3	24.3	26.17
Data transfer rate (KBytes/sec)	1750/4000	1875	1750/4000	2458	2507-12537
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	4Q88	2Q87	3Q86
COMMENTS	*256 byte sector		*512 byte sector		Parallel data transfer, 4 or 5 channels

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2361A	M2372K/KS	M2381K/KP	F6425H	F6425M4/N4
DISK/TREND GROUP	8	8	8	9	9
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Sputtered	Oxide Sputtered
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Mod. SMD, SCSI	Mod. SMD, IPI-2	Fujitsu	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 689.8	U: 823.9	U: 555.7	F: 1,890	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 49,728	F: 47,476	F: 47,476
Data surfaces per spindle	10	13.5	7.5	16	12
Heads per data surface	2	2/1	2/1	2	2
Tracks per surface	1682	1490	1490	2654	2360
Track density (TPI)	880	1193	1193	1350	1160
Maximum linear density (BPI)	18620 BPI 12413 FCI	20766 BPI 13844 FCI	25211 BPI 18908 FCI	24440 BPI 18330 FCI	24989 BPI 16659 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3620	3620	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	16	16	16	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	24.3	24.3	24.3	25.3
Data transfer rate (KBytes/sec)	2458	2458	3000	3000	3000
FIRST CUSTOMER SHIPMENT	2Q85	9/87	1Q88	12/88	3Q86
COMMENTS				Drive has 4 spindles	Drive has 4 spindles

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6427H	M2266H/HA/HB M2266S/SA/SB	M2380A	M2382K/P	M2391D
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film		Ferrite	Ferrite	Thin Film
Interface	Fujitsu	SCSI	Modified SMD	Mod. SMD, IPI-2	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,890	F: 1,165*	U: 1,000.2	U: 1,000.2	U: 965
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 46,080*	U: 49,728	U: 49,728	U: 45,792
Data surfaces per spindle	15	15	13.5	13.5	11
Heads per data surface	1	1	2/1	2/1	1
Tracks per surface	2655	1658	1490	1490	1916
Track density (TPI)	2080	1634	1193	1193	1456
Maximum linear density (BPI)	33310 BPI 24980 FCI	46635 BPI 34976 FCI	25211 BPI 18908 FCI	25211 BPI 18908 FCI	22764 BPI 17073 FCI
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4340	3600	3709	3620	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)	12	14.5	16	16	12
Average rotational delay (msec)	6.9	8.3	8.1	8.3	8.3
Average access time (msec)	18.9	22.8	24.1	24.3	20.3
Data transfer rate (KBytes/sec)	4500	4800 max.	3074-1844	3000	2750
FIRST CUSTOMER SHIPMENT	12/90	2Q90	1Q89	1Q88	1Q90
COMMENTS	Drive has maximum 16 spindles	*1024 byte block	Parallel data transfer, 4, 5 or 6 channels Total capacity varies in each version		

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	GOLDSTAR TELE-COMMUNICATION
DRIVE	M2391K	M2392D	M2392K	M2671P	GSH-3026
DISK/TREND GROUP	9	9	9	9	3
MARKET	OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	IPI-2	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,062	F: 1,842	U: 2,027	U: 2,648	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,400	F: 45,792	U: 50,400	U: 66,096	U: 10,416
Data surfaces per spindle	11	21	21	15	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1916	1916	1916	2671	615
Track density (TPI)	1456	1456	1456	2080	753
Maximum linear density (BPI)	25055 BPI 18791 FCI	22764 BPI 17073 FCI	25055 BPI 18791 FCI	33310 BPI 24983 FCI	15600
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	4340	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Stepping Motor
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Open Loop
Average positioning time (msec)	12	12	12	12	65 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	6.91	8.9
Average access time (msec)	20.3	20.3	20.3	18.91	73.9
Data transfer rate (KBytes/sec)	3000	2750	3000	4781	625
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	1Q90	2Q90	1989
COMMENTS					41.3 mm high

MANUFACTURER	GOLDSTAR TELE-COMMUNICATION	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	GSH-3040	9153 9154 97501B 97515B	7957B 97961	7957S	7958B 7962B
DISK/TREND GROUP	4	3	5	6	6
MARKET	OEM	Captive, OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	ST412	HP	SCSI	SCSI	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 52.27	F: 20	F: 81	F: 107	F: 152
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,605	F: 7,168	F: 16,128	F: 17,152	F: 16,128
Data surfaces per spindle	8	2	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	1400	1269	1572	1552
Track density (TPI)	910	1850	1590	1590	1590
Maximum linear density (BPI)	12500	12700	20500 BPI 13666 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI
Recording code	MFM	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3000	3350	3350	3350
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	45 (including settling)	75 (including settling)	17	17	17
Average rotational delay (msec)	8.3	10	8.95	8.95	8.95
Average access time (msec)	53.3	85	25.95	25.95	25.95
Data transfer rate (KBytes/sec)	625	500	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1990	12/85	3Q88	2Q88	4Q88
COMMENTS	41.3 mm high	51 mm high	HP 3000, 9000, 1000, 260	HP 9000	HP 3000, 9000, 1000, 260

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	7958S	97532E	97532D 97532S 97532T	97533D 97533S 97533T	97533E
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 161	U: 129.68	F: 108	F: 162	U: 195
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,152	U: 20,480	F: 16,384	F: 16,384	U: 20,480
Data surfaces per spindle	6	4	4	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1572	1583	1643	1643	1583
Track density (TPI)	1590	1590	1590	1590	1590
Maximum linear density (BPI)	20500 BPI 13666 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3350	3350	3350	3350	3350
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	17.5	17.5	17
Average rotational delay (msec)	8.95	8.95	8.95	8.95	8.95
Average access time (msec)	25.95	25.95	26.45	26.45	25.95
Data transfer rate (KBytes/sec)	1250	1250	*	*	1250
FIRST CUSTOMER SHIPMENT	2Q88	3Q87	3Q87	3Q87	3Q87
COMMENTS	HP 9000		*Transfer rate maximum: S- 2000 KB/sec. D- 4000 KB/sec. T- 4000 KB/sec.	*Transfer rate maximum: S- 2000 KB/sec. D- 4000 KB/sec. T- 4000 KB/sec.	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2233S/A	7959B	7959S	97536D 97536S 97536T	97536E
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2, PC AT	HPIB	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 234	F: 304	F: 323	F: 323.03	U: 389.04
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 16,128	F: 17,152	F: 16,384	U: 20,480
Data surfaces per spindle	5	12	12	12	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1511	1572	1572	1643	1583
Track density (TPI)	1850	1590	1590	1590	1590
Maximum linear density (BPI)	42000 BPI 28000 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI	20500 BPI 13666 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3350	3350	3350	3350
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)	13	17	17	17.5	17
Average rotational delay (msec)	8.3	8.95	8.95	8.95	8.95
Average access time (msec)	21.3	25.95	25.95	26.45	25.95
Data transfer rate (KBytes/sec)	1750-2500	1250	1250	*	1250
FIRST CUSTOMER SHIPMENT	4Q90	2Q88	2Q88	3Q87	3Q87
COMMENTS	41.3 mm high *Varies by zone	HP 9000, 3000, 1000	HP 9000	*Transfer rate maximum: S- 2000 KB/sec. D- 4000 KB/sec. T- 4000 KB/sec.	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97544D 97544S	97544E	97544P 97544T	C2200A	C2212A
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI-2	ESDI, HPIB	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 332	U: 398	F: 332	F: 335	F: 332
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,672	U: 34,143	F: 28,672	F: 29,184	F: 28,672
Data surfaces per spindle	8	8	8	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1447	1457	1447	1457	1447
Track density (TPI)	1666	1666	1666	1667	1667
Maximum linear density (BPI)	30552 BPI 20368 FCI	30552 BPI 20368 FCI	30552 BPI 20368 FCI	30552 BPI 20368 FCI	30552 BPI 20368 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4002	4002	4002	4002	4002
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)	16.5	17	16.5	17	9
Average rotational delay (msec)	7.49	7.49	7.49	7.5	7.5
Average access time (msec)	23.99	24.49	23.99	24.5	16.5
Data transfer rate (KBytes/sec)	4000 max.	2500 max.	5000 max.	2500	1500-4000
FIRST CUSTOMER SHIPMENT	2Q89	2Q89	9/89	1/90	2Q90
COMMENTS					HP 9000, S300

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2234S/A	C2235S	7937FL 7937H 7937XP	7937S	97548D 97548S
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Ferrite	Ferrite	Thin Film
Interface	SCSI-2, PC AT	SCSI-2	HPIB,Fiber Link	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 328	F: 422	F: 571	F: 571	F: 664
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 31,488	F: 31,488	F: 28,672
Data surfaces per spindle	7	9	13	13	16
Heads per data surface	1	1	1	1	1
Tracks per surface	1511	1511	1396	1396	1447
Track density (TPI)	1850	1850	1121	1121	1666
Maximum linear density (BPI)	42000 BPI 28000 FCI	42000 BPI 28000 FCI	18800 BPI* 14101 FCI	18800 BPI* 14101 FCI	30552 BPI 20368 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	4002
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)	13	13	20.5	20.5	16.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.49
Average access time (msec)	21.3	21.3	28.8	28.8	23.99
Data transfer rate (KBytes/sec)	1750-2500	1750-2500	2351	2351	4000 max.
FIRST CUSTOMER SHIPMENT	4Q90	4Q90	4Q86	4Q86	4Q88
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	*Variable Length Frequency Modulation	*Variable Length Frequency Modulation	

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97548E	97548P 97548T	97556E	97556P 97556T	C2201A C2202/03A
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI-2	ESDI	SCSI-2	ESDI, HPIB, FL
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 796	F: 664	U: 793	F: 673	F: 670
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 34,143	F: 28,672	U: 42,930	F: 36,864	F: 29,184
Data surfaces per spindle	16	16	11	11	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1457	1447	1680	1670	1457
Track density (TPI)	1666	1666	1863	1863	1667
Maximum linear density (BPI)	30552 BPI 20368 FCI	30552 BPI 20368 FCI	42000 BPI 28000 FCI	42000 BPI 28000 FCI	30552 BPI 20368 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4002	4002	4002	4002	4002
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)	17	16.5	15	15	17
Average rotational delay (msec)	7.49	7.49	7.5	7.5	7.5
Average access time (msec)	24.49	23.99	22.5	22.5	24.5
Data transfer rate (KBytes/sec)	2500 max.	5000 max.	2875	10000 max.	2500
FIRST CUSTOMER SHIPMENT	4Q88	9/89	3Q90	3Q90	1/90
COMMENTS					

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C2213A	97549P 97549T	97558E	97558P 97558T	97560
DISK/TREND GROUP	8	9	9	9	9
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI-2	ESDI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 664	F: 1,000	U: 1,263	F: 1,075	F: 1,367
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,672	F: 32,768	U: 42,930	F: 36,864	F: 36,864
Data surfaces per spindle	7	16	15	15	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1447	1918	1961	1952	1952
Track density (TPI)	1667	1875	1863	1863	1865
Maximum linear density (BPI)	30552 BPI 20368 FCI	40500 BPI 27000 FCI	42000 BPI 28000 FCI	42000 BPI 28000 FCI	42000 BPI 28000 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4002	4002	4002	4002	4002
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)	9	18	15	15	13.5
Average rotational delay (msec)	7.5	7.4	7.5	7.5	7.5
Average access time (msec)	16.5	25.4	22.5	22.5	21
Data transfer rate (KBytes/sec)	1500-4000	5000 max.	2875	10000 max.	10000 max.
FIRST CUSTOMER SHIPMENT	2Q90	1Q90	12/89	12/89	2/91
COMMENTS	HP 9000, S300				

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
DRIVE	97560E	97560P 97560T	C2204A	DK302-2	DK505-2
DISK/TREND GROUP	9	9	9	3	3
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	ESDI	SCSI-2	ESDI, FL	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,600	F: 1,367	F: 1,340	U: 25.5	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 42,930	F: 36,864	F: 29,184	U: 10,416	U: 10,416
Data surfaces per spindle	19	19	7	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1961	1952	1457	615	615
Track density (TPI)	1863	1865	1667	822	650
Maximum linear density (BPI)	42000 BPI 28000 FCI	42000 BPI 28000 FCI	30552 BPI 20368 FCI	13700	9490
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	MFM	MFM
Rotational speed (RPM)	4002	4002	4002	3550	3550
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Open Loop	Open Loop
Average positioning time (msec)	15	13.5	17	85 (including settling)	85 (including settling)
Average rotational delay (msec)	7.5	7.5	7.5	8.45	8.45
Average access time (msec)	22.5	21	24.5	93.45	93.45
Data transfer rate (KBytes/sec)	2875	5000 max.	2500	625	625
FIRST CUSTOMER SHIPMENT	12/89	5/90	2/90	9/86	3/85
COMMENTS			Drive has 2 spindles	41.3 mm high	41.3 mm high Mfg. by Tokico

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK302-3	DK511-3	DK511-5	DK521-5	DK812S-5
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412, SCSI	ST412, SCSI	ST412	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 38.2	U: 36.4	U: 51.0	U: 51.4	U: 51
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 20,672
Data surfaces per spindle	6	5	7	6	3
Heads per data surface	1	1	1	1	1
Tracks per surface	615	699	699	823	823
Track density (TPI)	822	784	784	960	760
Maximum linear density (BPI)	13700	9340	9340	9300	9650 BPI 6433 FCI
Recording code	MFM	MFM	MFM	MFM	2,7 RLL
Rotational speed (RPM)	3550	3600	3600	3600	3510
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	85 (including settling)	30	30	25	25
Average rotational delay (msec)	8.45	8.3	8.3	8.3	8.5
Average access time (msec)	93.45	38.3	38.3	33.3	33.5
Data transfer rate (KBytes/sec)	625	625	625	625	1209
FIRST CUSTOMER SHIPMENT	9/86	1Q84	1Q84	12/86	7/83
COMMENTS	41.3 mm high			41.3 mm high	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK511-8	DK512-8	DK512C-8	DK812S-8	DK312C-20
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ST412, SCSI	ESDI, SMD	SCSI	SMD	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.7	U: 86.1	F: 73.3	U: 85	F: 209
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,944	F: 17,920	U: 20,672	F: 19,456
Data surfaces per spindle	10	5	5	5	10
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	819	823	1076
Track density (TPI)	925	925	925	760	1660
Maximum linear density (BPI)	9250	18500 BPI 12333 FCI	18500 BPI 12333 FCI	9650 BPI 6433 FCI	38800 BPI 25866 FCI
Recording code	MFM	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3482	3482	3510	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)	23	23	23	25	16.8*
Average rotational delay (msec)	8.3	8.6	8.6	8.5	8.3
Average access time (msec)	31.3	31.6	31.6	33.5	25.1
Data transfer rate (KBytes/sec)	625	1209	1500 max.	1209	1500/4000
FIRST CUSTOMER SHIPMENT	2Q84	3/85	1/87	7/83	3Q89
COMMENTS					41.3 mm high *Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK312C-25	DK512-12	DK512-17	DK512C-12	DK512C-17
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI, SMD	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 251	U: 120.6	U: 172.3	F: 102.3	F: 146.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,456	U: 20,944	U: 20,944	F: 17,920	F: 17,920
Data surfaces per spindle	12	7	10	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	1076	823	823	819	819
Track density (TPI)	1660	925	925	925	925
Maximum linear density (BPI)	38800 BPI 25866 FCI	18500 BPI 12333 FCI	18500 BPI 12333 FCI	18500 BPI 12333 FCI	18500 BPI 12333 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3482	3482	3482	3482
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)	16.8*	23	23	23	23
Average rotational delay (msec)	8.3	8.6	8.6	8.6	8.6
Average access time (msec)	25.1	31.6	31.6	31.6	31.6
Data transfer rate (KBytes/sec)	1500/4000	1209	1209	1500 max.	1500 max.
FIRST CUSTOMER SHIPMENT	3Q89	3/85	3/85	1/87	1/87
COMMENTS	41.3 mm high *Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.				

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK512S-17	DK522-10	DK522C-10	DK524-20	DK524C-20
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 172.3	U: 103.4	F: 87.5	U: 200.5	F: 168.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,944	U: 20,944	F: 17,920	U:	F:
Data surfaces per spindle	10	6	6		
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	819	1105	1105
Track density (TPI)	925	960	960	1100	1100
Maximum linear density (BPI)	18500 BPI 12333 FCI	18500 BPI 12333 FCI	18500 BPI 12333 FCI	29800 BPI 19866 FCI	29800 BPI 19866 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3482	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)	23	25	25	25	25
Average rotational delay (msec)	8.6	8.3	8.3	8.3	8.3
Average access time (msec)	31.6	33.3	33.3	33.3	33.3
Data transfer rate (KBytes/sec)	1215	1250	1500 max.	1814	4000
FIRST CUSTOMER SHIPMENT	3/85	12/86	1/87	3Q88	4Q88
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK812S-12	DK812S-17	DK814S-17	DK814S-24	DK514-38
DISK/TREND GROUP	6	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SMD	Modified SMD	Modified SMD	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 119	U: 170.1	U: 170	U: 238	U: 382.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,672	U: 20,672	U: 32,768	U: 32,768	U: 30,240
Data surfaces per spindle	7	10	5	7	14
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	823	823	903
Track density (TPI)	760	760	800	800	1033
Maximum linear density (BPI)	9650 BPI 6433 FCI	9650 BPI 6433 FCI	18500 BPI 12333 FCI	18500 BPI 12333 FCI	26000 BPI 17333 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3510	3510	2632	2632	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	25	20	20	16
Average rotational delay (msec)	8.5	8.5	11.4	11.4	8.3
Average access time (msec)	33.5	33.5	31.4	31.4	24.3
Data transfer rate (KBytes/sec)	1209	1209	1815	1815	1815
FIRST CUSTOMER SHIPMENT	6/83	6/83	12/84	12/84	3Q87
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK514C-38	DK514S-38	DK814S-34	DK515-78	DK515C-78 DK515C-78D
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	MIG
Interface	SCSI	Modified SMD	Modified SMD	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 321.8	U: 382.3	U: 340	U: 780	F: 660.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 25,600	U: 30,240	U: 32,768	U: 40,960	F: 34,816
Data surfaces per spindle	14	14	10	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	898	903	823	1361	1356
Track density (TPI)	1033	1033	800	1296	1296
Maximum linear density (BPI)	26000 BPI 17333 FCI	26000 BPI 17333 FCI	18500 BPI 12333 FCI	40210 BPI 26806 FCI	40210 BPI 26806 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	2632	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	20	16	16
Average rotational delay (msec)	8.3	8.3	11.4	8.3	8.3
Average access time (msec)	24.3	24.3	31.4	24.3	24.3
Data transfer rate (KBytes/sec)	1500 max.	1815	1815	2458	1500/4000
FIRST CUSTOMER SHIPMENT	1Q88	3Q87	12/84	4Q88	4Q88
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK515S-78D	DK711S-60D DK711S-60S	DK815-5	DKU-85I-D14 DKU-85I-D24	DKU-97I
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM, Captive	OEM	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	224 mm OD 100 mm ID	14"	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	Modified SMD	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 780	U: 600	U: 525.38	F: 630	F: 635
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 30,240	U: 30,240	F: 47,476	F: 19,069
Data surfaces per spindle	14	22	14		20
Heads per data surface	1	1	1	2	2
Tracks per surface	1391	903	1241		1666
Track density (TPI)	1296	1033	860		720
Maximum linear density (BPI)	40210 BPI 26806 FCI	26000 BPI 17333 FCI	14585 BPI 9723 FCI		6425
Recording code	2,7 RLL	2,7 RLL	2,7 RLL		MFM
Rotational speed (RPM)	3600	4876	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	12	18	15	20/18
Average rotational delay (msec)	8.3	6.15	8.3	8.3	8.3
Average access time (msec)	24.3	18.15	26.3	23.3	28.3/26.3
Data transfer rate (KBytes/sec)	2458	2458	1815	3000	1198
FIRST CUSTOMER SHIPMENT		4Q87	11/84	4/86	1/81
COMMENTS		Oversized packaging		Drive has 4 spindles	Drive has 2 spindles

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-97S	H-6555	H-8576-12 H-8576-22	DK516-12	DK516C-16
DISK/TREND GROUP	8	8	8	9	9
MARKET	OEM	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	224 mm OD 100 mm ID	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	High Dens Oxide	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SMD	Hitachi	Hitachi	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 697.059	F: 500	F: 635	U: 1,229	F: 1,342
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,672	F: 28,884	F: 19,069	U: 45,880	F: 41,472
Data surfaces per spindle	20	14	20	15	15
Heads per data surface	2	1	2	1	1
Tracks per surface	1682	1237	1666	1787	2172
Track density (TPI)	720	860	720	1512	1954
Maximum linear density (BPI)	6425	14585 BPI 9723 FCI	6425	46375 BPI 34780 FCI	48525 BPI 36393 FCI
Recording code	MFM	2,7 RLL	MFM	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Rotary, Voice Coil	Dual, 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	18	20	14	13.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	26.3	28.3	22.3	21.8
Data transfer rate (KBytes/sec)	1240	1815	1198	2750	3030
FIRST CUSTOMER SHIPMENT	9/83	1Q85	4Q80	3Q90	3Q90
COMMENTS		Drive has 1 to 4 spindles	Drive has 2 spindles		

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK815-10	DK815-10A	DK816-20	DK816-20P	DKU-85I-E14 DKU-85I-E24 H-6585-14 H-6585-24
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	Captive,OEM,PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	224 mm OD 100 mm ID	224 mm OD 100 mm ID	224 mm OD 100 mm ID	224 mm OD 100 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Thin Film	Thin Film	Ferrite
Interface	Mod SMD, IPI-2	Modified SMD	IPI-2	IPI-2	IBM, Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,067	U: 1,067	U: 2,000	U: 1,869	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 74,600	U: 74,600	F: 47,476
Data surfaces per spindle	15	15	15	15	
Heads per data surface	1	1	1	1	2
Tracks per surface	1737	1737	1790	1790	
Track density (TPI)	1160	1220	1256	1256	
Maximum linear density (BPI)	20000 BPI 15000 FCI	19560 BPI 14670 FCI	35470 BPI 26602 FCI	35470 BPI 26602 FCI	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	13	13.5	13.5	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	21.3	21.8	21.8	25.3
Data transfer rate (KBytes/sec)	2460	2460	4500	9000*	3000
FIRST CUSTOMER SHIPMENT	1Q87	4Q87	3Q89	3Q90	12/85
COMMENTS				*Parallel data transfer, 2 channels	Drive has 4 spindles

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-86I-G14 DKU-86I-G24 H-6586-G14 H-6586-G24	DKU-86I-J14 DKU-86I-J24 H-6586-J14 H-6586-J24	DKU-86I-K14 DKU-86I-K24 H-6586-K14 H-6586-K24	DKU-98I H-8598-12 H-8598-22	H-6556-1
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	9.5"	9.5"	14"	9.5"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi	Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 630	F: 1,890	F: 1,260	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	15	15	15	20	15
Heads per data surface	1	1	2	2	1
Tracks per surface	1770 (Physical)	885	2655	1328 (Physical)	1770 (Physical)
Track density (TPI)				600	
Maximum linear density (BPI)				15240 BPI 10160 FCI	
Recording code				2,7 RLL	
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Dual, Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	11	12.5	16	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	21.3	19.3	20.8	24.3	23.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	3Q88	3Q88	3Q88	4Q82	3/88
COMMENTS	Drive has 8 spindles	Drive has 8 spindles	Drive has 8 spindles	Drive has 2 spindles 2 actuators per spindle	Drive has 4 spindles

MANUFACTURER	HITACHI	HITACHI	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS	HITACHI DATA SYSTEMS
DRIVE	H-6587-114 H-6587-124	H-6587-314 H-6587-324	7380-D	7380-J	7380-E
DISK/TREND GROUP	9	9	8	8	9
MARKET	Captive	Captive	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	9.5"	14"	9.5"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Thin Film	Ferrite
Interface	Hitachi	Hitachi	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 946	F: 2,920	F: 630	F: 630	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	15	15	10	15	12
Heads per data surface	2	2	4	1	4
Tracks per surface	1113	3436	664	885	1109
Track density (TPI)	1900	1900			
Maximum linear density (BPI)	29000 BPI 21750 FCI	29000 BPI 21750 FCI			
Recording code	1,7 RLL	1,7 RLL			
Rotational speed (RPM)	4260	4260	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, 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)	8.5	12	15	11	17
Average rotational delay (msec)	7.1	7.1	8.3	8.3	8.3
Average access time (msec)	15.6	19.1	23.3	19.3	25.3
Data transfer rate (KBytes/sec)	4200	4200	3000	3000	3000
FIRST CUSTOMER SHIPMENT	9/90	9/90			
COMMENTS	-114: max. 8 HDAs -124: max. 12 HDAs Also compatible mode to H-6586	-314: max. 8 HDAs -324: max. 12 HDAs Also compatible mode to H-6586	PCM 3380-D Drive has 4 spindles	PCM 3380-J Drive has 4 or 8 spindles per unit	PCM 3380-E Drive has 4 spindles

MANUFACTURER	HITACHI DATA SYSTEMS	HYOSUNG COMPUTER	HYOSUNG COMPUTER	HYOSUNG COMPUTER	IBIS
DRIVE	7380-K	HC8085	HC8128	HC8170E	2812
DISK/TREND GROUP	9	5	6	6	9
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Thin Film
Interface	IBM	ST412	ST412	ESDI	Custom, ISI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,890	U: 85.3	U: 127.9	U: 171.5	U: 2,830.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	U: 10,416	U: 15,624	U: 20,934	U: 99,840
Data surfaces per spindle	15	8	8	8	16
Heads per data surface	2	1	1	1	2
Tracks per surface	2655	1024	1024	1024	1776
Track density (TPI)		1053	1053	1053	769
Maximum linear density (BPI)		9290	13935 BPI 9250 FCI	19222 BPI 12815 FCI	32000 BPI 21333 FCI
Recording code		MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, DC Motor	Rotary, DC Motor	Rotary, DC Motor	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12.5	25	25	25	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	20.8	33.3	33.3	33.3	24.3
Data transfer rate (KBytes/sec)	3000	625	937.5	1250	12000
FIRST CUSTOMER SHIPMENT		1989	1989	1989	4Q87
COMMENTS	PCM 3380-K Drive has 4 or 8 spindles per unit				2 track parallel data transfer Drive has 1 spindle with 2 actuators

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8525-001,004 8525-G01,G04 8525-L01,L04	8530-021 8530-E21	WD-325	WDI-325	WDL-320
DISK/TREND GROUP	3	3	3	3	3
MARKET	Captive	Captive	OEM	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PS/2	PS/2-30	ST412	PC AT	PS/2-30
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	F: 20	U: 25.5	F: 21.3	U: 26.9 F: 20
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 12,920	U: 10,416	F: 8,704	F: 12,920
Data surfaces per spindle	4	2	4	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	610	774	612	612	774
Track density (TPI)	850	1170	850	841	1170
Maximum linear density (BPI)	13400	21700 BPI 14466 FCI	13400	13160	21700 BPI 14466 FCI
Recording code	MFM	2,7 RLL	MFM	MFM	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil
Servo type	Open Loop	Embedded	Open Loop	Open Loop	Embedded
Average positioning time (msec)	80 (including settling)	27	80 (including settling)	80 (including settling)	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	88.3	35.3	88.3	88.3	35.3
Data transfer rate (KBytes/sec)	625	1050	625	625	1050
FIRST CUSTOMER SHIPMENT	4Q88	10/88	5/86	6/88	
COMMENTS	41.3 mm high. PS/2 Optional drive w/38 ms average position. time made by Seagate	25.4 mm high	41.3 mm high	41.3 mm high	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4956-G10(40 MB) 4956-H10(40 MB)	5364-001	7541 7542	8530-001,E01	8530-E31
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ST412	IBM, ST412	Microchannel	Microchannel	PS/2-30, MC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 40	F: 41.92	F: 31.3	F: 31.3	F: 30
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 8,192	F: 12,800	F: 12,800	F: 16,384
Data surfaces per spindle	7	7	4	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	733	733	612	612	922
Track density (TPI)	815	815	841	841	1302
Maximum linear density (BPI)	9398	9398	19300	19300	26700 BPI 17800 FCI
Recording code	MFM	MFM			2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Open Loop	Open Loop	Embedded
Average positioning time (msec)	40	40	39 (including settling)	39 (including settling)	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	48.3	47.3	47.3	35.3
Data transfer rate (KBytes/sec)	625	625	937.5	937.5	1275
FIRST CUSTOMER SHIPMENT	9/86	6/85	4/89	4/89	9/89
COMMENTS	Series/1	System unit for System/36 PC	41.3 mm high IBM Industrial Computer	41.3 mm high PS/2	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8550-031 5551-S09 5551-T09 8555-031	8560-041 8580-041	8573-031	WD-L40	WDA-230
DISK/TREND GROUP	4	4	4	4	4
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	Microchannel	ST412	SCSI	Microchannel	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 31.3	F: 44.6	F: 30	U: 51.8 F: 40	U: 40.5 F: 31.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	F: 8,704	F: 16,384	F: 19,968	F: 15,360
Data surfaces per spindle	4	7	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	612	733	920	1038	1042
Track density (TPI)	841	815	1302	1517	2000
Maximum linear density (BPI)	19740	9398	26700 BPI 17800 FCI	31700 BPI 21133 FCI	35700 BPI 23800 FCI
Recording code		MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	39 (including settling)	40	19	16	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	47.3	48.3	27.3	24.3	28.3
Data transfer rate (KBytes/sec)	937.5	625	1250	1500	1100
FIRST CUSTOMER SHIPMENT	5/88	2Q87	3/90	4/90	4Q90
COMMENTS	41.3 mm high PS/2	PS/2		25.4 mm high	22.6 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDA-L40	WDL-330P	WDL-330R	WDP-L40	WDS-L40
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	PC XT	Microchannel	PC XT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 40	U: 35.4 F: 30.0	U: 35.4 F: 30.1	F: 40	U: 51.8 F: 40.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,968	F: 16,896	F: 16,384	F: 19,968	F: 19,968
Data surfaces per spindle	2	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1038	920	928	1038	1038
Track density (TPI)	1517	1344	1344	1517	1517
Maximum linear density (BPI)	31700 BPI 21133 FCI	26600 BPI 17333 FCI	26600 BPI 17333 FCI	31700 BPI 21133 FCI	31700 BPI 21133 FCI
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	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	16	23	19	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	31.3	27.3	24.3	24.3
Data transfer rate (KBytes/sec)	1500	1050/1250	1275	1500	1500
FIRST CUSTOMER SHIPMENT	6/90	4/90	4/90	6/90	6/90
COMMENTS	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	4956-G10(72 MB) 4956-H10(72 MB) 4956-J00(72 MB)	4965-E00	5363-P10	5364-003 5364-004 5364-023 5364-024	6150-115 6150-125 6150-B25 6151-115 6151-125 6151-B25
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 72	F: 72	F: 67.56	F: 65.9	U: 85.0 F: 73.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,664	F: 17,664	F: 16,640	F: 16,640	F: 17,920
Data surfaces per spindle	7	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	582	582	580	580	582
Track density (TPI)	648	648	648	648	648
Maximum linear density (BPI)	18942 BPI 12628 FCI	18942 BPI 12628 FCI	18942 BPI 12628 FCI	18942 BPI 12628 FCI	18942 BPI 12628 FCI
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)	30	30	30	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	38.3	38.3	38.3	38.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2/88	2/88	10/87	2/87	9/86
COMMENTS	Series/1	Storage expansion unit for Series/1	System unit for System/36 PC	System unit for System/36 PC	RT PC

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	7561 7562	8550-061 8570-A61,E61 8570-061,B61 5551-T0A 8555-061 8573-061	8560-071 8580-071 5571-T0A	8565-061	WD-380
DISK/TREND GROUP	5	5	5	5	5
MARKET	Captive	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	Microchannel	SCSI, MC	ESDI	SCSI, MC	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 60.8	F: 60.8	F: 70	F: 60	U: 103.5 F: 80
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 13,312	F: 18,432	F: 16,384	F: 18,815
Data surfaces per spindle	6	6	7	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	762	762	583	920	1063
Track density (TPI)	1169	1169	648	1302	1517
Maximum linear density (BPI)	21700 BPI 14466 FCI	21700 BPI 14466 FCI	18942 BPI 12628 FCI	26700 BPI 17800 FCI	31700 BPI 21133 FCI
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	Embedded	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	27	27	30	23	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	35.3	38.3	31.3	24.3
Data transfer rate (KBytes/sec)	1050	1050	1250	1250	1500
FIRST CUSTOMER SHIPMENT	4/89	5/88	2Q87	3/90	3/90
COMMENTS	41.3 mm high IBM Industrial Computer	41.3 mm high PS/2	PS/2	41.3 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WD-387	WD-387G	WD-387P	WDA-260	WDA-380
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	MIG
Interface	SCSI	Microchannel	SCSI, PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 80.7 F: 60.6	F: 60	U: 103.5 F: 80	U: 81.0 F: 62.9	U: 103.5 F: 80
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 16,384	F: 18,815	F: 15,360	F: 18,815
Data surfaces per spindle	6	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	767	920	1063	1042	1063
Track density (TPI)	1169	1302	1517	2000	1517
Maximum linear density (BPI)	21700 BPI 14466 FCI	26700 BPI 17800 FCI	31700 BPI 17333 FCI	35700 BPI 23800 FCI	31700 BPI 17333 FCI
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	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	27	23	19	20	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	31.3	27.3	28.3	24.3
Data transfer rate (KBytes/sec)	1050	1250	1500	1100	1500
FIRST CUSTOMER SHIPMENT	4/88	3/90	12/89	4Q90	6/90
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	22.6 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDS-380	WDS-387	0671-284	4967-2CA 4967-2CB	5360-BXX
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	14"	14"
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ESDI, SCSI	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 103.5 F: 80	F: 60.8	U: 284	F: 200.2	F: 200.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,815	F: 16,384	U: 21,080	F: 25,088	F: 25,088
Data surfaces per spindle	4	4	11	7	7
Heads per data surface	1	1	1	2	2
Tracks per surface	1063	933	1225	1140	1140
Track density (TPI)	1517	1302	1168	485	485
Maximum linear density (BPI)	31700 BPI 17333 FCI	26700 BPI 17800 FCI	21384 BPI 14256 FCI	9751	9751
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	MFM	MFM
Rotational speed (RPM)	3600	3600	3283	2964	2964
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	23	21.5	25	25
Average rotational delay (msec)	8.3	8.3	9.14	10.1	10.1
Average access time (msec)	24.3	31.3	30.64	35.1	35.1
Data transfer rate (KBytes/sec)	1500	1275	1250	1500	1500
FIRST CUSTOMER SHIPMENT	12/89	8/89	1Q88	7/83	7/83
COMMENTS	41.3 mm high	41.3 mm high		Series/1 384 KB Cache	System/36 5360-BX4 uses 2 spindles, with total 400.4 MB

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5363-P20 5363-P22	5363-S10	6150-13X 6150-B35 6150-4100 Opt. 6151-13X 6151-B35 6151-4100 Opt.	6156-001 6156-003	7012-320(#2120)
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ESDI	ESDI	ESDI	ESDI	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 106.2	F: 106.46	F: 114	F: 114	F: 120
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,640	F: 16,640	F: 17,920	F: 17,920	F: 16,384
Data surfaces per spindle	7	7	7	7	8
Heads per data surface	1	1	1	1	1
Tracks per surface	914	914	915	915	920
Track density (TPI)	1000	1000	1000	1000	1302
Maximum linear density (BPI)	19159 BPI 12772 FCI	19159 BPI 12772 FCI	19159 BPI 12772 FCI	19159 BPI 12772 FCI	26700 BPI 17800 FCI
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.	Embedded
Average positioning time (msec)	28	28	28	28	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	36.3	31.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1270
FIRST CUSTOMER SHIPMENT	10/87	9/90	4Q87	6/88	2Q90
COMMENTS	System unit for System/36 PC	AS/Entry	RT PC	Removable disk drive for RT PC 003 holds up to 3 disk modules 310 MB drive is optional	System/6000

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8102-A15	8570-121,B21 8570-A21,121 8573-121 5551-T0B 8580-A21,121 8565-121	8580-111 5571-T0B	9332-200 9332-220 9332-A11	9332-240 9332-250
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	SCSI, MC	ESDI	IPI-3	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 129.7	F: 120.5	F: 115	F: 200.3	F: 200.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	F: 18,432	F: 37,376	F: 37,376
Data surfaces per spindle	11	8	7	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	720	920	915	1346	1346
Track density (TPI)	850	1302	1000	1096	1096
Maximum linear density (BPI)	8770	26700 BPI 17800 FCI	19159 BPI 12772 FCI	23100 BPI 17325 FCI	23100 BPI 17325 FCI
Recording code	MFM	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3125	3600	3600	3119	3119
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	27	23	28	19.5	19.5
Average rotational delay (msec)	9.6	8.3	8.3	9.62	9.62
Average access time (msec)	36.6	31.3	36.3	29.12	29.12
Data transfer rate (KBytes/sec)	1031	1250	1250	2500	2500
FIRST CUSTOMER SHIPMENT	4/84	5/88	4Q87	8/86	2Q87
COMMENTS	8100 System -A17 model is 2 spindles	41.3 mm high PS/2	PS/2	System/36 System/38 AS/400	RT PC

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9402-Y10	WD-3158	WD-3158G	WD-3158P	WD-3160
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	MIG	MIG
Interface	SCSI-2	SCSI	SCSI, MC	SCSI, PC AT	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 160.08	U: 157.3 F: 120.5	U: 157.3 F: 120.5	U: 206.4 F: 160	U: 206.4 F: 160
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 16,384	F: 16,384	F: 18,815	F: 18,815
Data surfaces per spindle	7	8	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	949	925	925	1021	1021
Track density (TPI)	1201.5	1302	1302	1517	1517
Maximum linear density (BPI)	37341 BPI 28006 FCI	26700 BPI 17800 FCI	26700 BPI 17800 FCI	31700 BPI 21133 FCI	31700 BPI 21133 FCI
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4317.8	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.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12.5	23	23	19	16
Average rotational delay (msec)	6.95	8.3	8.3	8.3	8.3
Average access time (msec)	19.45	31.3	31.3	27.3	24.3
Data transfer rate (KBytes/sec)	4000	1250	1250		1500
FIRST CUSTOMER SHIPMENT	10/90	4/88	5/88	12/89	3/90
COMMENTS	AS/400	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDA-3160	WDS-3158	WDS-3160	0661-371	0661-467
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM	OEM	OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	MIG	MIG	MIG
Interface	PC AT	SCSI	SCSI	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 206.4 F: 160	F: 120.5	F: 160	U: 371 F: 320.1	U: 467 F: 400
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,815	F: 16,384	F: 18,815	F: 24,576	F: 24,576
Data surfaces per spindle	8	8	8	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1021	925	1063	949	1199
Track density (TPI)	1517	1302	1517	1201.5	1469
Maximum linear density (BPI)	31700 BPI 21133 FCI	26700 BPI 17800 FCI	31700 BPI 21133 FCI	37341 BPI 28006 FCI	38427 BPI 28820 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4317.8	4316
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	23	16	12.5	11.5
Average rotational delay (msec)	8.3	8.3	8.3	6.95	6.95
Average access time (msec)	24.3	31.3	24.3	19.45	18.45
Data transfer rate (KBytes/sec)	1500	1275	1500	4000 max.	5000 max.
FIRST CUSTOMER SHIPMENT	6/90	5/88	12/89	8/89	8/90
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	0671-387	0678-400	4967-3CA 4967-3CB	5360-BXA 5360-BXB 5360-C2X	5363-S20 5363-S22
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	14"	14"	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI, SCSI	IPI-3, SCSI	IBM	IBM	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 387	U: 476.5 F: 400.6	F: 358	F: 359.6	F: 314.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 21,080	U: 44,252 F: 37,376*	F: 25,088	F: 25,088	F: 17,408
Data surfaces per spindle	15	8	7	7	15
Heads per data surface	1	1	1	2	1
Tracks per surface	1225	1346	2048	2048	1225
Track density (TPI)	1168	1096	869	869	1168
Maximum linear density (BPI)	21384 BPI 14256 FCI	23100 BPI 17325 FCI	9751	9751	21384 BPI 14256 FCI
Recording code	2,7 RLL	1,7 RLL	MFM	MFM	2,7 RLL
Rotational speed (RPM)	3283	3119	2964	2964	3283
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Dual, Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	21.5	19.5	25	25	22
Average rotational delay (msec)	9.14	9.62	10.1	10.1	9.14
Average access time (msec)	30.64	29.12	35.1	35.1	31.14
Data transfer rate (KBytes/sec)	1250	2500	1500	1500	1250
FIRST CUSTOMER SHIPMENT	1Q88	6/86	9/86	2/86	9/90
COMMENTS		*Outer 893 tracks	Series/1	System/36 System uses multiple spindles	AS/Entry

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	6150-4300 Opt. 6150-5300 Opt. 6151-4300 Opt. 6151-5300 Opt.	7012-320(#2540) 7013-520(#2542) 7013-530(#2542) 7013-540(#2542) 7204-320	7013-520(#2500) 7013-530(#2500) 7016-730(#2500) 7203-001(#2300)	8580-311	8580-A31,321
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	Thin Film	Ferrite	MIG
Interface	ESDI	SCSI	SCSI	ESDI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 310	F: 320	F: 355	F: 314	F: 320
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 24,576	F: 27,648	F: 17,408	F: 24,576
Data surfaces per spindle	15	14	8	15	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	949	1632	1225	949
Track density (TPI)	1168	1201.5	1376	1168	1201.5
Maximum linear density (BPI)	21384 BPI 14256 FCI	37341 BPI 28006 FCI	31596 BPI 21064 FCI	21384 BPI 14256 FCI	37341 BPI 28006 FCI
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3283	4318	3600	3283	4318
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)	21.5	12.5	16	21.5	12.5
Average rotational delay (msec)	9.14	7	8.3	9.14	6.95
Average access time (msec)	30.64	19.5	24.3	30.64	19.45
Data transfer rate (KBytes/sec)	1250	4000 max.	1875	1250	2000
FIRST CUSTOMER SHIPMENT	7/88	2Q90	2Q90	1Q88	3/90
COMMENTS	RT PC	System/6000	System/6000 Mfg. by Maxtor	PS/2 Model 80	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9332-400 9332-402 9332-420	9332-440 9332-450	9332-A12	9371-10 9371-12 9371-14	9371-PS/2
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	MIG
Interface	IPI-3	SCSI	IPI-3	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 400.6	F: 400.6	F: 400.6	F: 295	F: 320
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 37,376	F: 37,376	F: 37,376	F: 24,576	F: 24,576
Data surfaces per spindle	8	8	8	14	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1346	1346	1346	949	949
Track density (TPI)	1096	1096	1096	1201.5	1201.5
Maximum linear density (BPI)	23100 BPI 17325 FCI	23100 BPI 17325 FCI	23100 BPI 17325 FCI	37341 BPI 28006 FCI	37341 BPI 28006 FCI
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3119	3119	3119	4317.8	4317.8
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	19.5	19.5	19.5	12.5	12.5
Average rotational delay (msec)	9.62	9.62	9.62	6.95	6.95
Average access time (msec)	29.12	29.12	29.12	19.45	19.45
Data transfer rate (KBytes/sec)	2500	2500	2500	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	7/88	2Q87	8/86	3/90	3/90
COMMENTS	AS/400 368 MB capacity when used with 9370 series	RT PC	System/36 System/38	41.3 mm high 9370	41.3 mm high 9370

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9402-C04 9402-C06	9404-C10 9404-C20 9404-C25	0681-500	3370-A02	7013-520(#2510) 7013-530(#2510) 7015-930(#2510) 7016-730(#2310) 7203-001(#2310)
DISK/TREND GROUP	7	7	8	8	8
MARKET	Captive	Captive	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	14"	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	MIG	MIG	MIG	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	IBM	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 320	F: 320	U: 579 F: 471	F: 729.8	F: 670
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 24,576	F: 29,696	F: 31,744	F: 27,648
Data surfaces per spindle	14	14	11	12	15
Heads per data surface	1	1	1	2	1
Tracks per surface	949	949	1458	1916	1632
Track density (TPI)	1201.5	1201.5	1677	800	1376
Maximum linear density (BPI)	37341 BPI 28006 FCI	37341 BPI 28006 FCI	30320	12134 BPI 8089 FCI	31596 BPI 21064 FCI
Recording code	1,7 RLL	1,7 RLL	PRML	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4317.8	4317.8	4986	2964	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12.5	12.5	11.2	19	18
Average rotational delay (msec)	6.95	6.95	6.02	10.1	8.3
Average access time (msec)	19.45	19.45	17.22	29.1	26.3
Data transfer rate (KBytes/sec)	4000	4000 max.	4000 max.	1859	1875
FIRST CUSTOMER SHIPMENT	9/90	2/90	3/90	2Q84	2Q90
COMMENTS	AS/400	41.3 mm high AS/400		4341 4361 4381	System/6000 Mfg. by Maxtor

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	7013-520(#2530) 7013-530(#2530) 7013-540(#2530) 7015-930(#2530) 7016-730(#2530)	9332-600 9332-602	9336-10	0681-1000	0685-B01
DISK/TREND GROUP	8	8	8	9	9
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	Thin Film	MIG	MIG	Thin Film
Interface	SCSI-2	IPI-3	SCSI-2	SCSI-2	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 857	F: 600	F: 471	U: 1,054 F: 857	U: 1,043.1 F: 855.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,696	F: 37,376	F: 29,696	F: 29,696	U: 44,280 F: 36,352
Data surfaces per spindle	20	8	11	20	6
Heads per data surface	1	1	1	1	2
Tracks per surface	1458	2017	1458	1458	3926
Track density (TPI)	1677	1500	1677	1677	1600
Maximum linear density (BPI)	30320	23570 BPI 17677 FCI	30320	30320	16200 BPI 10800 FCI
Recording code	PRML	1,7 RLL	PRML	PRML	2,7 RLL
Rotational speed (RPM)	4986	3119	4986	4986	3623
PERFORMANCE					
Actuator type	Linear, Voice Coil	Dual, Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Dual, Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11.2	19.5	11.2	11.2	18
Average rotational delay (msec)	6.02	9.62	6.02	6.02	8.28
Average access time (msec)	17.22	29.12	17.22	17.22	26.28
Data transfer rate (KBytes/sec)	4000 max.	2500	4000	4000 max.	3000
FIRST CUSTOMER SHIPMENT	2Q90	9/88	9/90	3/90	6/86
COMMENTS	System/6000	568 MB capacity when used with 9370 series	AS/400 9406 Disk unit, contains 2-4 disk drives		685-A01 has IPI-3 interface

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	3380-AJ4 3380-BJ4 3380-CJ2	3380-AK4 3380-BK4	3390-A14 3390-A18 3390-B14 3390-B18 3390-B1C	3390-A24 3390-A28 3390-B24 3390-B28 3390-B2C	9335-B01
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	10.8"	10.8"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260.4	F: 3,781.4	F: 1,892	F: 3,784	F: 855.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 56,664	F: 56,664	F: 36,352
Data surfaces per spindle	15	15	15	15	6
Heads per data surface	2	2	2	2	2
Tracks per surface	1770	5310	2226	4452	3924
Track density (TPI)	2089	2089	2235	2235	1600
Maximum linear density (BPI)	15190 BPI 10126 FCI 2,7 RLL	15190 BPI 10126 FCI 2,7 RLL	27940 BPI 20955 FCI 1,7 RLL	27940 BPI 20955 FCI 1,7 RLL	16200 BPI 10800 FCI 2,7 RLL
Recording code					
Rotational speed (RPM)	3620	3620	4260	4260	3623
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	12	16	9.5	12.5	18
Average rotational delay (msec)	8.3	8.3	7.1	7.1	8.28
Average access time (msec)	24.3	24.3	16.6	19.6	26.28
Data transfer rate (KBytes/sec)	3000	3000	4200	4200	3000
FIRST CUSTOMER SHIPMENT	10/87 (A,B)	10/87	12/89	12/89	8/86
COMMENTS	AJ4 & BJ4 have 2 spindles	Drive has 2 spindles	A14=2 HDAs A18=4 HDAs B14=2 HDAs B18=4 HDAs B1C=6 HDAs	A24=2 HDAs A28=4 HDAs B24=2 HDAs B28=4 HDAs B2C=6 HDAs	System/38 AS/400 9335-A01 has IPI-3 interface

MANUFACTURER	IBM	JVC	JVC	JVC	JVC
DRIVE	9336-20	JD-3824L	JD-3824R	JD-3824T	JD-3824TA
DISK/TREND GROUP	9	3	3	3	3
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI-2	Proprietary	Proprietary	Proprietary	Proprietary
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 857	F: 21.44	F: 21.44	F: 21.44	F: 21.47
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 29,696	F: 17,408	F: 17,408	F: 17,408	F: 24,576
Data surfaces per spindle	20	2	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1458	615	615	615	436
Track density (TPI)	1677	849	849	941	941
Maximum linear density (BPI)	30320	27410 BPI 18273 FCI	27410 BPI 18273 FCI	25610 BPI 17073 FCI	32331 BPI 21855 FCI
Recording code	PRML	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4986	2597	2597	2593	2332
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11.2	68 (including settling)	78 (including settling)	65 (including settling)	28 (including settling)
Average rotational delay (msec)	6.02	11.6	11.6	11.6	12.8
Average access time (msec)	17.22	79.6	89.6	76.6	40.8
Data transfer rate (KBytes/sec)	4000	937.5	937.5	937.5	1250
FIRST CUSTOMER SHIPMENT	9/90	2Q88	2Q87	3Q88	3Q89
COMMENTS	AS/400 9406 Disk unit, contains 2-4 disk drives	28.8 mm high	28.9 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	JVC	JVC	JVC	JVC	JVC
DRIVE	JD-E2825P	JD-3848H	JD-3848HA	JD-E3848V	JD-E3896V
DISK/TREND GROUP	3	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PCAT,Prop.,SCSI	Proprietary	Proprietary	PC AT, SCSI	PC AT/XT, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.45	F: 42.88	F: 42.95	F: 42.42	F: 84.84
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 17,408	F: 24,576	F: 24,576	F: 24,576
Data surfaces per spindle	2	4	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	581	615	436	862	862
Track density (TPI)	1300	941	941	1300	1300
Maximum linear density (BPI)	39665 BPI 26443 FCI	25610 BPI 17073 FCI	32331 BPI 21855 FCI	38145 BPI 25430 FCI	38145 BPI 25430 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3109	2593	2332	2332	2332
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	23	45 (including settling)	29 (including settling)	25	25
Average rotational delay (msec)	9.6	11.6	12.8	12.8	12.8
Average access time (msec)	32.6	56.6	41.8	37.8	37.8
Data transfer rate (KBytes/sec)	1250	937.5	1250	1250	1250
FIRST CUSTOMER SHIPMENT	4Q89	3Q88	3Q89	3Q89	1990
COMMENTS	19.1 mm high	31.4 mm high	31.4 mm high	20.8 mm high	25.4 mm high

MANUFACTURER	KALOK	KALOK	KALOK	KALOK	KALOK
DRIVE	KL320 Octagon 20	KL330 Octagon 30	KL341 Octagon I	KL343 Octagon I	KL386 Octagon II
DISK/TREND GROUP	3	4	4	4	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.62	U: 38.44*	F: 42.57	F: 42.57	F: 87.41
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	F: 15,360	F: 15,360	F: 17,322
Data surfaces per spindle	4	4	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	676	676	815
Track density (TPI)	814	814	814	814	911
Maximum linear density (BPI)	13533	20300 BPI 13533 FCI	23610 BPI 15740 FCI	23610 BPI 15740 FCI	28937 BPI 19292 FCI
Recording code	MFM	2,7 RLL*	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3375	3375	3375
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Servo type	Open Loop	Open Loop	Open Loop	Open Loop	Embedded
Average positioning time (msec)	40 (including settling)	40 (including settling)	30 (including settling)	29 (including settling)	25 (including settling)
Average rotational delay (msec)	8.3	8.3	8.8	8.8	8.8
Average access time (msec)	48.3	48.3	38.8	37.8	33.8
Data transfer rate (KBytes/sec)	625	937.5*	4500 max.	4500 max.	4500 max.
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	10/88	1/89	1Q90
COMMENTS	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	KOVO (ARITMA)	KYOCERA	KYOCERA	KYOCERA	KYOCERA
DRIVE	Aritma 5080	KC 20A	KC 20B	KC 30A	KC 30B
DISK/TREND GROUP	2	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	3336-11	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 25.5	U: 25.5	U: 38.4*	U: 38.4*
REMOVABLE	F: 200.0	--	--	--	--
Capacity per track (Bytes)	F: 13,030	U: 10,416	U: 10,416	U: 15,624*	U: 15,624*
Data surfaces per spindle	19	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	815	616	615	616	615
Track density (TPI)	370	835	800	835	800
Maximum linear density (BPI)	4040	12268	13464	18402 BPI 12268 FCI	20196 BPI 13464 FCI
Recording code	MFM	MFM	MFM	2,7 RLL*	2,7 RLL*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Servo type	Dedicated Surf.	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	30	65 (including settling)	62 (including settling)	65 (including settling)	62 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	73.3	70.3	73.3	70.3
Data transfer rate (KBytes/sec)	806	625	625	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	1986	1987	1987	1987	1987
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller

MANUFACTURER	KYOCERA	KYOCERA	KYOCERA	KYOCERA	KYOCERA
DRIVE	KC 40GA	KC 80GA	KC 80GS	KC 120DA	KC 120DS
DISK/TREND GROUP	4	4	4	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 40.54	F: 84.0	F: 81.08	F: 120.27	F: 120.27
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	F: 30,070	F: 30,070
Data surfaces per spindle	2	4	4	4	4
Heads per data surface	1	2	2	2	2
Tracks per surface	1069	1069	1069	1305	1305
Track density (TPI)	1309	1309	1309	1528	1528
Maximum linear density (BPI)	29589 BPI 19726 FCI	29589 BPI 19726 FCI	29589 BPI 19726 FCI	39939 BPI 26626 FCI	39939 BPI 26626 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	2746	2746	2746	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	28	23	23	19	19
Average rotational delay (msec)	10.92	10.92	10.92	8.3	8.3
Average access time (msec)	38.92	33.92	33.92	27.3	27.3
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	1Q90	4Q90	4Q90	1Q91	1Q91
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high

MANUFACTURER	MAGTRON	MAGTRON	MAGTRON	MAXTOR	MAXTOR
DRIVE	MT4115	MT4140	MT4170	7040A	7040S
DISK/TREND GROUP	6	6	6	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film		
Interface	ESDI, SCSI	ESDI, SCSI	ESDI, SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 138	U: 172	U: 207	F: 40.7	F: 40.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 17,920	U: 17,920	U: 17,920	F: 18,432	F: 18,432
Data surfaces per spindle	4	5	6	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1600	1600	1600	1170	1155
Track density (TPI)	1460	1460	1460	1490	1490
Maximum linear density (BPI)	20320 BPI 13546 FCI	20320 BPI 13546 FCI	20320 BPI 13546 FCI	30625 BPI 22969 FCI	30625 BPI 22969 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3703	3703
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	25	25	25	17	17
Average rotational delay (msec)	8.3	8.3	8.3	8.1	8.1
Average access time (msec)	33.3	33.3	33.3	25.1	25.1
Data transfer rate (KBytes/sec)	1250	1250	1250	1350	1350
FIRST CUSTOMER SHIPMENT	4/89	4/89	4/89	1Q90	1Q90
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	8051A	8051S	7080A	7080S	XT-1085
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite			Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.7	F: 45.1	F: 81.4	F: 80.7	U: 85.32
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 14,336	F: 14,336	F: 18,432	F: 18,432	U: 10,416
Data surfaces per spindle	4	4	4	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	745	799	1170	1155	1024
Track density (TPI)	1109	1109	1490	1490	1070
Maximum linear density (BPI)	23202 BPI 15468 FCI	23202 BPI 15468 FCI	30625 BPI 22969 FCI	30625 BPI 22969 FCI	9934
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	3484	3484	3703	3703	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	28	28	17	17	27
Average rotational delay (msec)	8.6	8.6	8.1	8.1	8.3
Average access time (msec)	36.6	36.6	25.1	25.1	35.3
Data transfer rate (KBytes/sec)	1000	1000	1350	1350	625
FIRST CUSTOMER SHIPMENT	2Q88	1Q88	1Q90	3Q90	2Q83
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high	

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	LXT-100	LXT-200	LXT-213	XT-1120R	XT-1140
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI, PC AT	SCSI, PC AT	SCSI, PC AT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 96	F: 207	F: 213	U: 127.99*	U: 143.42
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	*	*	U: 15,624*	U: 10,416
Data surfaces per spindle	8	7	7	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	733	1320	1320	1024	918
Track density (TPI)	1019	1591	1591	1070	1070
Maximum linear density (BPI)	26229 BPI 17486 FCI	28910 BPI 21682 FCI		14901 BPI 9934 FCI	9280
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL*	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	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)	29	15	15	27	25.8
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	23.3	23.3	35.3	34.1
Data transfer rate (KBytes/sec)	1250	1843 max.	1962 max.	937.5*	625
FIRST CUSTOMER SHIPMENT	3Q88	4Q88	3Q90	2Q87	2Q83
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	*With RLL controller	

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	XT-1240R	XT-2190	XT-4170E	XT-4170S	XT-4230E
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	ST412	ST412	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 239.98*	U: 191.23	U: 179.45	F: 157.93	U: 230.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 20,940	F: 18,432	U: 20,940
Data surfaces per spindle	15	15	7	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1224	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI)	14901 BPI 9934 FCI	11155	21064 BPI 14043 FCI	21064 BPI 14043 FCI	21064 BPI 14042 FCI
Recording code	2,7 RLL*	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	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)	27	28.9	14	14	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	35.3	37.2	22.3	22.3	24.3
Data transfer rate (KBytes/sec)	937.5*	625	1250	1500	1250
FIRST CUSTOMER SHIPMENT	2Q87	3Q84	2Q87	2/86	3Q90
COMMENTS	*With RLL controller				

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	XT-4280S	LXT-340	XT-4380E	XT-4380S	XT-8380E
DISK/TREND GROUP	6	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI, PC AT	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 248.17	F: 340	U: 384.53	F: 338.41	U: 410.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	*	U: 20,940	F: 18,432	U: 31,410
Data surfaces per spindle	11	7	15	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1560	1224	1224	1632
Track density (TPI)	1070	1613	1070	1070	1376
Maximum linear density (BPI)	21064 BPI 14043 FCI	*	21064 BPI 14043 FCI	21064 BPI 14043 FCI	31596 BPI 21064 FCI
Recording code	2,7 RLL	1,7 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	15	16	16	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	23.3	24.3	24.3	22.8
Data transfer rate (KBytes/sec)	1500	8000 max.	1250	1500	1875
FIRST CUSTOMER SHIPMENT	2/86	3Q90	2Q87	4Q87	1Q87
COMMENTS		41.3 mm high *Varies by zone 8 recording bands			

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	XT-8380S	LXT-437	LXT-535	P1-08E	P1-08S
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI-2, PC AT	SCSI-2, PC AT	ESDI	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 360.31	F: 437	F: 535	U: 811	U: 811
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	*	*	U: 50,644	U: 50,644
Data surfaces per spindle	8	9	11	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1560	1560	1778	1778
Track density (TPI)	1376	1600	1600	1498	1498
Maximum linear density (BPI)	31596 BPI 21064 FCI	*	*	52088 BPI 39066 FCI	52088 BPI 35674 FCI
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14.5	12 read/13 wr.	12 read/13 wr.	12.5	12.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.8	20.3/21.3	20.3/21.3	20.8	20.8
Data transfer rate (KBytes/sec)	1875	5000 max.	5000 max.	3040	3040
FIRST CUSTOMER SHIPMENT	1Q88	1Q91	1Q91	10/90	10/90
COMMENTS		41.3 mm high *Varies by zone	41.3 mm high *Varies by zone		

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	XT-8610E	XT-8702S	XT-8760E	XT-8760S	XT-8800E
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 615.3	U: 702.0	U: 768.9	F: 675.58	U: 800.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,410	U: 31,410	U: 31,410	F: 27,648	U: 41,888
Data surfaces per spindle	12	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1490	1632	1632	1274
Track density (TPI)	1376	1376	1376	1376	1376
Maximum linear density (BPI)	32320 BPI 21546 FCI	31596 BPI 21064 FCI	31596 BPI 21064 FCI	31596 BPI 21064 FCI	35020 BPI 21546 FCI
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	16.5	16.5	16.5	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.8	24.8	23.3
Data transfer rate (KBytes/sec)	1875	1875	1875	1875	2500
FIRST CUSTOMER SHIPMENT	3Q90	3Q90	1Q87	1Q88	3Q90
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	P0-12S	P1-12E	P1-12S	P1-13E	P1-16E
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	ESDI	SCSI-2	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,195	U: 1,234	U: 1,171	U: 1,351	U: 1,563
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 46,246	U: 50,644	U: 50,644	U: 46,246
Data surfaces per spindle	15	15	19	15	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1778	1216	1778	1778
Track density (TPI)	1376	1498	1498	1498	1498
Maximum linear density (BPI)	*	47566 BPI 35674 FCI		52088 BPI 39066 FCI	47566 BPI 35674 FCI
Recording code		1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	13	10.5	13	13
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	21.3	21.3	18.8	21.3	21.3
Data transfer rate (KBytes/sec)	2125-3750	3040	3040	3040	3040
FIRST CUSTOMER SHIPMENT	9/90	9/89	3/90	9/89	5/90
COMMENTS	*Varies by zone				

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MEMOREX TELEX	MEMOREX TELEX
DRIVE	P1-17E	P1-17S	P2-21S	3890-00J4	3890-02J4
DISK/TREND GROUP	9	9	9	8	8
MARKET	OEM	OEM	OEM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	ESDI	SCSI-2	SCSI-2	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,712	U: 1,712	U: 2,114	F: 630.24	F: 630.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,644	U: 50,644	*	F: 47,476	F: 47,476
Data surfaces per spindle	19	19	19	13.5	13.5
Heads per data surface	1	1	1	2	2
Tracks per surface	1778	1778	1778	990	990
Track density (TPI)	1498	1498	1498	1193	1193
Maximum linear density (BPI)	52088 BPI 39066 FCI	52088 BPI 39066 FCI	*	25211 BPI 18908 FCI	25211 BPI 18908 FCI
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3620	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)	13	13	13	12	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	21.3	21.3	21.3	20.3	20.3
Data transfer rate (KBytes/sec)	3040	3040	3040-4000	3000	3000
FIRST CUSTOMER SHIPMENT	5/90	3/90	11/90	1989	1989
COMMENTS			*Varies by zone	PCM 3380J Drive has 8 spindles	PCM 3380J Drive has 16 spindles

MANUFACTURER	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX	MFM TECHNOLOGY	MFM TECHNOLOGY
DRIVE	3835	3890-00K4	3890-02K4	11/11 Micro-Magnum	11/R Micro-Magnum
DISK/TREND GROUP	9	9	9	1	1
MARKET	PCM	PCM	PCM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	5.25" Cartridge	5.25" Cartridge
Nominal disk diameter	200 mm OD 63.5 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	IBM	ST506	ST506
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 855.8	F: 945.36	F: 945.36	U: 13.6	--
REMOVABLE	--	--	--	U: 13.6	U: 13.6
Capacity per track (Bytes)	F: 36,352	F: 47,476	F: 47,476	U: 10,640	U: 10,640
Data surfaces per spindle	14	13.5	13.5	4	2
Heads per data surface	2	2	2	1	1
Tracks per surface		1490	1490	640	640
Track density (TPI)	1368	1193	1193	908	908
Maximum linear density (BPI)	23400 BPI 15600 FCI	25211 BPI 18908 FCI	25211 BPI 18908 FCI	10890	10890
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	MFM	MFM
Rotational speed (RPM)	3656	3620	3620	3254	3254
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	17.5	16	16	40	40
Average rotational delay (msec)	8.2	8.3	8.3	9.2	9.2
Average access time (msec)	25.7	24.3	24.3	49.2	49.2
Data transfer rate (KBytes/sec)	3000	3000	3000	625	625
FIRST CUSTOMER SHIPMENT	3Q88	4Q89	4Q89	1986	1986
COMMENTS	PCM 9335	PCM 3380K Drive has 8 spindles	PCM 3380K Drive has 16 spindles		

MANUFACTURER	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MICROLAB
DRIVE	20/20 Micro-Magnum	20/R Micro-Magnum	5/5 Micro-Magnum	5/R Micro-Magnum	DFW 5025
DISK/TREND GROUP	1	1	1	1	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	5.25" Cartridge	5.25" Cartridge	5.25" Cartridge	5.25" Cartridge	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST506	ST506	ST506	ST506	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 24.25	--	U: 6.4	--	U: 25.6
REMOVABLE	U: 24.25	U: 24.25	U: 6.4	U: 6.75	--
Capacity per track (Bytes)	U: 10,640	U: 10,640	U: 10,032	F: 10,890	U: 10,416
Data surfaces per spindle	4	2	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1120	1120	320	311	615
Track density (TPI)	1250	1250	454	454	588
Maximum linear density (BPI)	11080	11080	8725	8617	9827
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	3248	3248	3443	3443	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor
Servo type	Embedded	Embedded	Embedded	Embedded	
Average positioning time (msec)	40	40	40	40	65
Average rotational delay (msec)	9.2	9.2	8.7	8.7	8.3
Average access time (msec)	49.2	49.2	48.7	48.7	73.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1990	1987	1986	1986	9/88
COMMENTS					41.3 mm high

MANUFACTURER	MICROLAB	MICROLAB	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	DFW 5053	DFW 5096	1335	1355	1375
DISK/TREND GROUP	4	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.3	U: 96.0	U: 85.3	U: 170.6	F: 145.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 20,832	F: 18,432
Data surfaces per spindle	5	9	8	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1024	1016
Track density (TPI)	1031	1031	1000	1055	1055
Maximum linear density (BPI)	9726	9726	9824	19804 BPI 13202 FCI	19804 BPI 13202 FCI
Recording code	MFM	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	28	28	28	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	31.3	31.3
Data transfer rate (KBytes/sec)	625	625	625	1250	1600
FIRST CUSTOMER SHIPMENT	10/89	10/89	3Q84	3Q85	1Q86
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1654-7	1674-7	1558-15	1565-8S	1578-15
DISK/TREND GROUP	6	6	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film	Thin Film/Ferr.
Interface	ESDI	SCSI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 182.1	F: 158	U: 382.3	U: 389	F: 331.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 18,432	U: 20,832	U: 31,250	F: 18,432
Data surfaces per spindle	7	7	15	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1249	1245	1224	1632	1220
Track density (TPI)	1100	1100	1075	1440	1075
Maximum linear density (BPI)	21185 BPI 14123 FCI	21185 BPI 14123 FCI	21231 BPI 14154 FCI	31846 BPI 21230 FCI	21231 BPI 14154 FCI
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	16	18	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	26.3	24.3	24.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1875	4000 max.
FIRST CUSTOMER SHIPMENT	1Q90	1Q88	4Q86	4Q89	2Q87
COMMENTS	41.3 mm high	41.3 mm high			

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1664-7	1684-7	1568-15	1588-15	1588-15D
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 389.3	F: 340	U: 765	F: 668	F: 668
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,248	F: 27,648	U: 31,250	F: 27,648	F: 27,648
Data surfaces per spindle	7	7	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1780	1776	1632	1628	1628
Track density (TPI)			1440	1440	1440
Maximum linear density (BPI)			31846 BPI 21230 FCI	31846 BPI 21230 FCI	31846 BPI 21230 FCI
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)	15	14	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	22.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1875	4000 max.	1875	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	1Q89	1Q89	2Q88	2Q88	7/90
COMMENTS	41.3 mm high	41.3 mm high			

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1518-15	1528-15	1530-15	1598-15	1598-15D
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,530	F: 1,346 U: 1,530	U: 1,010	F: 1,049	F: 1,036 U: 1,203
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 48,600	F: 43,008	U: 41,380	F: 36,864	F: 36,352
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2100	2100	1669	1919	1940
Track density (TPI)	1853	1853	1702		1702
Maximum linear density (BPI)	48608 BPI 36456 FCI	49532 BPI 37149 FCI	37664 BPI 28248 FCI		42462 BPI 31846 FCI
Recording code	1,7 RLL	1,7 RLL	1,7 RLL		1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14.5	14.5	14.5	14	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.8	22.8	22.8	22.3	22.8
Data transfer rate (KBytes/sec)	5000	5000	4000	4000 max.	5000
FIRST CUSTOMER SHIPMENT	8/90	7/90	7/90	3Q89	7/90
COMMENTS					

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	8040	HH-1050	HH-1060	HH-1090	5100
DISK/TREND GROUP	4	4	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42	U: 51.04	U: 79.99*	U: 95.81	U: 124.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,480	U: 10,416	U: 15,624*	U: 10,416	U: 20,832
Data surfaces per spindle	2	5	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1314	855
Track density (TPI)	1389	960	960	1250	1250
Maximum linear density (BPI)	32498 BPI 21665 FCI	10020	14935 BPI 9957 FCI	9840	25406 BPI 16937 FCI
Recording code	2,7 RLL	MFM	2,7 RLL*	MFM	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	28	28	28	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	36.3	36.3	36.3	26.3
Data transfer rate (KBytes/sec)	1500	625	937.5*	625	1250
FIRST CUSTOMER SHIPMENT	5/90	1/86	2/86	9/87	1Q89
COMMENTS	25.4 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	6100	7100	HH-1120	HH-2120	HH-2160
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	ST412	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 110	F: 110	U: 143.71*	U: 149.3	U: 186.08
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,435	U: 15,664*	U: 20,832	U: 20,833
Data surfaces per spindle	7	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	855	855	1314	1024	1276
Track density (TPI)	1250	1250	1250	1250	1250
Maximum linear density (BPI)	25406 BPI 16937 FCI	25406 BPI 16937 FCI	14760 BPI 9840 FCI	16896 BPI 11264 FCI	17920 BPI 11946 FCI
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	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)	18	18	28	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	36.3	36.3	36.3
Data transfer rate (KBytes/sec)	1250	1250	937.5*	1250	1250
FIRST CUSTOMER SHIPMENT	2Q89	2Q89	10/87	5/88	10/88
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	HH-3120	HH-3160	FH-2777	FH-3777	FH-21200
DISK/TREND GROUP	6	6	8	8	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 121.1	F: 169.5	U: 777	F: 687	U: 1,200
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 18,432	U: 31,740	F: 27,648	U: 41,664
Data surfaces per spindle	7	7	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1314	1314	1658	1658	1921
Track density (TPI)	1250	1250	1499	1499	1678
Maximum linear density (BPI)	19443 BPI 12962 FCI	19443 BPI 12962 FCI	29575 BPI 19717 FCI	29575 BPI 19717 FCI	40622 BPI 30466 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3558	3558	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	28	28	14	14	14
Average rotational delay (msec)	8.3	8.3	8.43	8.43	8.3
Average access time (msec)	36.3	36.3	22.43	22.43	22.3
Data transfer rate (KBytes/sec)	1250	1250	1875	2500	1875
FIRST CUSTOMER SHIPMENT	2/88	10/88	4Q90	4Q90	1Q91
COMMENTS	41.3 mm high	41.3 mm high			

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MILTOPE	MILTOPE	MILTOPE	MILTOPE
DRIVE	FH-31200	RDS-1500	RDS-5000	RDS-1720	RDS-3800
DISK/TREND GROUP	9	3	4	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Special	Special	Special	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI, NTDS	SCSI, NTDS	ESDI, NTDS	SCSI, NTDS
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,062	F: 18.5	F: 47.0	F: 159.3	U: 382
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 36,864	F: 9,216	F: 9,216	F: 19,456	U: 19,456
Data surfaces per spindle	15	3	5	8	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1921	670	1024	1024	1224
Track density (TPI)	1678	680	1000	960	1075
Maximum linear density (BPI)	40622 BPI 30466 FCI	9890	9824	19794 BPI 13196 FCI	19794 BPI 13196 FCI
Recording code	1,7 RLL	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	14	40	40	23	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	48.3	48.3	31.3	26.3
Data transfer rate (KBytes/sec)	2500	625	625	1250	1250
FIRST CUSTOMER SHIPMENT	1Q91	5/84	4Q86	3Q86	12/89
COMMENTS		Sold as militarized subsystem Removable disk assembly	Sold as militarized subsystem Removable disk assembly	Sold as militarized and ruggedized subsystem Removable disk assembly	Sold as militarized and ruggedized subsystem Removable disk assembly

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR333	MR335	MR535	MR3310A	MR3310S
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	MIG
Interface	ST412	ST412	ST412	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 30.9	U: 54.1	U: 50.85	F: 93.3	U: 93.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	F: 16,896	U: 16,896
Data surfaces per spindle	4	7	5	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	743	743	977	921	921
Track density (TPI)	1042	1042	1028	1300	1300
Maximum linear density (BPI)	13840	13840	9358	27200 BPI 18133 FCI	27200 BPI 18133 FCI
Recording code	MFM	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	20	20	28	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	28.3	36.3	31.3	31.3
Data transfer rate (KBytes/sec)	625	625	625	1250	1250
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	3Q86	4Q90	4Q90
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high Compatible with RLL controllers	41.3 mm high	41.3 mm high

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR335R	M4870F	MR3314A	MR3314S	M4875
DISK/TREND GROUP	5	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	Thin Film
Interface	ST412	SMD	PC AT	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 81.2*	U: 251.4	F: 124.4	F: 124.4	U: 408.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 20,480	F: 16,896	F: 16,896	U: 30,720
Data surfaces per spindle	7	12	8	8	13
Heads per data surface	1	1	1	1	1
Tracks per surface	743	1023	921	921	1023
Track density (TPI)	1042	1000	1300	1300	1000
Maximum linear density (BPI)	20760 BPI* 13840 FCI	10000	27200 BPI 18133 FCI	27200 BPI 18133 FCI	14100 BPI 9400 FCI
Recording code	2,7 RLL	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3544	3600	3600	3544
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	20	20	23	23	20
Average rotational delay (msec)	8.3	8.47	8.3	8.3	8.47
Average access time (msec)	28.3	28.47	31.3	31.3	28.47
Data transfer rate (KBytes/sec)	937.5*	1209	1250	1250	1814
FIRST CUSTOMER SHIPMENT	1Q90	4/84	4Q90	4Q90	3Q85
COMMENTS	41.3 mm high *With RLL controller		41.3 mm high	41.3 mm high	

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC
DRIVE	E1880B E1880C E1880D	HD354D	HD354VA	HD354VC	HD309AA
DISK/TREND GROUP	8	4	4	4	5
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	224 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	MIG
Interface	Mitsubishi	PC AT	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 630	F: 40	F: 40	F: 40	F: 90
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F:	F:	F:	F:
Data surfaces per spindle	15	4	4	4	6
Heads per data surface	2	1	1	1	1
Tracks per surface	885	615	615	615	928
Track density (TPI)	1060	944	944	944	1175
Maximum linear density (BPI)	21500 BPI 14333 FCI	16250	16250	16250	30000 BPI 20000 FCI
Recording code	2,7 RLL	MFM	MFM	MFM	2,7 RLL
Rotational speed (RPM)	3620	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	13	29	35	35	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	21.3	37.3	43.3	43.3	28.3
Data transfer rate (KBytes/sec)	3000	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	3Q88	1990	1Q90	1Q90	1Q90
COMMENTS	E1880B: 1 spindle E1880C: 4 spindles E1880D: 8 spindles	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	MITSUMI ELECTRIC	MITSUMI ELECTRIC	MITSUMI ELECTRIC	NEC	NEC
DRIVE	HD309AC	HD313AA	HD313AC	D3122	D3821
DISK/TREND GROUP	5	6	6	3	3
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	MIG	MIG	MIG	Ferrite	Ferrite
Interface	SCSI	PC AT	SCSI	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 90	F: 130	F: 130	U: 26.7	F: 22.52
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F:	F:	U: 10,416	F: 12,800
Data surfaces per spindle	6	8	8	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	928	963	963	642	440
Track density (TPI)	1175	1175	1175	850	850
Maximum linear density (BPI)	30000 BPI 20000 FCI	30000 BPI 20000 FCI	30000 BPI 20000 FCI	14000	17000 BPI 11333 FCI
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	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Torque Motor	Rotary, Torque Motor
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	20	20	20	28	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	28.3	28.3	36.3	36.3
Data transfer rate (KBytes/sec)	1250	1250	1250	625	937.5
FIRST CUSTOMER SHIPMENT	1Q90	2Q90	2Q90	5/88	5/88
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5126H	D5128	D3142	D3146H	D3735
DISK/TREND GROUP	3	3	4	4	4
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	MIG
Interface	ST412	ST412	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.62	U: 25.62	U: 53.4	U: 51.24	F: 45
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	F: 20,992
Data surfaces per spindle	4	4	8	8	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	642	615	1074
Track density (TPI)	700	700	850	850	1800
Maximum linear density (BPI)	9000	9000	14000	14000	30000 BPI 22500 FCI
Recording code	MFM	MFM	MFM	MFM	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3456
PERFORMANCE					
Actuator type	Linear, Torque Motor	Linear, Band, Stepping Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	40	85 (including settling)	28	35	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.7
Average access time (msec)	48.3	93.3	36.3	43.3	33.7
Data transfer rate (KBytes/sec)	625	625	625	625	1500
FIRST CUSTOMER SHIPMENT	4/86	10/87	1Q88	5/87	6/90
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	25.4 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3741	D3835	D3841	D5146H	D3661
DISK/TREND GROUP	4	4	4	4	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	MIG	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	SCSI	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 54.9	F: 45	F: 45.05	U: 51.24	U: 134.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624	F: 20,992	F: 12,800	U: 10,416	U: 20,992
Data surfaces per spindle	8	2	8	8	7
Heads per data surface	1	1	1	1	1
Tracks per surface	440	1075	440	615	915
Track density (TPI)	850	1800	850	700	1311
Maximum linear density (BPI)	17000 BPI 11333 FCI	30000 BPI 22500 FCI	17000 BPI 11333 FCI	9000	25484 BPI 16989 FCI
Recording code	2,7 RLL	1,7 RLL	2,7 RLL	MFM	2,7 RLL
Rotational speed (RPM)	3600	3456	3600	3600	3573
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Torque Motor	Linear, Torque Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	23	25	28	40	20
Average rotational delay (msec)	8.3	8.7	8.3	8.3	8.4
Average access time (msec)	31.3	33.7	36.3	48.3	28.4
Data transfer rate (KBytes/sec)	970	1500	937.5	625	1250
FIRST CUSTOMER SHIPMENT	7/89	2/90	12/87	4/86	11/88
COMMENTS	41.3 mm high	25.4 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3755 D3756	D3761	D3855 D3856	D3861	D5652
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	MIG	Ferrite	MIG	Ferrite	Ferrite
Interface	PC AT	PC AT	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	F: 118.05	F: 105	F: 118.05	U: 172.76
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,992	F: 17,920	F: 20,992	F: 17,920	U: 20,992
Data surfaces per spindle	4	7	4	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	1251	915	1251	915	823
Track density (TPI)	1800	1311	1800	1311	926
Maximum linear density (BPI)	32000 BPI 24000 FCI	25484 BPI 16989 FCI	32000 BPI 24000 FCI	25484 BPI 16989 FCI	18758 BPI 12505 FCI
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3456	3573	3456	3573	3573
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	20	25	20	23
Average rotational delay (msec)	8.7	8.4	8.7	8.4	8.4
Average access time (msec)	33.7	28.4	33.7	28.4	31.4
Data transfer rate (KBytes/sec)	1500	1250	1500	1250	1250
FIRST CUSTOMER SHIPMENT	6/90	9/89	12/89	3/89	2/86
COMMENTS	25.4 mm high D3756 has 19 msec. average positioning time	41.3 mm high	25.4 mm high D3856 has 19 msec. average positioning time	41.3 mm high	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5655	D5852	D5662	D5862	D2366
DISK/TREND GROUP	6	6	7	7	8
MARKET	Captive, OEM	Captive, OEM	OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ESDI	SCSI	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 179.86	F: 147.48	U: 385.41	F: 329.01	U: 800
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,992	F: 17,920	U: 20,992	F: 17,920	U: 40,960
Data surfaces per spindle	7	10	15	15	11.5
Heads per data surface	1	1	1	1	2/1
Tracks per surface	1224	823	1224	1221	1700
Track density (TPI)	1240	925	1240	1240	1070
Maximum linear density (BPI)	19610 BPI 13073 FCI	18759 BPI 12506 FCI	19660 BPI 13106 FCI	19660 BPI 13106 FCI	21400 BPI 14266 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3573	3573	3573	3573	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)	18	23	18	18	15
Average rotational delay (msec)	8.4	8.4	8.4	8.4	8.3
Average access time (msec)	26.4	31.4	26.4	26.4	23.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	2460
FIRST CUSTOMER SHIPMENT	12/87	5/87	11/87	11/87	1Q87
COMMENTS	41.3 mm high				

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5682	D5882	N7756	N7757	N7759
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive, OEM	Captive, OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	NEC	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 765.42	F: 664.7	F: 486.2	F: 750.5	F: 972
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,248	F: 27,136	F: 34,036	F: 38,708	F: 38,708
Data surfaces per spindle	16	16	9.5	11.5	11.5
Heads per data surface	1	1	2/1	2	2/1
Tracks per surface	1633	1633	1506	1686	1686
Track density (TPI)	1480	1480	1000	1070	1070
Maximum linear density (BPI)	30760 BPI 23070 FCI	30760 BPI 23070 FCI	18600 BPI 12400 FCI	21400 BPI 14266 FCI	21400 BPI 14266 FCI
Recording code	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3070	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	16	15	15	13
Average rotational delay (msec)	8.3	8.3	9.8	8.3	8.3
Average access time (msec)	24.3	24.3	24.8	23.3	21.3
Data transfer rate (KBytes/sec)	1875	1875	1860	2460	2460
FIRST CUSTOMER SHIPMENT	4/89	6/89	3Q84	1988	9/88
COMMENTS			Drive has 2 spindles	Drive has 2 spindles	

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2363	D2367	D2373	D2377	D2387
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	Modified SMD	IPI-2	SMD-E	IPI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,132	U: 1,132	U: 1,415	U: 1,415	U: 3,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 51,200	U: 51,200	U: 72,959
Data surfaces per spindle	13.5	13.5	13.5	13.5	15
Heads per data surface	2/1	2/1	2/1	2/1	2/1
Tracks per surface	2048	2048	2048	2048	2742
Track density (TPI)	1290	1290	1290	1290	1670
Maximum linear density (BPI)	21400 BPI 14266 FCI	21400 BPI 14266 FCI	26800 BPI 20100 FCI	26800 BPI 20100 FCI	37800 BPI 28350 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3700
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	15	15	15	12
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.1
Average access time (msec)	23.3	23.3	23.3	23.3	20.1
Data transfer rate (KBytes/sec)	2460	2460	3070	3070	4500
FIRST CUSTOMER SHIPMENT	5/87	9/87	10/87	12/87	4/90
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2463	D5892	N7766	N7767	N7768
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive, OEM	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	NEC	NEC	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,044	F: 1,400	F: 1,301.1	F: 635.3	F: 1,301.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 37,888	F: 50,400	F: 47,476	F: 32,768	F: 47,476
Data surfaces per spindle	13.5	19	13.5	11.5	13.5
Heads per data surface	2/1	1	2/1	2	2/1
Tracks per surface	2048	1678	2030	1686	2030
Track density (TPI)	1290	1603	1290	1070	1290
Maximum linear density (BPI)	21400 BPI 14266 FCI	45850 BPI 30567 FCI	26800 BPI 20100 FCI	21400 BPI 14266 FCI	26800 BPI 20100 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	15	14	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	22.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	2460	3000	3000	19600	3000
FIRST CUSTOMER SHIPMENT	8/87	6/90	3Q90	1988	10/89
COMMENTS			Drive has 4 spindles	N7767 uses 8 spindles in parallel array with 5 GB total capacity	Drive has 8 spindles

MANUFACTURER	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	8208X	8210X	8212X	8308	8312
DISK/TREND GROUP	6	6	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SMD, SCSI	SMD, SCSI	SMD, SCSI	H/P-SMD, SCSI	H/P-SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	SCSI(F): 142.0 (U): 187.3	SCSI(F): 177.5 (U): 234.2	SCSI(F): 265.6 (U): 350.2	SCSI(F): 323 (U): 394.8	SCSI(F): 529 (U): 592.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 21,912	U: 21,912	U: 21,912	U: 34,300	U: 34,300
Data surfaces per spindle	8	10	12	8	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1069	1069	1332	1439	1439
Track density (TPI)	1039	1039	1203	1236	1236
Maximum linear density (BPI)	10238	10238	10238	16200 BPI	16200 BPI
Recording code				10800 FCI 2,7 RLL	10800 FCI 2,7 RLL
Rotational speed (RPM)	3313.5	3313.5	3313.5	3313.5	3313.5
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19.5 (256 byte sector)	19.5 (256 byte sector)	21 (256 byte sector)	20	18
Average rotational delay (msec)	9	9	9	9	9
Average access time (msec)	28.5	28.5	30	29	27
Data transfer rate (KBytes/sec)	1209	1209	1209	1895	1895
FIRST CUSTOMER SHIPMENT	9/83	9/83	6/85	6/85	12/85
COMMENTS					

MANUFACTURER	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	8408	8412	8414	8508	8512
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD	SMD, SCSI	SMD, SCSI	SMD, SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 500	U: 750	U: 925	U: 588	U: 883
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,778	U: 41,778	U: 41,778	U: 49,200	U: 49,200
Data surfaces per spindle	8	12	14	8	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1496	1496	1583	1496	1496
Track density (TPI)	1368	1368	1368	1368	1368
Maximum linear density (BPI)	19800 BPI 13200 FCI	19800 BPI 13200 FCI	20300 BPI 13533 FCI	23300 BPI 15533 FCI	23300 BPI 15533 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3656	3656	3656	3656	3656
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	17.5	17.5	17	17.5	17.5
Average rotational delay (msec)	8.2	8.2	8.2	8.2	8.2
Average access time (msec)	25.7	25.7	25.2	25.7	25.7
Data transfer rate (KBytes/sec)	2550	2550	2550	3000	3000
FIRST CUSTOMER SHIPMENT	1/87	1/87	11/87	3/87	3/87
COMMENTS					

MANUFACTURER	NORTHERN TELECOM	ORCA TECHNOLOGY	ORCA TECHNOLOGY	ORCA TECHNOLOGY	ORCA TECHNOLOGY
DRIVE	8514	Shrike-320	Shrike-400	Falcon-E	Falcon-S
DISK/TREND GROUP	9	7	7	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD, SCSI	SCSI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,090	F: 336	F: 400	U: 765	F: 696.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 49,200	F: 24,576	*	U: 31,250	F: 28,160
Data surfaces per spindle	14	9	9	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1583	1495	1495	1632	1632
Track density (TPI)	1368	1750	1750	1400	1400
Maximum linear density (BPI)	23900 BPI 15933 FCI	38880 BPI 29160 FCI	38880 BPI 29160 FCI	32332 BPI 24249 FCI	32332 BPI 24249 FCI
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3656	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	16	12	12	14	14
Average rotational delay (msec)	8.2	8.3	8.3	8.3	8.3
Average access time (msec)	24.2	20.3	20.3	22.3	22.3
Data transfer rate (KBytes/sec)	3000	5000 max.	5000 max.	1875	1875
FIRST CUSTOMER SHIPMENT	11/87	2Q91	2Q91	4Q90	4Q90
COMMENTS		41.3 mm high	41.3 mm high *Varies by zone		

MANUFACTURER	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT
DRIVE	Hardcard 20	Plus Passport	Hardcard 40	Hardcard II 40	Plus Passport
DISK/TREND GROUP	3	3	4	4	4
MARKET	PCM, OEM	PCM, OEM	PCM, OEM	PCM	PCM, OEM
MEDIA: Generic type	Drive On Card	Removable Drive	Drive On Card	Drive On Card	Removable Drive
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium			Thin Film	Thin Film	
DRIVE: Heads	Ferrite	Ferrite	Ferrite	MIG	Ferrite
Interface	IBM PC	IBM PC	IBM PC	PC AT	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.2	--	F: 42.26	F: 40.2	--
REMOVABLE	--	F: 21.4	--	--	F: 42.6
Capacity per track (Bytes)	F: 8,704	F: 14,336 and 17,408	F: 14,336 and 17,408	F: 8,704	F: 14,336 and 17,408
Data surfaces per spindle	4	2	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	612	612	962	612
Track density (TPI)	812	812	812	1227	812
Maximum linear density (BPI)	13917 BPI 9278 FCI	21524 and 22392	21524 and 22392	27225 BPI 18150 FCI	21524 and 22392
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3000	3000	3662	3000
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	49 (including settling)	40*	40	25	40*
Average rotational delay (msec)	8.3	10	10	8.2	10
Average access time (msec)	57.3	50	50	33.2	50
Data transfer rate (KBytes/sec)	625	843.7/1031	843.7/1031	Up to 4000	843.7/1031
FIRST CUSTOMER SHIPMENT	6/86	6/88	5/87	--	6/88
COMMENTS	25.4 mm high	Drive with adapter mounts in half high 5.25" slot *About 27 msec using cache	25.4 mm high	25.4 mm high	Drive with adapter mounts in half high 5.25" slot *About 27 msec using cache

MANUFACTURER	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PRAIRIETEK	PRAIRIETEK
DRIVE	Hardcard II 80	XL50 Hardcard II XL	XL105 Hardcard II XL	120	220
DISK/TREND GROUP	5	5	6	3	3
MARKET	PCM	PCM	PCM	OEM	OEM
MEDIA: Generic type	Drive On Card	Drive On Card	Drive On Card	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	Ferrite
Interface	PC AT	PC AT	PC AT	PC AT/XT	SCSI, PC AT/XT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80.5	F: 52	F: 105	F: 21.4	F: 20
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	*	*	F: 17,408	F: 8,192
Data surfaces per spindle	4	2	4	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	962	1233	1233	615	612
Track density (TPI)	1227	1330	1330	1350	1150
Maximum linear density (BPI)	27225 BPI 18150 FCI	29307 BPI 19538 FCI	29307 BPI 19538 FCI	38452 BPI 25634 FCI	22500 BPI 15000 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3662	3662	3662	3307	3367
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	25	17**	17**	23	28
Average rotational delay (msec)	8.2	8.2	8.2	9.1	8.9
Average access time (msec)	33.2	25.2	25.2	32.1	36.9
Data transfer rate (KBytes/sec)	Up to 4000	4000	4000	1250	625
FIRST CUSTOMER SHIPMENT	--	10/90	10/90	1Q90	3/89
COMMENTS	25.4 mm high	23.5 mm high *Varies by zone **About 9 msec using cache	23.5 mm high *Varies by zone **About 9 msec using cache	15.4 mm high Ramp loaded heads	25.4 mm high Ramp loaded heads

MANUFACTURER	PRAIRIETEK	PROLOGICA	QUANTUM	QUANTUM	QUANTUM
DRIVE	240	W320B	40AT Go.Drive	40AT ProDrive	40S Go.Drive
DISK/TREND GROUP	4	5	4	4	4
MARKET	OEM	Captive, OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Thin Film	Ferrite	Thin Film
Interface	PC AT/XT	ST412	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.8	U: 25.5	F: 42	F: 42	F: 42
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	U: 10,416	*	*	*
Data surfaces per spindle	4	4	2	3	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	612	957	834	957
Track density (TPI)	1350	805	1801	1000	1801
Maximum linear density (BPI)	38452 BPI 25634 FCI	13014	46900 BPI 35175 FCI	22050 BPI 14700 FCI	46900 BPI 35175 FCI
Recording code	2,7 RLL	MFM	1,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3307	3555	3600	3662	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Embedded	Optical Encoder	Embedded
Average positioning time (msec)	28	48	19	19	19
Average rotational delay (msec)	9.1	8.45	8.3	8.2	8.3
Average access time (msec)	37.1	56.45	27.3	27.2	27.3
Data transfer rate (KBytes/sec)	1250	625	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	4Q89	4/89	3/91	5/88	3/91
COMMENTS	25.4 mm high Ramp loaded heads	Usable with RLL controller	15.7 mm high *Varies by zone Ramp loaded heads	41.3 mm high *Varies by zone	15.7 mm high *Varies by zone Ramp loaded heads

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	40S ProDrive	52AT ProDrive LPS	52S ProDrive LPS	80AT Gem	80AT Go.Drive
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	MIG	Thin Film	Thin Film
Interface	SCSI	PC AT	SCSI	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42	F: 52	F: 52	F: 84	F: 82
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	3	2	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	834	1219	1219	1678	957
Track density (TPI)	1000	1330	1330	1801	1801
Maximum linear density (BPI)	22050 BPI 14700 FCI	29307 BPI 19538 FCI	29307 BPI 19538 FCI	37724 BPI 28293 FCI	46900 BPI 35175 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3662	3662	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Optical Encoder	Optical Encoder	Optical Encoder	Embedded	Embedded
Average positioning time (msec)	19	17	17	19	19
Average rotational delay (msec)	8.2	8.2	8.2	8.3	8.3
Average access time (msec)	27.2	25.2	25.2	27.3	27.3
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	1/88	2/90	2/90	3/91	3Q91
COMMENTS	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	19.8 mm high *Varies by zone Ramp loaded heads	19 mm high *Varies by zone Ramp loaded heads

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	80AT ProDrive	80S Gem	80S Go.Drive	80S ProDrive	105AT ProDrive LPS
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Ferrite	MIG
Interface	PC AT	SCSI	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 84	F: 84	F: 82	F: 84	F: 105
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	6	2	4	6	4
Heads per data surface	1	1	1	1	1
Tracks per surface	834	1678	957	834	1219
Track density (TPI)	1000	1801	1801	1000	1330
Maximum linear density (BPI)	22050 BPI 14700 FCI	37724 BPI 28293 FCI	46900 BPI 35175 FCI	22050 BPI 14700 FCI	29307 BPI 19538 FCI
Recording code	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3662	3600	3600	3662	3662
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Optical Encoder	Embedded	Embedded	Optical Encoder	Optical Encoder
Average positioning time (msec)	19	19	19	19	17
Average rotational delay (msec)	8.2	8.3	8.3	8.2	8.2
Average access time (msec)	27.2	27.3	27.3	27.2	25.2
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	5/88	3/91	3Q91	1/88	--
COMMENTS	41.3 mm high *Varies by zone	19.8 mm high *Varies by zone Ramp loaded heads	19 mm high *Varies by zone Ramp loaded heads	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	105S ProDrive LPS	105S ProDrive	120AT ProDrive	120S ProDrive	160AT Gem
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	PC AT	SCSI, SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105	F: 105	F: 120	F: 120	F: 168
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	6	5	5	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1219	1019	1123	1123	1678
Track density (TPI)	1330	1225	1414	1414	1801
Maximum linear density (BPI)	29307 BPI 19538 FCI	22055 BPI 14700 FCI	27746 BPI 20810 FCI	27746 BPI 20810 FCI	37724 BPI 28293 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3662	3662	3605	3605	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Optical Encoder	Optical Encoder	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	17	19	14.3	14.3	19
Average rotational delay (msec)	8.2	8.2	8.3	8.3	8.3
Average access time (msec)	25.2	27.2	22.6	22.6	27.3
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	2/90	--	4Q89	3Q89	3/91
COMMENTS	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	19.8 mm high *Varies by zone Ramp loaded heads

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	160S Gem	170AT ProDrive	170S ProDrive	210AT ProDrive	210S ProDrive
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	PC AT	SCSI, SCSI-2	PC AT	SCSI, SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 168	F: 168	F: 168	F: 210	F: 210
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	4	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1678	1123	1123	1156	1156
Track density (TPI)	1801	1414	1414	1454	1454
Maximum linear density (BPI)	37724 BPI 28293 FCI	30000 BPI 22500 FCI	27746 BPI 20810 FCI	30000 BPI 22500 FCI	30000 BPI 22500 FCI
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3605	3605	3605	3605
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)	19	14.3	14.3	14.3	14.3
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	27.3	22.6	22.6	22.6	22.6
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	3/91	4Q89	1Q89	3Q89	4Q89
COMMENTS	19.8 mm high *Varies by zone Ramp loaded heads	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	RICOH
DRIVE	330AT ProDrive	330S ProDrive	425AT ProDrive	425S ProDrive	RH5130
DISK/TREND GROUP	7	7	8	8	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	5.25" Cartridge
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 331.2	F: 331.2	F: 425.8	F: 425.8	--
REMOVABLE	--	--	--	--	U: 12.75
Capacity per track (Bytes)	*	*	*	*	U: 10,416
Data surfaces per spindle	7	7	9	9	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1511	1512	1511	1512	612
Track density (TPI)	1695	1695	1695	1695	612
Maximum linear density (BPI)	36923 BPI 27692 FCI	36923 BPI 27692 FCI	36923 BPI 27692 FCI	36923 BPI 27692 FCI	10894
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	14**	14**	14**	14**	98 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.6
Average access time (msec)	22.3	22.3	22.3	22.3	106.6
Data transfer rate (KBytes/sec)	4000 max.	5000 max.	4000 max.	5000 max.	625
FIRST CUSTOMER SHIPMENT	--	--	--	--	3Q85
COMMENTS	41.3 mm high *Varies by zone **13 msec. average read positioning	41.3 mm high *Varies by zone **13 msec. average read positioning	41.3 mm high *Varies by zone **13 msec. average read positioning	41.3 mm high *Varies by zone **13 msec. average read positioning	41.3 mm high DMA license

MANUFACTURER	RICOH	RICOH	RODIME	RODIME	RODIME
DRIVE	RH5260 RH5261	RH5500	R03071A	R03071S	R03095A
DISK/TREND GROUP	1	1	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	5.25" Cartridge	5.25" Cartridge	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	Ferrite
Interface	ST506, SCSI	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 60.99	F: 60.99	F: 80.3
REMOVABLE	U: 25.5	F: 50.0	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 19,455	*	*	F: 20,833
Data surfaces per spindle	2	2	2	2	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1285	1217	1217	923
Track density (TPI)	1222	1200	1620	1620	1380
Maximum linear density (BPI)	10894	25750 BPI 17166 FCI	31884 BPI 23913 FCI	31884 BPI 23913 FCI	24763 BPI 16508 FCI
Recording code	MFM	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3473	3183	3611	3611	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	98 (including settling)	25	18	18	19
Average rotational delay (msec)	8.6	9.4	8.54	8.54	8.3
Average access time (msec)	106.6	34.4	26.54	26.54	27.3
Data transfer rate (KBytes/sec)	625	2000	1875	1875	1250
FIRST CUSTOMER SHIPMENT	1987	2Q89	1990	1990	1989
COMMENTS	41.3 mm high RH5261 has SCSI interface	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	41.3 mm high

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE	R03095T	R03099AP	R03128T	R03129TP	R03135A
DISK/TREND GROUP	5	5	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80.3	F: 80.39	F: 105.8	F: 107.46	F: 112.47
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	*	F: 17,408	*	F: 20,833
Data surfaces per spindle	5	4	7	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	923	1030	868	1091	923
Track density (TPI)	1380	1700	1380	1700	1380
Maximum linear density (BPI)	24763 BPI 16508 FCI	25804 BPI 17202 FCI	23875 BPI 15916 FCI	26731 BPI 17820 FCI	24763 BPI 16508 FCI
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)	19	18	18	18	19
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	27.3	26.3	26.3	26.3	27.3
Data transfer rate (KBytes/sec)	1250	1500	1250	1500	1250
FIRST CUSTOMER SHIPMENT	1988	1990	1988	1989	1989
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE	R03139AP	R03139TP	R03151A	R03151S	R03259A R03259AP
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 112.5	F: 112.5	F: 121.99	F: 121.99	F: 213.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	*	*
Data surfaces per spindle	5	5	4	4	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1168	1148	1217	1217	1235
Track density (TPI)	1700	1700	1620	1620	1700
Maximum linear density (BPI)	25805 BPI 17202 FCI	25805 BPI 17202 FCI	31884 BPI 23913 FCI	31884 BPI 23913 FCI	25804 BPI 17202 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3611	3611	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	Dedicated Surf.
Average positioning time (msec)	18	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.54	8.54	8.3
Average access time (msec)	26.3	26.3	26.54	26.54	26.3
Data transfer rate (KBytes/sec)	1500	1500	1875	1875	1500
FIRST CUSTOMER SHIPMENT	1989	1990	1990	1990	1Q89
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	41.3 mm high *Varies by zone

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	SAGEM
DRIVE	R03259TP	R03259TS	R03414T	R03534T	MSA 252-50
DISK/TREND GROUP	6	6	7	8	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Special
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	MIG	MIG	Ferrite
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 210.02	F: 210.02	F: 331	F: 426	--
REMOVABLE	--	--	--	--	F: 50
Capacity per track (Bytes)	*	*	F:	*	F: 23,040
Data surfaces per spindle	9	9	7	9	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1216	1216	1635	1568	720
Track density (TPI)	1700	1700	1800	1800	950
Maximum linear density (BPI)	26731 BPI 17820 FCI	25804 BPI 17202 FCI	38000 BPI 28500 FCI	38000 BPI 28500 FCI	19680 BPI 14760 FCI
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	18	14	14	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	22.3	22.3	25.3
Data transfer rate (KBytes/sec)	1500	1500	2500	2500	1500
FIRST CUSTOMER SHIPMENT	1990	1989	4/91	1990	10/90
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high *Varies by zone	Militarized Subsystem Removable Head/Disk Module

MANUFACTURER	SAGEM	SAGEM	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY
DRIVE	MSA 252-100	MSA 252-200	SHD2040N	SHD2041B	ST683J (9710-80) RSD
DISK/TREND GROUP	6	6	4	4	2
MARKET	OEM	OEM	OEM, Captive	OEM, Captive	OEM
MEDIA: Generic type	Special	Special	Fixed	Fixed	Removable Storage Drive
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	SCSI	ST412	PC AT	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	U: 51.2*	F: 47.0	--
REMOVABLE	F: 100	F: 200	--	--	U: 82.9
Capacity per track (Bytes)	F: 23,040	F: 23,040	U: 15,624*	F: 14,336	U: 20,160
Data surfaces per spindle	8	16	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	720	720	820	820	823
Track density (TPI)	950	950	1065	1065	550
Maximum linear density (BPI)	19680 BPI 14760 FCI	19680 BPI 14760 FCI	20196 BPI 13464 FCI	22386 BPI 14924 FCI	10000 BPI 6666 FCI
Recording code	1,7 RLL	1,7 RLL	2,7 RLL*	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3568	3525	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	17	17	35 (including settling)	29 (including settling)	27
Average rotational delay (msec)	8.3	8.3	8.4	8.51	8.3
Average access time (msec)	25.3	25.3	43.4	37.51	35.3
Data transfer rate (KBytes/sec)	1500	1500	937.5*	937.5	1209
FIRST CUSTOMER SHIPMENT	10/90	10/90	4Q88	1Q90	1Q83
COMMENTS	Militarized Subsystem Removable Head/Disk Module	Militarized Subsystem Removable Head/Disk Module	41.3 mm high *With RLL controller	41.3 mm high	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST124	ST125	ST125A	ST125N	ST225
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	PC AT	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.6	U: 25.6	F: 21.5	F: 21.5	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	F: 13,312	F: 13,312	U: 10,416
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	404	407	615
Track density (TPI)	824	824	824	824	588
Maximum linear density (BPI)	14953	14953	16546 BPI 11030 FCI	16546 BPI 11030 FCI	9827
Recording code	MFM	MFM	2,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Servo type	Open Loop	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	40 (including settling)	28 (including settling)	28 (including settling)	28 (including settling)	65 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	36.3	36.3	36.3	73.3
Data transfer rate (KBytes/sec)	625	625	937.5	937.5	625
FIRST CUSTOMER SHIPMENT	3Q89	3Q87	2Q89	1Q88	10/84
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST225N	ST225R	ST3025A	ST3025N	ST325A
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	PC AT	SCSI-2	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.3	U: 25.0*	F: 21.5	F: 21.5	F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	U: 18,750*	*	*	*
Data surfaces per spindle	4	2	1	1	2
Heads per data surface	1	1	1	1	1
Tracks per surface	615	667			
Track density (TPI)	588	588	1760	1760	1290
Maximum linear density (BPI)	9827	18897 BPI 12598 FCI	27000 BPI 18000 FCI	27000 BPI 18000 FCI	28922 BPI 19281 FCI
Recording code	MFM	2,7 RLL*	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3000	3600	3600	3048
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Rack, Stepping Motor
Servo type	Open Loop	Open Loop	Dedicated Surf.	Dedicated Surf.	Open Loop
Average positioning time (msec)	65 (including settling)	70 (including settling)	19	19	28 (including settling)
Average rotational delay (msec)	8.3	10	8.3	8.3	9.8
Average access time (msec)	73.3	80	27.3	27.3	37.8
Data transfer rate (KBytes/sec)	625	937.5*	1250-1750	1250-1750	1250-1750
FIRST CUSTOMER SHIPMENT	4Q85		2Q91	1Q91	3Q90
COMMENTS	41.3 mm high	41.3 mm high *With RLL controller	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST325N	ST325X	ST1057A	ST1057N	ST138
DISK/TREND GROUP	3	3	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC XT	PC AT	SCSI-2	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.4	F: 21.4	F: 53.4	F: 49.1	U: 38.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F:	F:	*	*	U: 10,416
Data surfaces per spindle	2	2	3	3	6
Heads per data surface	1	1	1	1	1
Tracks per surface		1230			615
Track density (TPI)	1015	1015	1300	1300	824
Maximum linear density (BPI)	22762 BPI 15175 FCI	22762 BPI 15175 FCI	20400 BPI 13600 FCI	20400 BPI 13600 FCI	14953
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3528	3528	3600
PERFORMANCE					
Actuator type	Rotary, Rack, Stepping Motor	Rotary, Rack, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band, Stepping Motor
Servo type	Open Loop	Open Loop	Dedicated Surf.	Dedicated Surf.	Open Loop
Average positioning time (msec)	28 (including settling)	45 (including settling)	19	19	28 (including settling)
Average rotational delay (msec)	8.3	8.3	8.5	8.5	8.3
Average access time (msec)	36.3	53.3	27.5	27.5	36.3
Data transfer rate (KBytes/sec)	1150	1150	1025-1500	1025-1500	625
FIRST CUSTOMER SHIPMENT	3Q90	2Q89	2Q91	1Q91	3Q87
COMMENTS	31.5 mm high	30 mm high	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST138A	ST138N	ST138R	ST151	ST157A
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 32.1	F: 32.2	U: 38.4*	U: 50.8	F: 44.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 13,312	U: 15,624*	U: 10,416	F: 13,312
Data surfaces per spindle	4	4	4	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	604	615	615	977	560
Track density (TPI)	824	824	824	1300	824
Maximum linear density (BPI)	22430 BPI 14953 FCI	22430 BPI 14953 FCI	22430 BPI 14953 FCI	14108	20280 BPI 13520 FCI
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, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Band, Stepping Motor
Servo type	Open Loop	Open Loop	Open Loop	Dedicated Surf.	Open Loop
Average positioning time (msec)	28 (including settling)	28 (including settling)	28 (including settling)	24	28 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	32.3	36.3
Data transfer rate (KBytes/sec)	937.5	937.5	937.5*	625	937.5
FIRST CUSTOMER SHIPMENT	2Q89	3Q87	3Q87	2Q88	1Q89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST157N	ST157R	ST238R	ST250R	ST251
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 48.6	U: 57.7*	U: 38.4*	U: 50.0*	U: 51.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	U: 15,624*	U: 18,750*	U: 10,416
Data surfaces per spindle	6	6	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	667	820
Track density (TPI)	824	824	588	588	777
Maximum linear density (BPI)	22430 BPI 14953 FCI	22430 BPI 14953 FCI	14740 BPI 9827 FCI	18897 BPI 12598 FCI	9935
Recording code	2,7 RLL	2,7 RLL*	2,7 RLL*	2,7 RLL*	MFM
Rotational speed (RPM)	3600	3600	3600	3000	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Servo type	Open Loop	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	28 (including settling)	28 (including settling)	65 (including settling)	70 (including settling)	28 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	10	8.3
Average access time (msec)	36.3	36.3	73.3	80	36.3
Data transfer rate (KBytes/sec)	937.5	937.5*	937.5*	937.5*	625
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	1Q86	3Q88	3Q87
COMMENTS	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST252	ST253 (94205-51) Wren 2 HH	ST3057A	ST3057N	ST351A/X
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	
Interface	ST412	ST412	PC AT	SCSI-2	PC AT/XT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2	U: 51.5	F: 53.4	F: 49.1	F: 42.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	*	*	*
Data surfaces per spindle	6	5	3	3	2
Heads per data surface	1	1	1	1	1
Tracks per surface	820	989			
Track density (TPI)	777	960	1760	1760	1290
Maximum linear density (BPI)	9935	9535	27000 BPI 18000 FCI	27000 BPI 18000 FCI	28922 BPI 19281 FCI
Recording code	MFM	MFM	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3048
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary
Servo type	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	40 (including settling)	28	19	19	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	9.8
Average access time (msec)	48.3	36.3	27.3	27.3	37.8
Data transfer rate (KBytes/sec)	625	625	1250-1750	1250-1750	1250-1750
FIRST CUSTOMER SHIPMENT	4Q89	1Q86	1Q90	1Q90	4Q90
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4053	ST1096N	ST1102A	ST1102N	ST177N
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	PC AT	SCSI-2	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.3	F: 83.9	F: 89.1	F: 84.0	F: 60.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 13,312	*	*	F: 13,312
Data surfaces per spindle	5	7	5	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	906			921
Track density (TPI)	1031	1300	1300	1300	1300
Maximum linear density (BPI)	9792	19893 BPI 13262 FCI	20400 BPI 13600 FCI	20400 BPI 13600 FCI	19893 BPI 13262 FCI
Recording code	MFM	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3528	3528	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)	28	20	19	19	20
Average rotational delay (msec)	8.3	8.3	8.5	8.5	8.3
Average access time (msec)	36.3	28.3	27.5	27.5	28.3
Data transfer rate (KBytes/sec)	625	937.5	1025-1500	1025-1500	937.5
FIRST CUSTOMER SHIPMENT	1/87	1Q89	4Q89	4Q89	1Q89
COMMENTS		41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST274A (94204-74) Wren 2 HH	ST277N	ST277R	ST278R	ST279R (94205-77) Wren 2 HH
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 65	F: 64.9	U: 76.9*	U: 76.8*	U: 77*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 17,408	U: 15,624*	U: 15,624*	U: 15,624*
Data surfaces per spindle	5	6	6	6	5
Heads per data surface	1	1	1	1	1
Tracks per surface	948	628	820	820	989
Track density (TPI)	960	777	777	777	960
Maximum linear density (BPI)	13489 BPI 8992 FCI	19869 BPI 13246 FCI	14902 BPI 9935 FCI	14902 BPI 9935 FCI	14302 BPI 9534 FCI
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, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil
Servo type	Dedicated Surf.	Open Loop	Open Loop	Open Loop	Dedicated Surf.
Average positioning time (msec)	28	28 (including settling)	28 (including settling)	40 (including settling)	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	48.3	36.3
Data transfer rate (KBytes/sec)	937.5	1250	937.5*	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	7/88	1/87	3Q86	4Q89	3Q87
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST280A (94204-71) Wren 2 HH	ST296N	ST3096A	ST3096N	ST4085 (94155-85) Wren 2
DISK/TREND GROUP	5	5	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI-2	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 71	F: 84.9	F: 89.1	F: 84.0	U: 85
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 17,408	*	*	U: 10,416
Data surfaces per spindle	5	6	3	3	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1032	820			1024
Track density (TPI)	960	777	1760	1760	980
Maximum linear density (BPI)	14357 BPI 9571 FCI	19869 BPI 13246 FCI	27000 BPI 18000 FCI	27000 BPI 18000 FCI	9400
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Open Loop	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	29	28 (including settling)	19	19	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	36.3	27.3	27.3	36.3
Data transfer rate (KBytes/sec)	937.5	1250	1250-1750	1250-1750	625
FIRST CUSTOMER SHIPMENT	7/88	4Q87	1Q90	1Q90	1986
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high *Varies by zone	25.4 mm high *Varies by zone	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4086 (94155-86) Wren II	ST4086E (94156-86) Wren 2	ST4096	ST4097 (94155-96) Wren 2	ST1100 Swift
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 86	U: 86.7	U: 96	U: 96	U: 100.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	9	9	9	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	925	925	1024	1024	1072
Track density (TPI)	960	960	1031	980	1350
Maximum linear density (BPI)	9274	9540	9792	9400	14019
Recording code	MFM	MFM	MFM	MFM	MFM
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	28	28	28	28	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	36.3	23.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	2Q84	2Q84	1Q86	1986	2Q88
COMMENTS					41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1111E Swift	ST1126A Swift	ST1126N Swift	ST1133A Swift	ST1133NS Swift
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	Ferrite	MIG	MIG
Interface	ESDI	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 111.9	F: 111.4	F: 107.0	F: 117	F: 117
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	F: 14,848	F: 14,848	F: 18,432	F: 18,432
Data surfaces per spindle	5	7	7	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1072	1072	1068	1272	1272
Track density (TPI)	1350	1350	1350	1543	1543
Maximum linear density (BPI)	28103 BPI 18735 FCI	22638 BPI 15092 FCI	22638 BPI 15092 FCI	28103 BPI 18735 FCI	28103 BPI 18735 FCI
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)	15	15	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	1250	1000	1000	1250	1250
FIRST CUSTOMER SHIPMENT	1Q89	1Q89	1Q89	4Q89	4Q89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1144A	ST1144N	ST1150R Swift	ST1162A Swift	ST1162N Swift
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI-2	ST412	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 124.7	F: 125.8	U: 150.7	F: 143	F: 137.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 15,624	F: 18,432	F: 18,432
Data surfaces per spindle	7	7	9	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface			1072	1072	1272
Track density (TPI)	1300	1300	1350	1350	1350
Maximum linear density (BPI)	20400 BPI 13600 FCI	20400 BPI 13600 FCI	21030 BPI 14020 FCI	22638 BPI 15092 FCI	22638 BPI 15092 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3528	3528	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)	19	19	15	15	15
Average rotational delay (msec)	8.5	8.5	8.3	8.3	8.3
Average access time (msec)	27.5	27.5	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	1025-1500	1025-1500	938	1000	1000
FIRST CUSTOMER SHIPMENT	2Q90	4Q90	2Q88	1Q89	1Q89
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1186A Swift	ST1186N Swift	ST1201A Swift	ST1201E Swift	ST1201N Swift
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	PC AT	SCSI	PC AT	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 164	F: 164	F: 177.5	U: 201.4	F: 171.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	F: 18,432	U: 20,880	F: 18,432
Data surfaces per spindle	7	7	9	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1272	1272	1072	1072	1072
Track density (TPI)	1543	1543	1543	1543	1543
Maximum linear density (BPI)	29000 BPI 19333 FCI	29000 BPI 19333 FCI	28103 BPI 18735 FCI	28103 BPI 18735 FCI	28103 BPI 18735 FCI
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)	15	15	15	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	4Q89	4Q89	1Q89	1Q89	1Q89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1239A Swift	ST1239N Swift	ST2106E (94216-106) Wren 3 HH	ST2106N (94211-106) Wren 3 HH	ST2125N (94221-125) Wren 5 HH
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 210.7	F: 204.2	U: 106	F: 89	F: 110
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	U: 20,880	F: 18,432	*
Data surfaces per spindle	9	9	5	5	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1272	1272	1024	1024	1544
Track density (TPI)	1543	1543	960	960	1280
Maximum linear density (BPI)	28103 BPI 18735 FCI	28103 BPI 18735 FCI	19058 BPI 12705 FCI	19058 BPI 12705 FCI	19213 BPI 12808 FCI
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)	15	15	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1125-1875
FIRST CUSTOMER SHIPMENT	3Q89	3Q89	2/87	2/87	
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST2182E (94246-182) Wren 6 HH	ST2209N (94221-209) Wren 5 HH	ST2274A (94244-274) Wren 6 HH	ST4135R (94155-135) Wren 2	ST4141E/N 94166-141 Wren 3
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Thin Film	Ferrite	Ferrite
Interface	ESDI	SCSI	PC AT	ST412	ESDI, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 182	F: 179	F: 193	U: 135*	U: 141
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,320	*	F: 27,648	U: 15,624*	U: 20,880
Data surfaces per spindle	5	5	5	9	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1453	1544	1453	960	969
Track density (TPI)	1459	1280	1459	980	960
Maximum linear density (BPI)	31699 BPI 21132 FCI	19213 BPI 12808 FCI	31699 BPI 21132 FCI	13670 BPI 9113 FCI	19058 BPI 12705 FCI
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)	15	18	16	28	16.4
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	26.3	24.3	36.3	24.7
Data transfer rate (KBytes/sec)	1875	1875	1875	937.5*	1250
FIRST CUSTOMER SHIPMENT	1/89		4/89	3Q87	2Q86
COMMENTS	41.3 mm high	41.3 mm high *Varies by zone	41.3 mm high	*With RLL controller	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4144R	ST4182E (94166-182) Wren 3	ST4182N (94161-182) Wren 3	ST6344J (9715-340) FSD	ST1400N
DISK/TREND GROUP	6	6	6	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	
Interface	ST412	ESDI	SCSI	SMD	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 144*	U: 182	F: 155	U: 344	F: 331
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 20,880	F: 19,456	U: 20,160	*
Data surfaces per spindle	9	9	9	12	7
Heads per data surface	1	1	1	2	1
Tracks per surface	1024	969	969	1422	
Track density (TPI)	1031	960	960	960	
Maximum linear density (BPI)	14688 BPI 9792 FCI	19058 BPI 12705 FCI	19058 BPI 12705 FCI	10000	
Recording code	2,7 RLL*	2,7 RLL	2,7 RLL	MFM	
Rotational speed (RPM)	3600	3600	3600	3600	4400
PERFORMANCE					
Actuator type	Linear, 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)	28	16.5	16.5	18	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	6.8
Average access time (msec)	36.3	24.8	24.8	26.3	20.8
Data transfer rate (KBytes/sec)	937.5*	1250	1250	1209	1875-3125
FIRST CUSTOMER SHIPMENT	3Q87	2Q86		4Q83	4Q90
COMMENTS	*With RLL controller				41.3 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1401N	ST1480A	ST1480N	ST2383A (94244-383) Wren 6 HH	ST2383E (94246-383) Wren 6 HH
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads				Thin Film	Thin Film
Interface	SCSI, SCSI-2	PC AT	SCSI, SCSI-2	PC AT	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 340	F: 426	F: 426	F: 338	U: 383
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	F: 27,648	U: 31,320
Data surfaces per spindle	9	9	9	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface				1747	1747
Track density (TPI)				1459	1459
Maximum linear density (BPI)				31699 BPI	31699 BPI
Recording code				21132 FCI 2,7 RLL	21132 FCI 2,7 RLL
Rotational speed (RPM)	4400	4400	4400	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)	14	14	14	16	16
Average rotational delay (msec)	6.8	6.8	6.8	8.3	8.3
Average access time (msec)	20.8	20.8	20.8	24.3	24.3
Data transfer rate (KBytes/sec)	2500-3125	1875-3125	1875-3125	1875	1875
FIRST CUSTOMER SHIPMENT	5/90	4Q90	3Q90	4/89	1/89
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST2383N (94241-383) Wren 6 HH	ST4350N (94171-350) Wren 4	ST4376N (94171-344) (94171-376) Wren 4	ST4383E (94186-383) Wren 5	ST4384E (94186-383H) Wren 5
DISK/TREND GROUP	7	7	7	7	7
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film		
Interface	SCSI	SCSI	SCSI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 338	F: 307	F: 330	U: 383	U: 383
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	*	U: 20,880	U: 20,880
Data surfaces per spindle	7	9	9	13	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1261	1412	1549	1412	1224
Track density (TPI)	1459	1280	1280	1280	1280
Maximum linear density (BPI)	31674 BPI 21116 FCI	19058 BPI 12705 FCI	19058 BPI 12705 FCI	19600 BPI 13066 FCI	19600 BPI 13066 FCI
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)	14	16.5	17.5	18	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	24.8	25.8	26.3	22.8
Data transfer rate (KBytes/sec)	2250-2265	1250-1875	1125-1875	1250	1250
FIRST CUSTOMER SHIPMENT	7/89	3/87	10/87	2/88	2/88
COMMENTS	41.3 mm high *Varies by zone	*Varies by zone	*Varies by zone		

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4385N (94181-385H) Wren Runner	ST4442E (94186-442) Wren 5	ST6315J (9715-300) FSD	ST8368 (9720-368) Sabre 1	ST2502N (94241-502) Wren 6 HH
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Thin Film		Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SMD	SMD,SMD-E,SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 337	U: 442	U: 315	U: 368	F: 440
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 20,880	U: 20,160	U: 30,240	*
Data surfaces per spindle	15	15	9.5	10	7
Heads per data surface	1	1	2/1	1	1
Tracks per surface		1412	1646	1217	1755
Track density (TPI)	1280	1280	1040	960	1459
Maximum linear density (BPI)	22000 BPI 14666 FCI	19600 BPI 13066 FCI	10000	15185 BPI 10123 FCI	31674 BPI 21116 FCI
Recording code	2,7 RLL	2,7 RLL	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	10.7	16	20	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	19	24.3	28.3	26.3	24.3
Data transfer rate (KBytes/sec)	1875-2000	1250	1209	1815	1875-2750
FIRST CUSTOMER SHIPMENT	1Q89	2/88	4Q85	11/85	9/89
COMMENTS	*Varies by zone				41.3 mm high *Varies by zone

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST4702N (94181-702) Wren 5	ST4766E (94196-766) Wren 6	ST4766N (94191-766) Wren 6	ST4767N (94601-767H) Wren Runner-2	ST6515 (9715-500) FSD
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	SCSI, SCSI-2	Mod.SMD,IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 613	U: 766	F: 676	F: 676	U: 516
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 31,320	F: 28,672	*	U: 30,240
Data surfaces per spindle	15	15	15	15	12
Heads per data surface	1	1	1	1	2
Tracks per surface	1546	1632	1632	1356	1422
Track density (TPI)	1280	1459	1459	1600	960
Maximum linear density (BPI)	26000 BPI 17333 FCI	30500 BPI 20333 FCI	30500 BPI 20333 FCI	30600 BPI 20400 FCI	15159 BPI 10106 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	4800	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)	16.5	15.5	16.5	11.9	18
Average rotational delay (msec)	8.3	8.3	8.3	6.25	8.3
Average access time (msec)	24.8	23.8	24.8	18.15	26.3
Data transfer rate (KBytes/sec)	1500-2000	1875	1875	3000	1825
FIRST CUSTOMER SHIPMENT	5/88	8/88	9/88	3/90	4Q83
COMMENTS	*Varies by zone			*Varies by zone	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST8500 (9720-500) Sabre 2	ST8741 (9720-736) Sabre 3	ST8851 (9720-850) Sabre 4	ST41200N (94601-12G) Wren 7	ST41201 (97500-12G) (97509-12G) Elite 1
DISK/TREND GROUP	8	8	8	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Mod.SMD, SCSI	Mod.SMD, SCSI	SMD,SCSI,IPI-2	SCSI, SCSI-2	Mod. SMD, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 500	U: 741	U: 851	F: 1,050	U: 1,200
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,088	U: 30,240	U: 41,088	*	U: 33,600
Data surfaces per spindle	10	15	15	15	17
Heads per data surface	1	1	1	1	1
Tracks per surface	1217	1635	1381	1931	2101
Track density (TPI)	960	1289	1089	1600	1801
Maximum linear density (BPI)	19816 BPI 13210 FCI	14981 BPI 9987 FCI	19816 BPI 13210 FCI	32750 BPI 24562 FCI	33344 BPI 22229 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	15	15	15	11.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	5.56
Average access time (msec)	26.3	23.3	23.3	23.3	17.06
Data transfer rate (KBytes/sec)	2465	1815	2465	1875-2625	3000
FIRST CUSTOMER SHIPMENT	2Q87	2Q87	3Q87	5/89	1Q90
COMMENTS				*Varies by zone	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST41520 (97501-15G) Elite 1	ST41600N Elite 1	ST81123J (97200-1123) Sabre 5	ST81154K (97229-1154) Sabre 2	ST81236 (9720-1230) Sabre 5
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	Mod. SMD	IPI-2	SMD,SCSI,IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,600 F: 1,352	U: 1,600 F: 1,352	U: 1,123	U: 1,154	U: 1,236
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	U: 45,792	U: 50,400	U: 50,400
Data surfaces per spindle	17	17	15	14	15
Heads per data surface	1	1	1	1	1
Tracks per surface	2101	2101	1635	1635	1635
Track density (TPI)	1801	1801	1289	1289	1289
Maximum linear density (BPI)	*	*	22955 BPI 15303 FCI	25264 BPI 16842 FCI	25264 BPI 16842 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	5400	5400	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)	11.5	11.5	15	15	15
Average rotational delay (msec)	5.56	5.56	8.3	8.3	8.3
Average access time (msec)	17.06	17.06	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	3000	3000-4500	2747	6000	3000
FIRST CUSTOMER SHIPMENT	2Q90	3Q90	3Q88	4Q88	2Q88
COMMENTS	*Varies by zone	*Varies by zone	22 Mhz version of Sabre 5	2 head parallel version of Sabre 5	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST82272J Sabre 6	ST82368K (97299-2368) Sabre PTD	ST82500 (9720-2500) Sabre 6	ST83050K Sabre 7 2HP	ST83220K Sabre 7
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Modified SMD	IPI-2	SMD,SCSI,IPI-2	IPI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,272	U: 2,368	U: 2,500	U: 3,050	U: 3,220
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 45,792	U: 53,599	U: 50,400	U: 127,680	U: 63,840
Data surfaces per spindle	19	18	19	18	19
Heads per data surface	1	1	1	1	1
Tracks per surface	2611	2611	2611	2655	2655
Track density (TPI)	1880	1880	1880	1912	1912
Maximum linear density (BPI)	21987 BPI 14658 FCI	24200 BPI 16133 FCI	25409 BPI 16939 FCI	32202 BPI 24151 FCI	32202 BPI 24151 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	4365	4365
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)	8.3	8.3	8.3	6.87	6.87
Average access time (msec)	20.3	20.3	20.3	18.87	18.87
Data transfer rate (KBytes/sec)	2747	27000	3000	9340	4670
FIRST CUSTOMER SHIPMENT	1Q90	3Q90	1Q90	4Q90	3Q90
COMMENTS	22 Mhz version of Sabre 6	9 head parallel version of Sabre 6		2 head parallel version of Sabre 7	

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SONY
DRIVE	803	7050	806	807	SRD2040Z
DISK/TREND GROUP	5	5	6	7	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	
Interface	Priam, SMD	Priam, SMD	Priam,SMD,SCSI	Priam,SMD,SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.68	U: 70.49	U: 227	U: 344	F: 42.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 13,400	U: 20,160	U: 20,160	F: 16,900
Data surfaces per spindle	5	5	11	11	4
Heads per data surface	1	1	1	1	1
Tracks per surface	850	1049	1023	1552	624
Track density (TPI)	960	960	1040	1040	980
Maximum linear density (BPI)	9167	6597	9167	12096	25500 BPI 17000 FCI
Recording code	MFM	MFM	MFM	MFM	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
Average positioning time (msec)	35	42	20	25	29
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	43.3	50.3	28.3	33.3	37.3
Data transfer rate (KBytes/sec)	1209	806	1210	1210	1250
FIRST CUSTOMER SHIPMENT	9/83	4Q81	5/84	6/84	1/89
COMMENTS					41.3 mm high

MANUFACTURER	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION
DRIVE	8380-B04	8380-BP4	8380-RXX	8380E	8380F
DISK/TREND GROUP	9	9	9	9	9
MARKET	PCM, OEM	PCM, OEM	PCM	PCM, OEM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IBM	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 1,260	Subsystem: 10,080 to 30,240 in 2.52 increments	F: 2,520.97	F: 3,780
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	15	15	15/15/19	15	19
Heads per data surface	2	2	2	2	2
Tracks per surface	1770	1770	1770/3540/4192	3540	4192
Track density (TPI)	800	800	800/1400/1650	1400	1650
Maximum linear density (BPI)	15240 BPI	15240 BPI	15240 BPI	*	15240 BPI
Recording code	10160 FCI 2,7 RLL	10160 FCI 2,7 RLL	10160 FCI 2,7 RLL	2,7 RLL	10160 FCI 2,7 RLL
Rotational speed (RPM)	3620	3620	3620	3620	3620
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, 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)	16	12	11/14/16	17	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	20.3	19.3/22.3/24.3	25.3	24.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	1983	12/87	1988	6/86	1Q89
COMMENTS	PCM 3380 Drive has 2 spindles	PCM 3380J Drive has 2 spindles	PCM 3380J,E,K Subsystem has 8 spindles 1X or 2X or 3X by pairs	PCM 3380-BE4 *Not announced Drive has 2 spindles	PCM 3380K Drive has 2 spindles

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	TEAC	TEAC	TOKICO
DRIVE	SQ555	SQ5110	SD-340	SD-380	TD3041C
DISK/TREND GROUP	1	1	4	5	4
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Generic type	SQ400	SQ800	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite			MIG
Interface	SCSI	SCSI	SCSI-2, PC AT	SCSI-2, PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 43.01	F: 86.02	F: 40
REMOVABLE	F: 44.39	F: 88.8	--	--	--
Capacity per track (Bytes)	F: 17,408	*	F: 20,480	F: 20,480	F: 17,920
Data surfaces per spindle	2	2	2	4	3
Heads per data surface	1	1	1	1	1
Tracks per surface	1275	1774	1050	1050	928
Track density (TPI)	1086	1475	1500	1500	1175
Maximum linear density (BPI)	23642 BPI 15761 FCI	28546 BPI 19031 FCI	32155 BPI 21437 FCI	32155 BPI 21437 FCI	28000 BPI 18666 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3220	3220	2358	2358	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Dedicated Surf.
Average positioning time (msec)	20	20	23	20	20
Average rotational delay (msec)	9.32	9.32	12.7	12.7	8.3
Average access time (msec)	29.32	29.32	35.7	32.7	28.3
Data transfer rate (KBytes/sec)	1250	1250	1000	1000	1250
FIRST CUSTOMER SHIPMENT	1Q88	1Q91	4Q89	4Q89	10/88
COMMENTS	41.3 mm high Removable data cartridge	41.3 mm high *Varies by zone Removable data cartridge	25.4 mm high	25.4 mm high	41.3 mm high

MANUFACTURER	TOKICO	TOKICO	TOKICO	TOKICO	TOKICO
DRIVE	TD3081C	TD3091A	TD3091C	TD3135A	TD3135C
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	MIG	MIG	MIG	MIG
Interface	SCSI	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 80	F: 90	F: 90	F: 130	F: 130
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 19,968	F: 19,968	F: 19,968	F: 19,968
Data surfaces per spindle	5	5	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	928	928	963	964	963
Track density (TPI)	1175	1175	1175	1175	1175
Maximum linear density (BPI)	28000 BPI 18666 FCI	30000 BPI 20000 FCI	30000 BPI 20000 FCI	30000 BPI 20000 FCI	30000 BPI 20000 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3296	3296	3296	3296
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)	20	20	20	20	20
Average rotational delay (msec)	8.3	9.1	9.1	9.1	9.1
Average access time (msec)	28.3	29.1	29.1	29.1	29.1
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	10/88	4/90	10/89	9/90	12/89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-232FB MK-232FBS MK-232FC	MK-134FA	MK-56FB	MK-156FA	MK-156FB
DISK/TREND GROUP	4	4	5	6	6
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 45.4	U: 53.4	U: 86.5	U: 173.0	F: 147.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	U: 10,416	U: 10,416	U: 20,832	F: 18,432
Data surfaces per spindle	3	7	10	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	845	733	830	830	830
Track density (TPI)	1100	1000	900	900	900
Maximum linear density (BPI)	28443 BPI 18962 FCI	13600	9383	18766 BPI 12510 FCI	18766 BPI 12510 FCI
Recording code	2,7 RLL	MFM	MFM	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	25	25	25	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	33.3	31.3	33.3
Data transfer rate (KBytes/sec)	1250	625	625	1250	1250
FIRST CUSTOMER SHIPMENT	1Q89	3Q87	3/85	4/86	9/86
COMMENTS	41.3 mm high MK-232FBS has 19 msec. average positioning time	41.3 mm high			

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-186FB	MK-234FB MK-234FBS MK-234FC	MK-234FC	MK-286FC	MK-355FA
DISK/TREND GROUP	6	6	6	7	7
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	SCSI	PC AT	Modified SMD	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 165.9	F: 106.0	F: 106.0	U: 374.3	U: 467.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	F: 17,920	F: 17,920	U: 41,340	U: 31,248
Data surfaces per spindle	10	7	7	11	9
Heads per data surface	1	1	1	1	1
Tracks per surface	823	845	845	823	1661
Track density (TPI)	900	1100	1100	765	1450
Maximum linear density (BPI)	9000 BPI 6000 FCI	28443 BPI 18962 FCI	28443 BPI 18962 FCI	19300 BPI 12867 FCI	32200 BPI 24150 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	18	25	25	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	33.3	33.3	26.3	24.3
Data transfer rate (KBytes/sec)	1210	1250	1250	2480	1875
FIRST CUSTOMER SHIPMENT	4Q83	1Q89	1Q89	4/86	4Q89
COMMENTS		41.3 mm high MK-234FBS has 19 msec. average positioning time	41.3 mm high		

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-355FB	MK-288FC	MK-358FA	MK-358FB	MK-388FA
DISK/TREND GROUP	7	8	8	8	8
MARKET	OEM	Captive, OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI, SCSI-2	Modified SMD	ESDI	SCSI, SCSI-2	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 405.2	U: 510.3	U: 778.5	F: 675.3	U: 720.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,136	U: 41,340	U: 31,248	F: 27,136	U: 41,340
Data surfaces per spindle	9	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1661	823	1661	1661	1162
Track density (TPI)	1450	765	1450	1450	1000
Maximum linear density (BPI)	32200 BPI 24150 FCI	19300 BPI 12867 FCI	32200 BPI 24150 FCI	32200 BPI 24150 FCI	19300 BPI 12867 FCI
Recording code	1,7 RLL	2,7 RLL	1,7 RLL	1,7 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	18	16	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	26.3	24.3	24.3	26.3
Data transfer rate (KBytes/sec)	1500/5000	2480	1875	1500/5000	2480
FIRST CUSTOMER SHIPMENT	4Q89	4/86	4Q89	--	12/87
COMMENTS					

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD93024-A Centaur	WD93024-X Explorer	WD93028-AD Atlas	WD93034-X Explorer	WD93044-A Centaur
DISK/TREND GROUP	3	3	3	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	PC XT	PC AT	PC XT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.62	F: 21.62	F: 21.62	F: 32.43	F: 43.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 13,824	F: 13,824	F: 13,824	F: 13,824
Data surfaces per spindle	2	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	782	782	782
Track density (TPI)	1021	1021	1013	1021	1021
Maximum linear density (BPI)	22175 BPI 14783 FCI	22175 BPI 14783 FCI	21278 BPI 14185 FCI	22175 BPI 14783 FCI	22175 BPI 14783 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3329	3329	3557	3329	3329
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Servo type	Open Loop	Open Loop	Open Loop	Open Loop	Open Loop
Average positioning time (msec)	19.3 (including settling)	28 (including settling)	61.6 (including settling)	28 (including settling)	19.3 (including settling)
Average rotational delay (msec)	9.0	9.0	8.4	9.0	9.0
Average access time (msec)	28.3	37	70	37	28.3
Data transfer rate (KBytes/sec)	640	640	200	640	640
FIRST CUSTOMER SHIPMENT	6/89	9/89	10/88	9/89	6/89
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD93044-X Explorer	WD93048-AD Atlas	WDAB130	WDAC140 Caviar	WDAC280 Caviar
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite		Ferrite	Ferrite
Interface	PC XT	PC AT	PC AT/XT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43.24	F: 43.24	F: 31.4	F: 42.5	F: 85.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 13,824	*	F: 19,968	F: 19,968
Data surfaces per spindle	4	4	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	995	1079	1079
Track density (TPI)	1021	1013	1730	1401	1401
Maximum linear density (BPI)	22175 BPI 14783 FCI	21278 BPI 14185 FCI	35970 BPI 23980 FCI	31576 BPI 21057 FCI	31576 BPI 21057 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3329	3557	3383	3598	3598
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Open Loop	Open Loop	Embedded	Embedded	Embedded
Average positioning time (msec)	28 (including settling)	61.6 (including settling)	19	18	18
Average rotational delay (msec)	9.0	8.4	8.8	8.2	8.2
Average access time (msec)	37	70	27.8	26.2	26.2
Data transfer rate (KBytes/sec)	640	200	4500	4000	4000
FIRST CUSTOMER SHIPMENT	9/89	10/88	1Q91	4/90	4/90
COMMENTS	41.3 mm high	41.3 mm high	15.3 mm high *Varies by zone	25.4 mm high	25.4 mm high

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WDAH260	WDAP2100 Piranha	WDAP4200 Piranha	WDSP2100 Piranha	WDSP4200 Piranha
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT/XT	PC AT	PC AT	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 62.8	F: 104.9	F: 209.8	F: 104.9	F: 209.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	F: 20,480	F: 20,480	F: 20,480	F: 20,480
Data surfaces per spindle	4	4	8	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	995	1200	1280	1280	1280
Track density (TPI)	1730	1575	1575	1575	1575
Maximum linear density (BPI)	35970 BPI 23980 FCI	35574 BPI 23716 FCI	35574 BPI 23716 FCI	35574 BPI 23716 FCI	35574 BPI 23716 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	3383	3610.4	3610.4	3610.4	3610.4
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	19	16	16	14.4	14.4
Average rotational delay (msec)	8.8	8.31	8.31	8.31	8.31
Average access time (msec)	27.8	24.31	24.31	22.71	22.71
Data transfer rate (KBytes/sec)	4500	5000	5000	5000	5000
FIRST CUSTOMER SHIPMENT	1Q91	11/90	11/90	7/90	7/90
COMMENTS	19 mm high *Varies by zone	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

MANUFACTURER	WESTERN DIGITAL	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	WDSC8320	YD-3042	YD-3081B	YD-3161B	YD-3181B
DISK/TREND GROUP	7	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	MIG	Ferrite	MIG	MIG	MIG
Interface	SCSI-2	SCSI	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 371 F: 320.1	F: 43.52	F: 45.45	F: 45.45	F: 45.45
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 14,336	F: 21,504	F: 21,504	F: 21,504
Data surfaces per spindle	14	4	2	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	949	788	1059	1059	1059
Track density (TPI)	1201.5	1104	1500	1370	1370
Maximum linear density (BPI)	37341 BPI 28006 FCI	22391 BPI 14927 FCI	32513 BPI 21675 FCI	34750 BPI 23166 FCI	34750 BPI 23166 FCI
Recording code	1,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
Rotational speed (RPM)	4317.8	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, DC Motor	Linear, DC Motor	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12.5	28	28	19	19
Average rotational delay (msec)	6.95	8.3	8.3	8.3	8.3
Average access time (msec)	19.45	36.3	36.3	27.3	27.3
Data transfer rate (KBytes/sec)	4000 max.	1062	1548	1548	1548
FIRST CUSTOMER SHIPMENT	8/89	2Q88	2Q90	4Q90	4Q90
COMMENTS	41.3 mm high Manufactured by IBM	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high

MANUFACTURER	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA	Y-E DATA
DRIVE	YD-3082	YD-3082B	YD-3083B	YD-3084B	YD-3162B
DISK/TREND GROUP	5	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	MIG	MIG	MIG	MIG
Interface	SCSI	SCSI	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 87.04	F: 90.96	F: 136.46	F: 181.96	F: 90.96
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 14,336	F: 21,504	F: 21,504	F: 21,504	F: 21,504
Data surfaces per spindle	8	4	6	8	4
Heads per data surface	1	1	1	1	1
Tracks per surface	788	1059	1059	1059	1059
Track density (TPI)	1104	1500	1500	1500	1370
Maximum linear density (BPI)	22391 BPI 14927 FCI	32513 BPI 21675 FCI	32513 BPI 21675 FCI	32513 BPI 21675 FCI	34750 BPI 23166 FCI
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	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	28	28	28	28	19
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	36.3	27.3
Data transfer rate (KBytes/sec)	1062	1548	1548	1548	1548
FIRST CUSTOMER SHIPMENT	2Q88	2Q90	2Q90	2Q90	4Q90
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	25.4 mm high

MANUFACTURER	Y-E DATA	ZENTEK	ZENTEK	ZENTEK	
DRIVE	YD-3182B	H3040A	H3060A	H3100A H3100S	
DISK/TREND GROUP	6	4	5	6	
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	
DRIVE: Heads	MIG	Ferrite	Ferrite	MIG	
Interface	SCSI	PC AT	PC AT	SCSI, PC AT	
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 90.96	F: 40	F: 60	F: 100	
REMOVABLE	--	--	--	--	
Capacity per track (Bytes)	F: 21,504	F: 13,312	F: 14,336	F: 17,408	
Data surfaces per spindle	4	4	5	7	
Heads per data surface	1	1	1	1	
Tracks per surface	1059	855	855	855	
Track density (TPI)	1370	1088	1088	1300	
Maximum linear density (BPI)	34750 BPI 23166 FCI	20600 BPI 13733 FCI	22000 BPI 14667 FCI	27500 BPI 18333 FCI	
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	
Rotational speed (RPM)	3600	3600	3600	3600	
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	
Servo type	Embedded	--	Dedicated Surf.	Dedicated Surf.	
Average positioning time (msec)	19	30	30	20	
Average rotational delay (msec)	8.3	8.3	8.3	8.3	
Average access time (msec)	27.3	38.3	38.3	28.3	
Data transfer rate (KBytes/sec)	1548	3900	3900	3900	
FIRST CUSTOMER SHIPMENT	4Q90	1Q91	1Q91	3Q91	
COMMENTS	25.4 mm high	41.3 mm high	41.3 mm high	41.3 mm high	

MANUFACTURER PROFILES

1990 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing moving head rigid magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1989 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. "1989 total net sales" covers the fiscal year ending December 31, 1989, 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. Northern Telecom is listed with U.S. firms for convenience.

Exchange rates

The exchange rates used in converting the financial data of non-U.S. manufacturers to dollars is given below. The average exchange rate for 1989 is used, as reported by the U.S. Federal Reserve Bulletin and rounded to three significant figures.

Country	Currency	Currency units per U.S. dollar
Brazil	Cruzeiro	2.81
France	Franc	6.38
Italy	Lira	1372.0
Japan	Yen	138.0
South Korea	Won	674.0
Taiwan	Dollar	26.4
United Kingdom	Pound	0.609
West Germany	Deutsch mark	1.88

U.S. Manufacturers

ALPHA DATA, INC.
20750 Marilla Street
Chatsworth, CA 91311

Alpha Data is a privately held manufacturer of head-per-track disk drives. The firm has been trying for several years to develop the market for an unusual 14" moving head drive using plated disks. The current version has 520 megabytes capacity and 18 millisecond average access time, achieved by using 10 heads per data surface. The drive transfers data through 8 parallel channels, achieving a 15 megabyte/second data transfer rate.

AMPEX CORPORATION
401 Broadway
Redwood City, CA 94063

After having manufactured OEM disk drives for 15 years, the firm's small remaining market share became unprofitable, and most production was phased out in 1986. At its peak, the Ampex product line consisted of numerous 14" disk pack and fixed disk drive models, plus several low-end 5.25" drives licensed from Rodime. The only product remaining in production is a 14" fixed disk drive with parallel data transfer.

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 company started out developing 3.5" and 2.5" disk drives employing very high areal densities -- more than 100 million bits per square inch. The initial target was development of a single disk 105 megabyte drive for production start in the fourth quarter of 1989, followed by a 200 megabyte drive later. A 2.5" 50 megabyte drive was also announced. The drives were to be among the first to use glass substrates. Nippon Sheet Glass is one of Areal's major investors. In 1990, management reorganizations resulted in Swartz leaving the company, along with the 3.5" development effort. Areal is now concentrating on 2.5" drives and moved into a new production facility in mid-1990.

AURA ASSOCIATES
12930 Saratoga Avenue
Saratoga, CA 95070

Aura Associates is a firm founded by industry veterans in mid-1986, and currently plans to complete the development 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 an actual production start up will depend on additional financing.

BRAND TECHNOLOGIES, INC.
9559 Irondale Avenue
Chatsworth, CA 91311

Brand Technologies was formed in 1986 by Avi Brand, a veteran of Pertec and Computer Memories, to develop voice coil 5.25" drives. The firm acquired rights to some of CMI's tooling and equipment to speed up the development process for its own drives, and first shipments began in early 1987. Initial products included 85 and 128 megabyte full-size drives. In mid-1987, Brand concluded an agreement with Hyosung Computer, a Korean firm, in which Hyosung obtained a minority interest in Brand and agreed to manufacture drives for Brand in Korea and distribute the drives in the Far East on an exclusive basis. The severe drop in industry pricing levels for 85 megabyte 5.25" drives which occurred in 1988, made distribution in the U.S. impractical, and Brand is no longer selling 5.25" drives. The company began production of several models of 3.5" drives in the 170 megabyte to 226 megabyte range in mid-1990.

CARDIFF PERIPHERALS CORPORATION
5421 Avenida Encinas
Carlsbad, CA 92008

Cardiff Peripherals has carried on several years of product development activity, under several organizational and financing arrangements, after being founded by industry veteran Frank Lutz -- first with 5.25" drives, later with 3.5" drives. The firm announced high performance 3.5" drives with up to 127 megabytes capacity in 1987, but that program has been dropped due to component delays and other problems. New 3.5" drives with up to 347 megabyte capacity have now been announced, and the firm is attempting to establish a suitable manufacturing arrangement in Asia.

CERPLEX TECHNOLOGIES
1270 North Kraemer Boulevard
Anaheim, CA 92806

Cerplex is the renamed successor of Century Data, Inc. After several years of flat sales, Century Data Systems was sold in mid-1986 by Xerox,

and in a complicated restructuring involving Cybernex, the previous thin film head manufacturer, evolved into Century Data, Inc., combining the operations of Century Data Systems, Cybernex Advanced Storage Technology (CAST), Amcodyne, Tecstor, and Ford-Higgins, a subsystem producer. The Century product line had been in transition for years, as newer fixed disk drives gradually replaced products in production before the acquisition by Xerox in 1979. Century pinned its hopes on higher capacity 8" drives introduced during the past three years, with sales emphasis primarily on plug compatible subsystems for the DEC add-on market. The design of the CAST 5.25" product line was licensed in 1988 to Magtron, a Taiwanese start-up producer of disk drives.

The change of company name in 1990 reflects another corporate reorganization and a new emphasis on drive refurbishment as a primary line of business, although disk drives remain in production at a low level.

COMPORT CORPORATION
2075 Zanker Road
San Jose, CA 95131

Comport was founded in 1987 by several key former employees of ill-fated LaPine Technology. As a result of the disinclination of U.S. venture capital firms to invest in the disk drive industry, Comport turned to Samsung Electronics for initial funding and a manufacturing agreement. Initial products, 3.5" disk drives ranging from 51 to 85 megabyte capacities, were introduced at the Spring 1988 Comdex. Samsung was slow to ramp up to expected production volumes, and Comport's attempts to secure funding for continuing operations led to a minority investment in November, 1988, by Priam, with an option to purchase the firm and an agreement to supply 3.5" drives to Priam for resale. The agreements with Priam were terminated in mid-1989. Comport went into Chapter 11 bankruptcy in the fall of 1989 while it attempted to increase Asian manufacturing, but was unsuccessful and ceased operations in 1990.

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

1989 disk sales: $701,800,000
1989 Total net sales: $704,900,000 Net income: $41,500,000

By any measure, the rapid growth of Conner Peripherals is one of the industry's outstanding success stories. The firm is headed by Finis Conner, cofounder of Seagate Technology, and the firm's first product was designed by a development company organized by John Squires, until early 1985 a key member of the Miniscribe technical staff. The company attracted a minority investment by Compaq Computer and installed a high volume production facility in San Jose to make 3.5" 40 megabyte drives.

By mid-1987, shipments, mostly to Compaq, had reached high levels, and facilities were already being 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 which will make the Conner disk drive product line in Italy. The joint venture provides captive drives to Olivetti and OEM drives for sale in Europe. Conner increased its share of ownership from 51% to 81% in 1990, and the firm established an additional wholly owned factory in Scotland.

By mid-1989, Conner's 3.5" product line had expanded to drives of 210 megabytes capacity, and included 1" high 20 and 40 megabyte 3.5" drives which have achieved outstanding success in the growing laptop computer market. In late 1989, Conner introduced 17.5 millimeter high 2.5" drives which have also been a major success in the emerging notebook computer market, plus 19.8 millimeter high 3.5" 20 and 40 megabyte drives. Sales to Compaq have declined to about 20% of the Conner total in recent quarters, reflecting continued success in attracting new OEM business.

DATA GENERAL CORPORATION
4400 Computer Drive
Westboro, MA 01581

1989 disk sales: $121,800,000
1989 total net sales: $1,314,395,000 (FY ending 9/30/89) Net income: ($119,730,000)

Data General manufactured all disk drive requirements internally for years, covering its requirements with several captive disk cartridge, disk pack and 14" Winchester drives. Despite the addition to its product line of several drives purchased from outside disk drive manufacturers, Data General continued with introduction of internally developed drives, adding low-end 8" drives in 1982, plus a 354 megabyte 14" fixed drive in 1983, subsequently extended to 592 megabytes in late 1984 and 888 megabytes in 1988. An 8" 500 megabyte drive was also introduced in 1988. Disk drive manufacturing was located in a new facility at Durham, New Hampshire. Data General has had difficulty in keeping up with its competition in recent years, and during the last year halted internal production of disk drives in favor of using OEM drives in its computer systems.

DDC PERTEC
Subsidiary of Digital Development Corporation
20400 Plummer Street
Chatsworth, CA 91311

Pertec, a pioneer manufacturer of OEM 14" disk cartridge drives, was acquired by Triumph-Adler in early 1980. After struggling to bring its disk drive line up to date, the initial 8" Winchester drives announced a few

years ago were dropped in favor of a new series of 8" high capacity drives which extended to 1,246 megabytes capacity. Olivetti purchased Triumph-Adler in 1986 and sold Pertec to Digital Development Corporation, which integrated all operations under a single management, with the disk drive operations under the DDC Pertec name. Production ceased in 1990, since the firm's low market share prevented profitable operations.

DIGITAL EQUIPMENT CORPORATION
146 Main Street
Maynard, MA 01754

1989 disk sales: $1,254,500,000
1989 total net sales: $12,741,956,000 (FY ending 7/01/89) Net income: $1,072,610,000

Until the 1980s, most revenues from DEC's internally manufactured disk drives were derived from disk cartridge drives, notably the high volume RL02 and its predecessors. However, in 1981 a new family of 14" Winchester drives appeared. The RA81, a 14" rack mounted Winchester drive with a formatted capacity of 456 megabytes was the big revenue producer for DEC until surpassed by follow-on products. The other early drive in the group is the RA60, a rack mounted disk pack drive with 205 megabytes formatted capacity. These were DEC's first internally designed and produced high-end disk drives, and the manufacturing start-up for the drives and their controller was painful, but significant to the firm's profitability. In late 1983, DEC started shipping the RC25 "Aztec", a long delayed 8" disk cartridge drive, superseding the 14" RL02 -- but too late to maintain the company's disk cartridge drive market at its previous size.

Starting in early 1987, the company started shipments of the follow-on to the RA81, the 622 megabyte RA82. Since 1988, DEC has been shipping the 9" 1.2 gigabyte RA90 from a highly automated plant in Colorado Springs, the first drive in which DEC has manufactured both the heads and media internally, and the successor to the RA81/RA82 series. As a replacement for the earlier disk cartridge drives, DEC became a major customer for 5.25" drives manufactured by both Micropolis and Maxtor, but is now producing the captive RA70, RF31 and RF71 full size high-end 5.25" drives, plus the RF30 half high 5.25" drive with 150 megabyte capacity.

DMA TECHNOLOGIES
601 Pine Avenue
Goleta, CA 93117

DMA Systems started shipments of its 5.25" 5/5 megabyte fixed-removable disk cartridge drive in 1982, and established an early leadership position in the 5.25" disk cartridge field, despite relatively high prices compared to fixed disk drives. Manufacturing licenses were sold to Memorex and Newbury Data, both of which later discontinued all OEM disk drive operations, and also to Ricoh and MFM, which are both still producing disk

cartridge drives. However, the market was slower to respond to DMA's product and pricing than the firm had anticipated. DMA ran out of funds and was forced to cease operations by its bank in August, 1985, but re-established production a few months later. By mid-1986, the bank had been paid off and the firm restarted operations as DMA Technologies. A 25.5 megabyte SCSI drive with removable media was announced in mid-1988.

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

1989 disk sales: $533,400,000
1989 total net sales: $11,899,000,000 (FY ending 10/31/88) Net income: $829,000,000

Hewlett-Packard has an extensive manufacturing operation for captive disk drives at Boise, Idaho, established in 1977, supplemented in mid-1983 with a facility in Bristol, England, and by production of 3.5" Winchester drives at Greeley, Colorado. H-P has made disk cartridge, disk pack, and fixed Winchester disk drives at Boise, which is also the firm's development facility for advanced head and disk technology. During 1987, H-P introduced 5.25" drives with capacities up to 389 megabytes and 8" drives with up to 571 megabytes. The sputtered disks used in 3.5", 5.25" and 8" drives are produced at Boise. Also during 1987, the company launched an OEM sales program for rigid disk drives, spearheaded by the new 5.25" models. The OEM program has proved to be successful for H-P, and the product line has been expanded to include new 5.25" drives with capacities over 1 gigabyte. In mid-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.

IBIS SYSTEMS, INC.
4197 Calle Tesoro
Camarillo, CA 93010

Ibis was one of the most ambitious of the industry's many start-up companies from the early 1980's, with a plan to make OEM and PCM versions of a 3380 equivalent drive. After finding that the technical complexities of such a project are very real, and having learned the extent of the resources needed to launch an adequate sales and service organization, Ibis changed its strategy to concentrate on a parallel data transfer version of the drive.

This plan resulted in Ibis' leadership in parallel transfer drives used with supercomputers and high-end imaging systems, but also exposed Ibis to the ups-and-downs of a volatile marketplace. The firm was forced to cut back employment sharply in 1989 and has consolidated into smaller facilities. Production of disk drives is being curtailed, in favor of development of subsystems using purchased disk drives.

IMPRIMIS TECHNOLOGY INCORPORATED
Subsidiary of Control Data Corporation
12501 Whitewater Drive
Minnetonka, MN 55343

In early 1988, Control Data established its Data Storage Products Group as a separate subsidiary, and in September of 1988, the new subsidiary was launched as Imprimis Technology. Imprimis was the second largest producer of OEM rigid disk drives when it was sold in a $450 million deal to Seagate Technology, in early October, 1989.

As Control Data, the company became the dominant OEM drive supplier in the 1970's on the strength of successful product lines in 14" disk cartridge drives, "storage module" disk pack drives, plus mid-range and large fixed disk drives. But many of the older OEM drives peaked in shipments years ago, and Control Data went through a long dry spell. Control Data's share of worldwide OEM revenues fell to 15.3% in 1986 from 1980's peak of 55%. But after seven years of watching its role as the leader in OEM disk drives gradually evaporate, Control Data was able to stabilize its position through installation of new management. During its last few years, Control Data successfully maintained a flow of major new 8", 5.25" and 3.5" drives, to replace declining shipments of older models.

Until 1988, many of the disk drives sold by Control Data were designed and manufactured by Magnetic Peripherals, Inc., a joint venture with Honeywell, Unisys and Bull. In 1987, Control Data bought out its minority partners. Control Data was a participant in the plug compatible disk drive market for several years, but its late start in the 3380 market prompted the firm to phase out of the PCM market in 1985. Until 1986, Control Data also was the managing partner in Optical Storage International (now Laser Magnetic Storage International), an optical disk joint venture with Philips. However, majority control is now in Philips' hands, and the Control Data minority interest has been retained by that firm.

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1989 disk sales: $9,650,300,000
1989 total net sales: $62,710,000,000 Net income: $3,758,000,000

IBM manufactures 14", 10.8", 8", 5.25", 3.5" and 2.5" fixed disk drives at several factories in the United States, Europe, Japan and Brazil. The revenue leader is clearly high-end disk drives for mainframe computers, during the 1980's the 3380 family, now being superseded by the 3390. 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 in the last two years introduced several drives which place it in the first tier of mid-range and low-end disk drive manufacturers. These include the 320 megabyte 3.5" "Lightning", the 857 megabyte 5.25" "Redwing", single disk 1" high 3.5" drives and a new family of 2.5" drives.

The 3390 "Soquel" was delayed, after an embarrassing July, 1989, announcement which was called off at the last minute, but finally announced and shipped in late 1989, becoming the firm's major drive for mainframe applications. The "Sutter," expected in mid-1990 but delayed for another year, will be a 5.25" drive operating at 5,400 RPM with over 1 gigabyte capacity, with possible early usage with low-end mainframes, then as a general replacement for the 3380K. In the mid-range, additional models in the 3.5" Lightning series have been announced and more are coming, as are enhancements to the 5.25" Redwing. The low-end, with high volume production well established at IBM's Fujisawa plant, is expected to see more 1" high 3.5" drives with more capacity, plus new 2.5" models with capacities over 100 megabytes.

IBM's first significant OEM sales of disk drives were made in 1984, involving the 3380 -- both Siemens and Honeywell are still buying the drive. For disk drives broadly sold on an OEM basis, it will be more difficult for IBM to establish a significant OEM disk drive business, due to tough competition and a rapidly changing market. Despite the difficulties, IBM has had some success in marketing its low-end 3.5" diameter drives in the personal computer aftermarket through CMS Enhancements. Since mid-1989, the Lightning 320 megabyte 3.5" drive has been resold by Western Digital in the OEM market and through distribution, and has been offered by System Industries in a DEC add-on subsystem. IBM is still a significant, but occasional, buyer of OEM disk drives, primarily small diameter drives purchased to meet a requirement too small to justify internal production, or to fill in during an IBM production shortfall.

In the fall of 1990, IBM created the new Storage Systems Products Division, encompassing the previous General Products Division, which held responsibility for more than twenty years for disk and tape drives for mainframe applications, and Low End Disk Operations, established during the 1980's to coordinate IBM's worldwide development and manufacturing operations for disk drives used in PCs and mid-range systems.

KALOK CORPORATION
1287 Anvilwood Avenue
Sunnyvale, CA 94089

1989 disk sales: $36,100,000

Kalok was founded in 1987 by Wayne Lockhart and Steve Kaczeus, a well-known designer of low-end disk drives. The firm has announced 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. In order to broaden its production base, Kalok has established a plant in the Philippines, the first hard disk drive producer to do so. Shipments from this facility began in late 1989, but Kalok will also continue its manufacturing arrangements with OPC.

MAXTOR CORPORATION
150 River Oaks Parkway
San Jose, CA 95134

1989 disk sales: $412,100,000
1989 total net sales: $491,134,000 (FY ending 3/31/90) Net income: $18,943,000

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 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 up to 190 megabyte 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, now 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 to be produced by a joint venture with Kubota, maintaining the Maxtor role as a leading edge supplier of OEM disk drives. The departure of several key employees had some impact, but Maxtor is back on a growth track and recently announced 5.25" drives with up to 2.1 gigabyte capacity, and became the first company to announce a 3.5" drive with more than 500 megabytes capacity.

In 1990, Maxtor acquired the Miniscribe product line and manufacturing facilities, converting them into a subsidiary renamed Maxtor Colorado. The Miniscribe acquisition provides Maxtor with a 1" high 3.5" drive product line currently with 40 and 80 megabyte models, a higher capacity 1" 3.5" drive in the near future, and a 2.5" drive also in development. With the acquisition, Maxtor now has multiple production facilities in Singapore, Hong Kong, Malaysia and the U.S. Maxtor is also planning a production facility in Europe.

MEMOREX TELEX CORPORATION
4343 S. 118th East Avenue
Tulsa, OK 74146

1989 disk sales: $37,400,000

The pioneer magnetic media and plug compatible disk drive producer originally known as Memorex Corporation was acquired by Burroughs in late 1981, and Burroughs placed all disk drive development and manufacturing responsibility for the entire company in the Memorex organization. In late 1986, however, Burroughs sold the disk drive sales and service operations of Memorex to a group of Memorex executives, retaining only the rigid disk

development and manufacturing operations. Telex was acquired by Memorex in early 1988 and the firm adopted its new name. Plug compatible disk drive subsystems now sold and serviced by Memorex Telex use various drive mechanisms manufactured by Unisys, Fujitsu and Northern Telecom. Memorex, now headquartered in Europe, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations.

MFM TECHNOLOGY, INC.
North Andover, MA 01845

MFM started manufacturing 5.25" disk cartridge drives in 1985 under license from DMA Systems. The firm had previously been involved in providing service for DMA drives, and offered controller development services. Increased capacity versions of the original designs are planned.

MICROPOLIS CORPORATION
21123 Nordhoff Street
Chatsworth, CA 91311

1989 disk sales: $301,800,000
1989 total net sales: $307,334,000 Net income: ($49,766,000)

Known as the originator of what were then considered high capacity 5.25" flexible disk drives, Micropolis entered the 8" Winchester disk drive market in 1979, and became a factor in the marketplace, after the usual Winchester early production problems. The company became a market leader in high capacity 5.25" drives -- the first firm to establish volume deliveries of 85 megabyte models. Micropolis has been the 5.25" industry leader at 85 megabytes and 170 megabytes, and is also in contention for leadership at 380 megabytes and 760 megabytes. A half high 180 megabyte drive was announced in late 1987 but suffered production delays during most of 1988. Heavy price competition in lower capacity "cash cow" products and delays in getting newer products into volume production have hurt Micropolis' financial results during the last two years. The firm had to cancel its 3.5" development program in order to concentrate on 5.25" drives, for which it retains an excellent reputation with the major system manufacturers which constitute most of its customer base.

MICROSCIENCE INTERNATIONAL CORPORATION
90 Headquarters Drive
San Jose, CA 95134

1989 disk sales: $75,600,000
1989 total net sales: $81,666,000 Net income:($7,820,000)

Microscience International, incorporated in 1982, started shipments in mid-1983 for its half high 5.25" drive using plated disks, and with sever-

al innovative design features intended to improve reliability. 3.5" drives were also added to the line, including both OEM and card-mounted versions. A half high voice coil 5.25" drive with 50 megabytes capacity was added in early 1986, followed by drives with up to 144 megabytes capacity. A shift in customer demand from 5.25" drives to 3.5" drives hampered growth in 1989, but newer 3.5" drives introduced in 1989 and 1990 are helping to expand 1990 sales.

Microscience has established a joint venture, Microscience Shenzen, in the People's Republic of China, but commencement of operations has been delayed pending approvals from the U.S. and Chinese governments. The firm joined with the Wearnes organization to establish a manufacturing facility in Singapore, now in production, and started its own production in Taiwan in 1987 for voice coil drives. Microscience weathered a management change in 1987, and in 1990 became a publicly owned company. In 1990, Microscience also expanded its product line by purchasing the rights to manufacture and market the Siemens 5.25" 777 megabyte and 1.2 gigabyte drives.

MILTOPE CORPORATION
1770 Walt Whitman Road
Melville, NY 11747

Miltope manufactures both flexible and rigid disk drives for use in its line of militarized peripherals, which includes disk, tape and bubble memory subsystems. Miltope's internally manufactured Winchester drives include 5.25" and 3.5" models incorporating heads and media in removable cartridges. In 1988, Miltope acquired the disk drive product line of Vermont Research.

MINISCRIBE CORPORATION
1871 Lefthand Circle
Longmont, CO 80501

1989 disk sales: $469,100,000
1989 total net sales: $349,848,000 (9 months) Net income: ($116,071,000)

Production of Miniscribe's 5.25" Winchester drives started in late 1981, and soared in late 1982 as IBM started taking 5.25" deliveries for the personal computer program. It was not an easy life, with drastic changes in IBM's procurements in 1984, coupled with the adverse fortunes of some of Miniscribe's other customers which lost market share in the personal computer wars to IBM.

Despite successful development of 3.5" drives and voice coil 5.25" drives, business problems caused by loss of IBM's purchases in early 1985 led to the departure of the founding management, to be replaced by a trouble-shooting team installed by Hambrecht & Quist, the investment banking firm which led a rescue financing operation. The new management focused on commercialization of the new drives approaching production startup, with a tough cost control program, and Miniscribe returned to profitability.

Unfortunately, internal controls were not adequately maintained, and the company was forced to restate its financial results for several past years, while a new management focused product development on 1" high 3.5" drives in an attempt to regain momentum.

In 1990, Maxtor acquired the product line and manufacturing facilities of the faltering company and converted it into a subsidiary firm, Maxtor Colorado Corporation.

NORTHERN TELECOM, INC.
Subsidiary of Northern Telecom, Ltd. (Canada)
259 Cumberland Bend
Nashville, TN 37228

1989 disk sales: $53,600,000
1989 total net sales: $6,105,500,000 Net income: $354,100,000

Northern Telecom's Memory Systems Division in Ann Arbor, Michigan, is shipping a family of high performance 8" Winchester drives. These drives are used for captive applications with Northern Telecom and have been supported with an active OEM sales program. In September, 1989, Northern Telecom announced its long-awaited new drives using perpendicular recording, with heads and disks from Censtor, and offering capacities up to 2.2 gigabytes. However, in 1990 Northern Telecom decided that disk drive manufacturing did not fit the firm's strategic direction and has elected to shut down production in 1991.

ORCA TECHNOLOGY
1751 Fox Drive
San Jose, CA 95131

Formed in July, 1990, Orca was founded by senior personnel from Maxtor, Priam and Televideo. Orca has purchased the rights to manufacture the 3.5" "Shrike" 400 megabyte drive that had been under development by Priam before Priam's demise, as well as rights to the Priam 5.25" 760 megabyte "Falcon" drive, and a considerable amount of Priam's tooling, inventory and fixtures. The firm plans to be shipping evaluation drives by late 1990, with eventual offshore production anticipated.

PLUS DEVELOPMENT CORPORATION
Subsidiary of Quantum Corporation
1778 McCarthy Boulevard
Milpitas, CA 95035

The Plus Hardcard is 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, first shipped in

October, 1985, was 10 megabytes, supplemented in 1986 with a 20 megabyte model and in 1987 by a 40 megabyte model. 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 has been contracted out to Matsushita-Kotobuki Electronics.

The Hardcard attracted a flood of competition, both from other disk drive manufacturers and from firms specializing in the personal computer aftermarket. Both types of competitors were able to quickly enter the market, by combining controller boards with 3.5" drives already in production, but Plus has maintained market leadership through alert marketing and new product introductions, plus competitors' concern about Plus' patent holdings. Saturation of the market for the lower capacity Hardcard models has resulted in Plus adopting a more aggressive pricing strategy and introducing higher capacity drives. The company is also moving towards becoming a general supplier of storage products to the aftermarket.

PRAIRIETEK CORPORATION
1830 Lefthand Circle
Longmont, CO 80501

Prairietek was established in 1986 by Terry Johnson, founder of Miniscribe, and announced the first of a new breed, the 2.5" rigid disk drive, in late 1988. The capacity of the initial drive was 20 megabytes, with an average 28 millisecond seek time. PrairieTek also announced in late 1989 a follow-on 40 megabyte model, achieved by increasing the capacity on each of two disks to 20 megabytes. Notebook computers are the initial target market for PrairieTek, as the drive is not only physically small, but uses little power. At Fall Comdex in 1989, the firm announced a 2.5", 20 megabyte drive only 15.4 millimeters high.

Faced with aggressive competition from Conner Peripherals, Prairietek entered into an agreement with Alps Electric to manufacture drives on a contract basis, in order to improve overall manufacturing capability. Production from Alps commenced in 1990.

PRIAM CORPORATION
20 West Montague Expressway
San Jose, CA 95134

1989 disk sales: $72,100,000
1989 total net sales: $122,700,000 (FY ending 6/30/89) Net income: ($25,400,000)

Priam became a significant supplier of OEM Winchester disk drives in 1981, as volume production was achieved for the firm's original line of mid-

range 14" drives and shipments of 8" drives got under way. 8" Winchesters, with capacities up to 344 megabytes, eventually became the firm's leading products. After abortive efforts to enter the high capacity 5.25" market, Priam acquired Vertex Peripherals in early 1985, with its successful 5.25" product line. However, Priam was slow to penetrate the market for high-end 5.25" drives, and during a several year period of poor financial results the firm had several management changes.

Priam ultimately was unable to overcome its lack of resources and move its newer products into full production. The firm ceased production in 1990, and the bankruptcy court sold various disk drive products and development programs to Atasi Technology, Sequel and Orca Technology, with the after-market resale operation to Priam Systems.

QUANTUM CORPORATION
1804 McCarthy Boulevard
Milpitas, CA 95035

1989 disk sales: $382,600,000 (including Plus Development)
1989 total net sales: $446,291,000 (FY ending 3/31/90) Net income: $47,212,000

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

In 1985, the company established Plus Development as a wholly owned subsidiary, to pioneer development and marketing of unique 3.5" drives for the personal computer market. Growth in shipments of OEM drives resumed in 1987 and 1988, due to the success of new 3.5" drives. Production of 5.25" drives ended in 1989.

While Quantum has designed its low-end 3.5" drives, manufacturing is done in Japan by Matsushita-Kotobuki Electronics. MKE has rights to distribute the drives it manufactures within Japan, under a Quantum license. High-end 3.5" drives are manufactured in a new, highly automated facility in California. European production is planned in the future.

Quantum's OEM products now include 3.5" drives from 42 to 425 megabytes (formatted) capacity with SCSI and PC/AT interfaces. 2.5" 42 and 84 megabyte drives were introduced in September, 1990. Quantum has emphasized drive intelligence, including such features as self testing and cache.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1989 disk sales: $2,477,900,000 (including Imprimis)
1989 total net sales: $1,371,568,000 Net income: $349,000
(FY ending 6/30/89)

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 the changes IBM made in the PC attachment opportunity for disk drives, by "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 after a disappointing and unprofitable 1988 winter quarter, 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 distribution. The Imprimis headquarters function has been completely integrated into Seagate's, and operational control of products and manufacturing has now been divided into "California", "Twin Cities" and "Oklahoma" operations.

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

Sequel was created in November, 1989 as the result of a management buyout of the Unisys rigid disk drive and media production facilities. Sequel will supply new drives to Unisys as well as refurbishing older drives from Unisys and other manufacturers. The firm also supplies some media on an OEM basis. Shortly after its establishment, Sequel acquired the rights to

manufacture several of Priam's 14", 8" and 5.25" product lines. At present, Sequel intends to emphasize disk drive production and refurbishment in media sizes of 8" and larger. Activity in the 5.25" area is confined to repair and refurbishment only.

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

1989 disk sales: $125,200,000
1989 total net sales: $982,520,000 Net income: $47,749,000

After great success in the second half of the 1970's as the leader in plug compatible disk drives, STC's shipments dropped in 1982-1983, as IBM 3380 shipments started in earnest. STC's volume shipments of 3380 equivalent drives didn't start until early 1984, too late to save the company from failures in its other new business areas. The firm's management had launched expensive programs to build mainframe computers and optical disk drives -- and had acquired firms in other areas, with extensive bank borrowing.

In October, 1984, the bankers wouldn't wait, and the company was thrown into Chapter 11. Disk drive order rates suffered because of the loss of credibility brought on by bankruptcy, but improved with the availability of the STC double capacity 3380 equivalent drive in mid-1986. After a series of complex negotiations with creditors, the firm emerged from bankruptcy in mid-1987.

Orders for STC's innovative 1/2" tape cartridge library system have been strong, and have been instrumental in restoring STC's position in the storage products industry. However, shipments of drives equivalent to IBM's 3380K did not start until 1989, and the firm has never regained its earlier share of the IBM plug compatible market. About 23% of 1989 revenues were derived from disk drives, controllers and solid state disks. In 1990, the firm began discussing new products incorporating disk drive arrays to be sold into the PCM marketplace. The low-end of the array product line will incorporate array hardware and software from Array Technology, which will be resold by Storage Technology. The high-end "Iceberg" array project is expected to be announced in 1991.

SYQUEST TECHNOLOGY
47923 Warm Springs Boulevard
Fremont, CA 94538

1989 disk dales: $35,300,000

SyQuest was started in early 1982 to make disk drives using 3.9" (100 mm) plated disks, in both fixed and removable disk configurations. After initial early emphasis on the personal computer aftermarket, SyQuest

established significant OEM sales, with major shipments to the segment of the PC market controlled by governmental security requirements. The firm is now emphasizing a new removable 5.25" drive with formatted capacity of 44 megabytes, using an embedded SCSI controller, and has achieved significant success in the Macintosh add-on market. In 1989, Syquest began operations in Singapore.

UNISYS CORPORATION
Burroughs Place
Detroit, MI 48232

1989 disk sales: $145,000,000
1989 total net sales: $10,096,000,000 Net income: ($639,000,000)

After many years of captive disk drive production, Burroughs acquired Memorex in late 1981. All Burroughs disk drive operations were then consolidated in the firm's Memorex subsidiary, including production of captive drives. The 1986 acquisition of Sperry by Burroughs led to changes in the combined company's strategy toward data storage; while the disk drive manufacturing operations were retained, flexible media and the plug compatible marketing and service operations of Memorex were sold to the operation's management. Unisys then sold the 13% interest in the Magnetic Peripherals, Inc., joint venture, acquired with Sperry, to Control Data. Further trimming of operations in 1989 included closing the old Memorex plant in Santa Clara, which was subsequently sold to Sequel in a leveraged management buyout along with rights to manufacture and maintain the Unisys drives.

WESTERN DIGITAL CORPORATION
2445 McCabe Way
Irvine, CA 92714

1989 disk sales: $266,200,000
1989 total net sales: $992,100,000 (FY ending 6/30/89) Net income: $34,300,000

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. The product line now consists of 3.5" drives in the 20 to 210 megabyte range, with emphasis on models utilizing embedded controllers. Western Digital plans to be a broad-line disk drive producer, and maintains a disk drive development facility in San Jose dedicated to future product designs. In mid-1989, Western Digital started remarketing the IBM Lightning 320 megabyte (formatted) 3.5" drive.

Asian Manufacturers

(All fiscal years end in March, 1989, unless otherwise noted. Firms are in Japan unless otherwise noted.)

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

1989 total net sales: $2,728,015,000 Net income: $39,719,000

Alps Electric, founded in 1948, is a high growth manufacturer of electronic components and sub-assemblies for television, audio, instruments and computer applications. The firm builds floppy disk drives on an OEM basis, notably for Apple Computer and IBM, and started production in the U.S. in 1987. In 1988, a facility to make various computer peripherals was established in Ireland. About 16% of Alps' shipments are computer peripherals, but these are mostly floppy disk drives and printers. In 1985, Alps introduced a line of 5.25" half high and 3.5" rigid disk drives. In 1986, Alps became the first manufacturer to announce a 30 mm high 3.5" drive. A 25.4 mm high, 20 megabyte drive was announced in 1987, a 50 megabyte version in 1988 and 100 megabyte (formatted) versions in 1990. 20.8 mm high drives in the 43 megabyte (formatted) range were introduced in 1989.

Alps has entered into an agreement with PrairieTek to produce the PrairieTek 2.5" drives on a contract basis. Production under this contract began in 1990. Alps may use the drives on a captive basis in its own system products but may not sell drives independently.

EPSON (See Seiko Epson)

ESPERT CO., LTD. (Previously Peripheral Technology International, Ltd.)
Songnam Building
1358-6 Seocho-dong
Seocho-ku, Seoul
Korea

Peripheral Technology was founded in 1985 to develop a 3.5" drive first shipped in 1986, with founders who had worked together at Dataproducts. 70% of PTI was owned by Haitai International, a Korean consumer products company, but in mid-1987, this interest was sold to Live Systems, a Japanese company serving the medical market. Production is now in a Korean facility, after initial production runs were contracted to Oriental Precision. In early 1989, control of PTI was assumed by Tongil Machinery Co., a manufacturer of machine tools and auto parts, as a diversification move. In February, 1990, the company was renamed EsPerT. The product line includes 3.5" drives from 38 to 77 megabyte capacity.

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

1989 disk sales: $61,700,000
1989 total net sales: $4,926,429,000 Net income: $68,900,000

Fuji Electric was established in 1923 and is the firm from which Fujitsu was born in 1935. Fuji Electric still owns about 13.5% of Fujitsu (which owns 7% of Fuji Electric). The firm manufactures power generating equipment, electrical equipment for the transportation sector, vending machines and instrumentation. Data storage products include sputtered media and 3.5" disk drives. The firm began selling 3.5" drives under its own name in 1985, but cut back on export sales in 1988, squeezed by exchange rates and low priced competition. 3.5" 100 megabyte drives were introduced in 1990.

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

1989 disk sales: $1,803,200,000
1989 total net sales: $17,291,533,000 Net income: $506,613,000

Fujitsu derives about 71% of its sales from the computer industry and is known as the leading manufacturer of computers for the Japanese domestic market. Fujitsu is also a major exporter to the worldwide computer market. Since 1982, the company has been among the leaders in worldwide disk drive revenues, and skillfully managed a transition from older removable disk drives to a product line consisting mainly of fixed disk drives in all capacity ranges and in several disk diameters.

Fujitsu has marketed most of its captive drives in OEM versions, using industry standard OEM interfaces, and is now a leader in the U.S. market for OEM rigid disk drives. Fujitsu is also a major factor in the IBM plug compatible disk drive market with sales of Eagle series drives through Amdahl. Particularly effective in the OEM market has been the series of high performance 8" 48/84/168/337/690/824/1000/2000/2600 megabyte drives, and the 10.5" "Eagle" series of high performance drives with up to 3.0 MB/second transfer rate. A 5.25" drive with 1.26 gigabyte capacity was introduced at the Spring, 1990, Comdex to join existing 778 megabyte and 389 megabyte models. Fujitsu has joined the "reliability wars" by specifying its high capacity 5.25" drives at 200,000 hours MTBF. Fujitsu also has a 3.5" rigid drive series extending to 182 megabytes in production.

Fujitsu is manufacturing some of its high performance drives at a major facility near Portland, Oregon, which is now in full operation, although HDAs are still made in Japan.

GOLDSTAR TELECOMMUNICATIONS CO., LTD.
20, Yoido-dong
Yongdungpo-gu
Seoul 150, South Korea

1989 total net sales: $233,933,000 Net income: ($18,922,000)

GoldStar Telecommunications is a joint venture between the Lucky GoldStar Group, Siemens, Fuji Electric and DEG, a German firm. The firm's main activities are in telecommunications equipment (76%), computers and peripherals (14.2%) and other electronic equipment (9.8%). Already in volume floppy drive production, GoldStar began manufacturing 3.5" and half high 5.25" drives in 1988. The current product line includes drives ranging from 26.5 to 50 megabytes.

GREENERY TECHNOLOGY
48 Park Avenue
Science-Based Industrial Park
Hsin Chu
Taiwan

Greenery is preparing to produce 3.5", 60 megabyte drives based upon technology developed by ITRI, a government research organization. Production is scheduled to start in late 1990.

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

1989 disk sales: $1,170,000,000
1989 total net sales: $46,363,562,000 Net income: $1,344,152,000

Hitachi remains Japan's largest manufacturer of electrical and electronic equipment and a major manufacturer of computer systems. The firm currently makes a wide range of Winchester technology fixed disk drives which are sold as captive drives with Hitachi computer systems and, in several cases, as OEM drives. In addition to significant OEM sales of smaller capacity fixed disk drives, Hitachi also sells IBM compatible 3380 equivalent drives through Hitachi Data Systems (formerly National Advanced Systems, before acquisition by Hitachi), and in 1983 started selling 3380 equivalent drives for distribution in the European PCM market through BASF, and currently through Comparex, the joint venture PCM vendor owned by BASF and Siemens. 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. In the spring of 1987, Hitachi began shipping rigid disk drives from a manufacturing facility in Norman, Oklahoma, which makes 14" and smaller high-end rigid drives and a line of 5.25" optical disk drives. Also in 1987, Hitachi announced a 380 megabyte 5.25" drive as well as filling in its line with several lesser capacity

half high 5.25" drives. Hitachi introduced an unusual 600 megabyte 5.25" drive in 1987 that rotates the disks at nearly 4,900 RPM -- a harbinger of things to come in the high-end drive market. By mid-1990, the 5.25" line extended to 1.65 gigabytes. In 1989, Hitachi introduced a 251 megabyte 3.5" drive, following with a 419 megabyte 3.5" drive in 1990.

HYOSUNG COMPUTER
Division of Tongyang Nylon Company
183 Hoge-dong
Anyang-si, Kyunggi-do
South Korea

Hyosung was formed in 1979 to help its parent diversify into the computer industry. The firm produces a variety of small systems and specialized terminals. The computers are sold in the U.S. under the Maxar brand. In 1987, Hyosung made a minority investment in Brand Technologies and started production of the Brand full size 5.25" drives, for sale by Hyosung.

JVC (VICTOR COMPANY OF JAPAN, LTD.)
4-8 Nihonbashi-Honcho
Chuo-ku, Tokyo 103

1989 disk sales: $42,200,000
1989 total net sales: $5,945,586,000 Net income $108,814,000

JVC's revenues are generated mostly by consumer electronics products. The firm has been the beneficiary of sharp growth in the home video recorder market and consumer electronics now account for 84% of total revenues. Matsushita Electric Industrial holds 51.2% ownership. JVC is now expanding into software (now 6% of revenues) and computer peripherals, starting in 1984 with 5.25" floppy disk drives, a program since dropped due to small market share and unfavorable exchange rates. 3.5" rigid drives were first shipped in 1985, and the present 3.5" product line includes 25.4 mm high and 20.8 mm high drives aimed at the laptop computer market, plus a 19.1 mm high 2.5" drive. JVC began to ship CD-ROM drives in 1987.

KYOCERA CORPORATION
2-14-9 Tamagawadai
Setagaya-ku, Tokyo 158

1989 disk sales: $57,200,000
1989 total net sales: $2,453,132,000 Net income: $214,775,000

Kyocera is the world's largest manufacturer of ceramic packages for integrated circuits, and also makes a variety of electronic and optical components. As the result of an investment and manufacturing agreement with LaPine Technology, Kyocera started production in 1986 of LaPine's 3.5"

drives and shipped significant quantities until mid-1987. In late 1986, Kyocera and Prudential-Bache, both of which had been minority shareholders in LaPine, purchased the remainder of the firm, with Kyocera obtaining one third ownership and Prudential-Bache two thirds. Due to the shifting exchange rate, Kyocera was not able to meet LaPine's quantity requirements profitably, and a shortfall in shipments occurred. Inability of the partners to agree on a mutually satisfactory course of action resulted in a suit against Kyocera by LaPine. LaPine's operations were subsequently halted, and Kyocera has been producing the drives under its own name. A 40 megabyte (formatted) 3.5" drive with PC/AT interface was introduced in 1990.

MAGTRON INC.
10F-2, 270 Section 4, Chung Hsiao E. Road
Taipei, Taiwan

Magtron was founded in September, 1988, as Damax, but was subsequently renamed. The firm has licensed the CAST 5.25" drive designs and is currently in production at a moderate level. The product line includes 115, 140, and 170 megabyte half high drives. In 1989, a subsidiary, Pacific/Magtron, was established in the U.S. to market the Magtron products and to serve as a design center for new 3.5" drives.

MATSUSHITA COMMUNICATION INDUSTRIAL CO., LTD.
4-3-1 Tsunashima-Higashi
Kohoku-ku, Yokohama 223

1989 total net sales: $2,620,439,000 Net income: $87,021,000

Matsushita Communication Industrial is a member of the Matsushita Electric Industrial group, a worldwide giant in appliances and electronics. MEI holds 56.6% ownership. MCI was the licensee for Shugart Associates' flexible disk drives in Japan. In 1981, MCI added several Winchester technology fixed disk drives, including low-end 5.25" drives. 3.5" Winchesters were added to the product line in 1985. The 3.5" rigid disk product line was extended to 81 megabytes, and MCI entered a joint development agreement with Priam to cooperatively design 3.5" high-end drives. Success proved elusive, and the company is now de-emphasizing rigid disk drives.

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

1989 total net sales: $1,642,015,000 Net income: $61,599,000

Matsushita-Kotobuki Electronics has concentrated primarily on production of VCRs on an OEM basis for a number of U.S. consumer electronics manufac-

turers and distributors, as well as for sale under the Matsushita "Panasonic" brand name. Matsushita Electric Industrial owns 57.3% of MKE. In 1985 Plus Development established a contract manufacturing arrangement with MKE for the Hardcard, which evolved into a manufacturing program for the highly successful 3.5" OEM drives offered by Plus' parent company, Quantum Corporation. MKE has the rights to sell the Quantum drives under license in the Japanese domestic OEM market, and activated a marketing program in 1989. MKE has since made similar manufacturing agreements with other manufacturers of storage products.

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

1989 disk sales: $85,700,000
1989 total net sales: $19,677,106,000 Net income: $385,573,000

In addition to being one of Japan's largest electronic and electrical products manufacturers, Mitsubishi Electric is a leader in the domestic small business systems market. The company has ended production of a variety of removable disk types and now manufactures small and mid-range Winchester technology drives at a highly automated facility near Osaka. Captive shipments have been the major portion of Mitsubishi's disk drive shipments, but the firm is now emphasizing OEM business in small diameter Winchester drives. 3.5" drives to 120 megabytes, 5.25" low-end drives, and 8" and 9" drives to 630 megabytes are in production as of mid-1990.

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

1989 total net sales: $1,017,469,000 (FY ending 1/31/90) Net income: ($2,615,000)

Mitsumi is primarily a component manufacturer, but also manufactures floppy drives (about 8% of 1989 sales) and is beginning to manufacture 3.5" 40 megabyte to 130 megabyte (formatted) rigid disk drives as well. Mitsumi has had a rigid drive development program in place for some time, but so far has had some difficulties in having products ready to catch the start of the newest product cycles.

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

1989 disk sales: $1,365,700,000
1989 total net sales: $22,327,805,000 Net income: $466,988,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 47% 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 include 14", 9", 8", 5.25" and 3.5" disk diameters, with large scale production for several small diameter drives. Sales of the smaller drives have been very strong as a result of success in the OEM market and the strong position of NEC in the Japanese personal computer market. NEC, Fujitsu, and NTT jointly developed a 2.2 gigabyte drive using thin film technology. The drives will be packaged to provide capacities as large as 8.8 gigabytes using multiple spindles. The 5.25" product line now reaches 1.4 gigabytes, and the 9" line has been extended to 3 gigabytes.

NEC has the distinction of being the first of the major Japanese drive producers to begin producing small form factor rigid disk drives offshore with the establishment of a factory in the Philippines.

ORIENTAL PRECISION COMPANY, LTD.
C.P.O. Box 1301
Seoul, South Korea

1989 total net sales: $143,269,000 Net income: $($14,246,000)

OPC, founded in 1953, is one of Korea's pioneering firms in the electronics industry. It is a major supplier of telecommunications equipment, broadcasting equipment, and a volume producer of small computers and peripherals. In the past, OPC produced a 3.9" cartridge disk drive on a contract manufacturing basis for SyQuest, as well as 3.5" drives for Peripheral Technology. Most recently, OPC made a minority investment in Kalok, and since mid-1988 has been manufacturing Kalok's 3.5" drives in substantial quantities on a contract basis for sale by Kalok. OPC has the rights to sell the Kalok drive in the Korean OEM drive market, and has been doing so.

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

1989 total net sales: $5,282,907,000 Net income: $128,884,000

Copiers, sensitized papers and photographic equipment provide the major portion of Ricoh's revenues, but the firm has been investing in a growing

line of data processing equipment since 1979. About 28% of revenues are derived from information processing products. Its first disk drives were 8" floppy drives made under a license from Calcomp, but the expanding line now includes several types of printers, plus 5.25" and 3.5" floppy disk drives used in both captive and OEM applications.

In 1985, Ricoh obtained a license to make the DMA 5.25" cartridge disk drive design, and production began in 1986. An expanded capacity version has since been introduced. When DMA encountered major financial difficulties, Ricoh became the major source for the drive. In 1989, Ricoh announced a 50 megabyte removable cartridge drive.

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

1989 total net sales: $5,942,261,000 Net income: $235,035,000

Samsung Electronics, founded in 1969, is Korea's largest electronics company, producing a variety of consumer, industrial and computer products. About 21% of sales are from information processing and telecommunication equipment. Samsung made a minority investment in Comport, a 1977 U.S. start-up, and manufactured Comport's 3.5" line of disk drives until Comport went out of business. Distribution rights in Korea have been retained by Samsung.

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

Epson is a member of the privately held Suwa Seikosha/Epson group owned by members of the Hattori family, which also control Japan's Seiko companies, known for watches and electronics. Epson is best known for its dot-matrix printers, but also manufactures a portable computer, displays, line printers, paper tape equipment and floppy disk drives. In 1985, Epson introduced a line of half high 5.25" rigid disk drives with capacities to 20 megabytes. Epson has since broadened its product line to include 3.5" drives up to 72 megabytes, but the firm dropped its plans to produce 40 and 80 megabyte 5.25" drives. Current production of rigid drives is on an exclusive basis for other manufacturers.

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

1989 disk sales: $127,200,000
1989 total net sales: $15,944,608,000 Net income: $524,871,000

Sony's growth in the consumer electronics market has become more difficult as saturation looms in sectors of the market, and the firm's management has made it clear that expansion in office products is a major company objective. Several computer systems have been announced in recent years, and the company achieved a worldwide impact with the 3.5" microfloppy, which has become an industry standard. Sony's microfloppy drive and media shipments have grown, first as Hewlett-Packard selected the drive for its personal computers, then as Apple chose the drive for its Macintosh systems. Sony proposed a 2.0 megabyte FDD 3.5" media standard in 1985, which has also become an industry standard with help from IBM, which selected it for the PS/2 product line.

The firm's first entry into the rigid disk drive market came in 1987, with half high 5.25" SCSI drives offering up to 40 megabytes formatted, but Sony decided to withdraw the product due to late market entry. Undiscouraged, Sony introduced a 42 megabyte 3.5" drive in 1989 and was able to obtain a significant contract from Apple Computer.

TATUNG CO.
22 Chungshan N. Road, Sec. 3
Taipei, Taiwan

In 1986, Tatung began shipments, under its own name, of 5.25" half high Winchester disk drives made under license from Xebec. The firm made similar drives for Xebec under a contract manufacturing agreement until the end of 1989. Relatively few were produced and most of these have been shipped to Xebec. While not yet in production, Tatung has indicated a desire to enter the 3.5" drive market in the future.

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

1989 total net sales: $622,923,000 Net income: ($4,295,000)

TEAC has 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 69% of sales, mostly in floppy disk drives. TEAC has shipped 5.25" flexible disk drives since 1978. In 1982, TEAC acquired a manufacturing license from Seagate Technology for its 5.25" Winchester disk drives, with rights to market the drives in Japan and the Far East. The firm added a 12 megabyte half high

drive in 1983, followed by a 25 megabyte version in 1985 and 50 megabytes in 1986. Concentration on the highly competitive floppy disk market and the strong dollar have combined to hurt TEAC, as the firm has had difficulty in sustaining profits over a long period. Shinano Tokki, a subsidiary producing motors for disk drives, was sold in 1989. The firm began manufacturing 3.5" drives with capacities in the 43 megabyte to 86 megabyte (formatted) range in late 1989.

TOKICO, LTD.
1-6-3, Fujimi
Kawasakiku, Kawasaki 210

1989 disk sales: $36,100,000
1989 total net sales: $823,097,000 Net income: $15,695,000

Tokico, a member of the Hitachi group (Hitachi has 21.1% ownership), is a manufacturer of automotive equipment, including shock absorbers, brakes and air compressors. Factory automation is a newly developed product area. The company began disk drive manufacturing with a 5.25" fixed disk drive design derived from the discontinued Nippon Peripherals Ltd. joint venture with Fujitsu, with versions of the Tokico drive sold separately by Hitachi and by the Hitachi group trading company, Nissei Sangyo. A half high version went into production in late 1983. More recently, the 5.25" product line has been discontinued. The 3.5" line extends from 40 to 130 megabytes capacity. Tokico began to market its disk drive products under its own name in 1987 and is now concentrating on its 3.5" drive product line.

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

1989 disk sales: $203,300,000
1989 total net sales: $27,528,478,000 Net income: $864,793,000

Toshiba is a major factor in consumer electric and electronic products, plus a wide range of industrial electronic products and heavy electric power equipment. The company also has a leading position in the Japanese office computer market. Disk drives supplied by Toshiba include rigid, floppy and optical drives. Rigid disk drive production is concentrated in newer Winchester technology fixed disk drives in low and mid-range capacities, in 8", 5.25", and 3.5" disk diameters, plus a recently announced 2.5" series. The product line currently extends to 765 megabytes for 5.25" drives and to 721 megabytes for 8" drives. Toshiba's presence in the U.S. OEM rigid disk drive market was strongly enhanced when it acquired the OEM disk drive operations of Memorex from Burroughs, and Toshiba has continued to expand its U.S. operations, and recently established a design center in Southern California.

TOSOH CORPORATION
1-7-7 Akasaka
Minato-ku, Tokyo 107

1989 total net sales: $1,854,248,000 Net income: $45,071,000

Tosoh was founded in 1935 under the name Toyo Soda. The firm was renamed in 1987. Tosoh is a major chemical products manufacturer and produces materials for use in the electronics industry, including sputtered thin film media for 3.5" and 5.25" rigid disk drives. The firm initially intended to begin manufacturing in mid-1987 a drive based upon the designs of now defunct Applied Information Memories, but deferred production until a more competitive design could be accomplished.

Y-E DATA, INC.
Subsidiary of Yaskawa Electric Mfg. Co., Ltd.
1-1 Higashi-Ikebukuro 3-chome
Toshima-ku, Tokyo 170

1989 total net sales: $188,419,000 Net income: $1,463,000

Yaskawa Electric produces primarily heavy electrical machinery and automation equipment. Y-E Data is best known for its line of floppy disk drives, with the firm's biggest success coming in 1984 when it was selected by IBM as supplier for the 1.6 megabyte 5.25" drive used in the PC/AT. At the 1986 NCC show, Y-E Data's 3.5" 50 megabyte drive was introduced by C. Itoh Electronics, a major importer of Japanese electronic industry products for the U.S. market. Higher capacity 3.5" drives were introduced in 1988 and 1990.

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

Zentek, which is a joint venture between Universal Scientific Industrial Co., Ltd., and Longshine Electronics, was established in September, 1989. Much of the engineering team comes from Longshine and Priam. USI is a manufacturer of film hybrid integrated circuits. Zentek is preparing to manufacture 60 megabyte and 100 megabyte 3.5" drives based on designs developed by ITRI, a government research agency. Volume production is scheduled for 1991.

European Manufacturers

COMPAREX INFORMATIONSSYSTEME GMBH
Joint venture of BASF and Siemens
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. The joint venture markets systems and peripherals made by Fujitsu and Hitachi. Current disk drive activities involve only PCM 3380 equivalent drives produced by Hitachi, plus an optical drive produced by LMSI and integrated with a Cygnet jukebox. Semiconductor and cartridge tape systems, both made by third parties, are also offered.

DZU
6000 Stara Zagora
Bulgaria

1989 disk sales: $127,700,000

DZU is the new 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.

Disk drives manufactured have been manufactured since the 1960's by DZU, the Bulgarian state computer organization, and are exported throughout Eastern Bloc countries by Isotimpex, the foreign trade organization for Bulgarian computer equipment and other electronic products. DZU, which operates 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.

KOVO
Jankovcova 2
17088 Praha 7
Czechoslovakia

KOVO is the Czechoslovakian import/export agency with jurisdiction over that country's trade in computers and related products. Included in the current product line are computers and peripheral equipment manufactured by Zbrojovka Brno and Aritma, both diversified manufacturing operations. 14" disk cartridge and disk pack drives are produced in small quantities.

LEXIKON S.P.A. (Previously Olivetti Peripheral Equipment)
Subsidiary of Ing. C. Olivetti & C., S.p.A.
via Torino, 603
10090 S. Bernardo d'Ivrea (Torino)
Italy

1989 total net sales: $7,254,000,000 Net income: $163,000,000

After many years of manufacturing 5.25" and later 3.5" drives, first under the name Olivetti Peripheral Equipment, and later Lexikon, the Olivetti disk drive operations were folded into a joint venture company. In 1988, a joint venture with Conner Peripherals was established to manufacture and sell Conner drives in Europe, as well as supply the captive Olivetti requirements. The Lexikon disk drive manufacturing facilities at Ivrea were turned over to the joint venture, named Conner Peripherals Europe, and all production of the Lexikon disk drive models was discontinued. Conner Peripherals Europe expects to move into a new plant near the existing Ivrea facility in the near future.

NEWBURY DATA RECORDING, LTD.
Subsidiary of Data Recording Instruments Co., Ltd.
Hawthorne Road, Staines
Middlesex TW18 3BJ
England

Newbury Data is the current name for the organization once known as Data Recording Equipment, or DRE. Disk drives were manufactured for several years by a joint venture company owned by DRI, its parent firm, and Magnetic Peripherals, Inc., the U.S. disk drive development and manufacturing firm managed by Control Data. When the joint venture was dissolved in 1983, DRI regained ownership. Newbury Data then placed emphasis on newer disk drives, some produced under manufacturing licenses with U.S. firms, including a license from Maxtor for high capacity 5.25" drives. For its disk drive program Newbury eventually concentrated entirely on high capacity 5.25" drives, including 380 megabyte models. In 1988, a decision was made by the parent company, DRI, to sell Newbury Data, which was subsequently completed, followed by the shut down of disk drive production in 1989.

NIXDORF COMPUTER AG
Furstenallee 7
4790 Paderborn
West Germany

For several years Nixdorf manufactured storage module disk pack drives in Berlin, West Germany, under a license from Control Data, for captive shipment with Nixdorf systems, until the program was discontinued in 1987.

After starting production for its own internally developed 8" and 5.25" Winchester drives, Nixdorf decided that volume did not warrant internal design and production, and the company switched to external procurement for all of its rigid disk drive needs. In April of 1990, Siemens and Nixdorf announced that Siemens was purchasing 51% of Nixdorf and that Nixdorf would be merged with existing Siemens operations to become the Siemens/Nixdorf Informationsystems AG subsidiary of Siemens.

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

1989 disk sales: $79,400,000
1989 total net sales: $96,110,000 (FY ending 9/30/89) Net income: ($41,484,000)

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. The company then announced 170 megabyte half high 5.25" drives and high capacity 8" and 3.5" models, but was slow to establish production. All but 3.5" drives have been dropped. The line of 3.5" drives currently extends from 61 through 429 megabytes (formatted).

Perhaps as a way of offsetting disappointing sales, Rodime surprised the industry by obtaining patent coverage on the concept of a 3.5" drive -- claiming no new technology, only a reduction in size. The firm then sued Miniscribe and Conner Peripherals for patent infringement. When IBM announced the PS/2 family, which uses 3.5" drives, it sued Rodime to invalidate the patent, and Rodime bravely met the challenge by countersuing IBM for patent infringement. Miniscribe opted out of the legal proceedings by taking a license. Meantime, after extensive patent office preliminaries, the affair began a long tour of the U.S. federal court system.

In early 1989, top management was completely overhauled as Rodime came perilously near bankruptcy, and most manufacturing has been moved from Glenrothes and Boca Raton to Singapore, to improve production efficiency. Rodime obtained some refinancing, and its new management hopes to be able to return Rodime to profitability.

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 removable disk drives ranging in capacity from 50 to 200 megabytes. These, also, are militarized products.

SIEMENS AG
Communications Group
Siemensallee 2
D-8011 Poing
West Germany

1989 disk sales: $83,800,000
1989 total net sales: $32,514,787,000 (FY ending 9/30/89) Net income: $838,830,000

After many years of producing 14" rigid disk drives of its own design in Munich for captive use with Siemens mainframe systems, Siemens developed a 5.25" Winchester disk drive with capacities up to 300 megabytes, and started deliveries in early 1986. 380 and 770 megabyte models were added in 1988 and a 1.2 gigabyte model in 1989. Siemens sold the drives in non-captive markets as well as in captive systems.

In late 1986, Siemens and BASF agreed to create a joint venture company, Comparex Informationssysteme GmbH, to market the plug compatible IBM mainframe peripherals that BASF and Siemens were purchasing from Japanese manufacturers and remarketing in Europe. Comparex began operations in January, 1987. In April of 1990, Siemens announced it was purchasing 51% of Nixdorf and planned to merge Nixdorf into its data and information systems group, which will become Siemens/Nixdorf Informationsystems AG.

Siemens never was able to achieve a production volume permitting profitable operation of its disk drive product line, and in 1990 announced it would withdraw from the 5.25" rigid disk drive business, selling its disk drive product line to Microscience International.

South American Manufacturers

DIGIREDE INFORMATICA LTDA.
Av. Angelica, 2582
01228 Sao Paulo SP
Brazil

1989 total net sales: $73,000,000 Net income: $4,000,000

Digirede manufactures rigid disk drives, multiuser microcomputers, banking automation equipment, POS systems and industrial automation equipment. The company, which is privately held, was founded in 1977 and has been manufacturing rigid disk drives under an agreement with Maxtor initiated in November of 1985. In 1989, rigid disk drives represented 18% of Digirede's revenues. The product line includes Maxtor 5.25" designs up to 240 megabytes, using ST506 and RLL controllers. Higher capacity models are planned for production in 1990. Much of the drive content is locally produced, although media, heads and motors are still imported.

EDISA INFORMATICA S/A
BR 290 Km 75
Distrito Industrial Gravatai
94000 Gravatai RS
Brazil

Edisa is a joint venture between Hewlett-Packard and Ioschpe, a large Brazilian firm with interests in construction equipment, pharmaceuticals, paper and electronics. Edisa is best known as a supplier of automated banking equipment, but in 1990 began producing the Hewlett-Packard 380 megabyte 5.25" drive (Coyote I) in its own facility. Key components are purchased from Hewlett-Packard.

ELEBRA INFORMATICA
Rua Geraldo Flausino Gomes, 78
04575 Sao Paulo SP
Brazil

1989 total net sales: $163,300,000 Net income: $17,500,000

Founded in 1978, Elebra is a producer of minicomputers, defense electronics, industrial control electronics, data communications and peripheral equipment. Minicomputers are made under license from DEC. The peripheral equipment product line includes rigid and floppy disk drives, printers, and tape drives and accounted for 54% of 1989 revenues. Of the revenues related to peripherals, 11.2% came from rigid disk drives and 23.2% from floppy disk drives. All of the floppy drives are 5.25" half height types. Manufacturing of rigid disk drives began in 1985. Current drive production includes 9" and 5.25" Wren designs under license from Seagate, but

the firm is also developing and manufacturing its own designs for low-end 3.5" drives. Production of 8" drives ceased in 1989.

FLEXDISC TECHNOLOGIA S.A.
Rua Dom Aguirre, 176
04671 Santo Amaro
Sao Paulo SP
Brazil

Flexdisc, a privately held company, was founded in 1979. 1989 revenues were about $6,000,000. Floppy disk drives for Apple II computers were the firm's original products, but streamer tape drives, IBM compatible 500 kilobyte and 1.6 megabyte floppy drives, and rigid disk drives are now also produced. Rigid drives were first made under license from Seagate in 1983 and then Vertex in 1985. A new 3.5" 20 megabyte stepping motor drive designed by Flexdisc is scheduled for production in 1990.

MICROLAB S/A
Av. Nova York, 381
21041 Bonsucesso
Rio de Janeiro RJ
Brazil

Founded in 1961, Microlab started as a defense contractor for the Brazilian Navy and then diversified into products for the oil industry. Since 1970, the firm has produced military radar and communications equipment as well as process control and power distribution equipment. Rigid disk drive production began in 1985 with a 300 megabyte pack drive licensed from Ampex. The firm has also produced the Megavault 8" drive and Atasi 5.25" 50 megabyte drive under license. The Atasi drive went out of production in 1989, while the Ampex and Megavault designs had their last production year in 1988. Current products are licensed from Seagate and include ST506 and RLL 5.25" drives up to 144 megabyte capacity. 3.5" drives are planned for introduction in late 1990.

PROLOGICA INDUSTRIA E COMERCIO DE MICROCOMPUTADORES LTDA.
Rua Fidencio Ramos, 302
04551 Villa Olimpia
Sao Paulo SP
Brazil

Prologica began as a retail store for electronic components, but soon moved into sales of kits for radios and, eventually, sales of microcomputer kits. The company decided to produce floppy drives in 1982 and actually started production of an IBM compatible 500 kilobyte drive in 1983. In 1984, the firm established a related company, Microperifericos, to manufacture drives for OEM customers and to do contract manufacturing. Rigid

drive production began in 1983 with a 5.25" 5 megabyte CMI look-alike. 3.5" 12 and 25 megabyte drives were produced in mid-1987 and an improved performance version was introduced in 1988.

MULTIDIGIT S. A.
BR 290 Km 22
Distrito Industrial Gravatai
94000 Gravatai RS
Brazil

Multidigit manufactures 5.25" flexible disk drives and 5.25" stepper motor rigid disk drives with capacities under 60 megabytes. The firm also licensed an 8" 330 megabyte drive from Pertec. Production quantities are small.

DISK/TREND ON DISK

1990 DISK/TREND REPORT

INTRODUCTION

DISK/TREND ON DISK is a set of floppy disks containing 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.

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.

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.

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.

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.

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 1990 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1990 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

IBM is a trademark of International Business Machines Corporation.

Lotus and Lotus 1-2-3 are trademarks of Lotus Development Corporation.

MS-DOS is a trademark of Microsoft Corporation.

AutoImport is a trademark of White Crane Systems, Inc.

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 Auto-Import 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.

NOTE: If you have elected to receive data on 360 kilobyte 5.25" diskettes, there will be two diskettes containing statistical tables and two diskettes with specification tables. In each case, diskette # 1 contains data for product groups one through five. The remainder is on diskette # 2. Otherwise, there will be one diskette for statistical tables and one for 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 command is:

   COPY A:*.PRN

   The utility file names are of the form FORMLIN?.PRN. The files are specific to use with Lotus 1-2-3 data parsing if you prefer not to use AutoImport for file translation.

   Installing AutoImport: If you have a hard disk, create a directory named AIMP (You could use other names if you prefer). Now place Auto-Import disk 1 in drive A and type: A:INSTALL 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 Auto-Import disks and use only the copies in following steps. In a floppy-only system, AutoImport disk 1 should be in drive A when AutoImport is in use for file translation.

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

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

   /FR<filename>

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

   X= Type of data
   F (Flexible disk drive data)
   R (Rigid disk drive data)
   O (Optical disk drive data)

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

   ZZ= Year of Report.

   Examples:
   File RT11.WK1 is Rigid Disk Drive Report Table 11
   File FT2.WK1 is Flexible Disk Drive Report Table 2
   File OT1.WK1 is Optical Disk Drive Report Table 1

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

If you don't use AutoImport

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

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

- o FORMLINA.PRN — Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
- o FORMLINB.PRN — Used with Table 2.
- o FORMLINF.PRN — Used with Tables 3 and 4.
- o FORMLIND.PRN — Used with Application tables.
- o FORMLINE.PRN — Used with Track Height and Track Density tables. in 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 after you have seen how it is done for the other tables, this should not be too big a job.

After you have used spreadsheet tools to translate a file, you will understand why we recommend AutoImport for this function.

Using AutoImport:

Using AutoImport is a two-step process. Step one is creation of a translation mask for each format used in files to be converted. The typical DISK/TREND Report uses 5 to 7 standard mask designs (which have been precomputed and included on your Statistical Tables disk) plus additional masks that are dependent upon table content, as some table types have variable numbers of columns. You will have to create your own masks for such tables, but this can be done easily as shown below.

Step two is the translation process. Once the mask has been created, it can be used with any table matching the mask format. See the table below which relates table types to specific masks.

MASK TABLE

Mask File Name	Rigid Report	Flexible Report	Optical Report
MASKA	<-------- Table 1--------->		Tables 1,2
	<------------ Product Group Revenue ---------->		
	<------------ Product Group Shipment ---------->		
MASKB	<-------- Table 2 -------->		Tables 3,4
MASKC	Tables 3 to 8	Tables 3,4	Tables 5 to 12
MASKD	<----- All Product Group Application Tables ------->		
MASKE	N/A	Track Height, Track Density	Write-Once/ Erasable Analysis
MASKF	<-------------- Applications Summary ---------->		
MASKG	N/A*	Product Group Market Share	N/A*

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

TABLE NUMBER TO MASK CROSS-REFERENCE

Table Number	1990 Rigid Report	1989 Flexible Report	1990 Optical Report
1	MASKA	MASKA	MASKA
2	MASKB	MASKB	MASKA
3	MASKC	MASKC	MASKB
4	MASKC	MASKC	MASKB
5	MASKC	--	MASKC
6	MASKC	--	MASKC
7	MASKC	MASKF	MASKC
8	MASKC	MASKA	MASKC
9	--	MASKA	MASKC
10	--	MASKE	MASKC
11	MASKA	MASKD	MASKC
12	MASKA	MASKG	MASKC
13	--	MASKA	--
14	--	MASKA	--
15	MASKD	MASKE	--
16	--	MASKE	--
17	MASKA	MASKD	MASKA
18	MASKA	MASKG	MASKA
19	--	MASKA	--
20	--	MASKA	--
21	MASKD	--	MASKD
22	MASKA	--	--
23	MASKA	MASKD	MASKA
24	--	MASKG	MASKA
25	--	MASKA	--
26	MASKD	MASKA	--
27	--	--	MASKE
28	MASKA	--	MASKD
29	MASKA	MASKD	MASKA
30	--	MASKG	MASKA
31	--		MASKD
32	MASKD		MASKA
33	--		MASKA
34	MASKA		MASKA
35	MASKA		MASKA
36	--		--
37	--		--
38	MASKD		MASKE
39	--		MASKA
40	MASKA		MASKA
41	MASKA		--
42	--		--
43	--		MASKE
44	MASKD		MASKA
45	--		MASKA
46	MASKA		--
47	MASKA		--

Cross-reference (continued)

Mask File Name	1989 Rigid Report	1989 Flexible Report	1990 Optical Report
48	--		MASKE
49	--		
50	MASKD		
51	--		
52	MASKA		
53	MASKA		
54	--		
55	--		
56	MASKD		
57	--		
58	MASKA		
59	MASKA		
60	--		
61	--		
62	--		
63	MASKD		
64	--		

-- indicates that the format of this table is variable or non-standard. 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:*.MSK
   ```

   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 'TRANSLATE' menu item using the arrow keys or just type 'T'. (The AutoImport menu system works just like the menus in Lotus 1-2-3.)

3. When the next screen appears, enter the name of the mask to use on the top line where the highlighted space is. 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'.

4. Select the output file name. Type OFT (Output:File:Type-in)

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

   Examples: RT4 FT12 OT14

5. Enter the input file name using the same file naming convention as above. Type IT (Input:Type-in)

   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: RT4.90R FT12.90F OT14.900

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 typing /TS and then selecting your preference from the menu of choices displayed.

7. You are ready to translate. Type 'G' for 'GO' or select 'GO' using the arrow keys. You will see the file being translated scroll by as the translation proceeds.

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 return to the AutoImport main menu and then /E (Exit) 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 'Mask' using the arrow keys or type 'M'.

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

   Example: RT50.90R

   To name the file, type /FIT (File:Input:Type-in). When the highlighted blank space appears, fill it in with the file name and press 'Enter'. The contents of the file will now appear on the screen.

3. Next define the header lines. These are lines that are translated to the spreadsheet as a single cell of text. Place the cursor at the top of the header area, normally at the left top of the report table. Now type /LH (Line:Header). Using the down arrow key, expand the highlighted area until it extends to just above the first row of numerical data. Press 'Enter'. If there are any footnotes at the bottom, the lines in which they appear can be treated the same way by locating the header at the left margin of the first footnote line, typing /LH, 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. Type /AY (Auto:Yes). This step actually creates the mask. Check to be sure all figures have been delineated properly. If not, see below.

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

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

   - Place cursor in left margin of offending line. Type /CW to adjust width and then use arrow keys to move right column margin clear of the column of values.

   - Set cursor on last position of column to the right of the left margin labels. Type /DCO to delete this one column from the mask.

   - Now place cursor in first space to the right of the left margin label column. Type /C and then adjust the column width to encompass all places in the values column you have been working with. This will restore the mask column, also.

5. Save the mask in a mask file. Type /FMS (File:Mask:Save). Fill in the name of the mask file.

   Example: RT50MSK

6. Save the output file. Type /FOT (File:Output:Type-in). Now enter the file name.

   Example: RT50. You don't need to enter the file extender.

7. To make more masks, repeat from step 2. To quit the mask function, type /Q (quit). This returns you to the AutoImport main menu. To leave AutoImport, type /E.

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 are supplied on two diskettes if 360 kilobyte diskettes were supplied to you. 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. Place the floppy disk marked 'Specifications' 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 spreadsheet system disk in drive A. Use the DOS 'DIR' command to examine the file directory on the 'Tables' disk. If there are any special instructions, they will be in a file named READ.ME. To see these instructions, at the DOS prompt type:

   TYPE A:READ.ME (Use the appropriate drive letter if not A)

   If you wish to print the instructions, turn on your printer and type:

   TYPE A:READ.ME>PRN

2. Do this step if you have a hard disk. Log into the hard disk directory in which your spreadsheet normally stores worksheet files. Using the DOS 'COPY' command, copy all the specification table files to the hard disk. This can be done in one step using the copy command as follows:

   COPY A:?S*.*

3. Now you are ready to start Lotus 1-2-3 or other spreadsheet. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus spreadsheet system disk in drive A. If you are using a rigid disk system, place the spreadsheet system disk in floppy drive A. If your spreadsheet is not Lotus 1-2-3, you will have to translate the data from Lotus 1-2-3 to your format. Almost all spreadsheet packages of recent vintage are able to do this translation. After translation, if needed, start your spreadsheet as usual. After obtaining the blank spreadsheet image on the screen, use the spreadsheet File Retrieve command to select a file. The equivalent Lotus 1-2-3 command is:

   /FR<filename>

The file names are in the format XSYZZ.WK1 or XSYZZ.WKS, depending upon which version of Lotus 1-2-3 you are using. X,Y, and Z are:

X= F (Flexible disk drive data)
O (Optical disk drive data)
R (Rigid disk drive 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: RS190 Rigid disk specification table, Groups 1 to 5
RS290 Rigid disk specification table, Groups 6 to 9

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

Using the specification data base

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

The specification data base fits into a worksheet format of 25 to 30 columns, depending upon whether rigid, optical or floppy drives are involved, and a row count of up to 500 rows. Each row represents a specific record, and is equivalent to a single column in the Specifications section of the DISK/TREND report. Each column represents a specific specification parameter, and is equivalent to one row of the 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 database 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 /DQE0 command. Similarly, it is possible to extend the input range to add more products, but be sure you move the output range so that there is no overlap.

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

- o There are other 'pop-up' programs resident in the memory of your computer. These should be removed.
- o You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.
- o If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You probably will have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 640K memory, you will probably get this message.

Combining specification data bases: Lotus 1-2-3 allows you to combine worksheets into a larger worksheet. If you think your computer has enough memory, you can combine the specification data bases by doing the following:

1. Load the worksheet RS190 from the specification diskette (specification diskette 1 if you have 360 kilobyte diskettes) into a new worksheet. Now move the worksheet cursor to column A and the row just under the last manufacturers name.
2. Load the worksheet from RS290 from the specification diskette (or specification diskette 2) using the Lotus command /FCC.
3. Edit the worksheet to remove the header and criteria range areas that were loaded with the second worksheet.
4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.
5. Copy the column header row using the /C command to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the last column of data.

6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it to a new file name first so that you can easily reload if you make an unrecoverable alteration.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups you are interested in into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

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

If you are interested in only a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and then use the second file for analysis. The smaller file will take less time to process.

Technical support

Just about all of your questions regarding the use of DISK/TREND ON DISK should be answered in this manual or in the Lotus 1-2-3 reference manual. However, if you need to contact us to resolve any points of confusion, report errors, or otherwise receive comfort:

Call us at: 415-961-6209

Ask for Technical Support

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.

1996 DISK/TREND® REPORT

RIGID DISK DRIVES

May, 1996

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FOREWORD

After a year marked by major merger and acquisition activity, the rigid disk drive industry remains as competitive and committed to quick step product development as ever. Several manufacturers face interesting challenges as they commit major product programs to magnetoresistive heads for the first time. Others risk major financial bets as they try to convince major system manufacturers to move to low-end 5.25" drives for home computers or to 3" drives for notebook computers. Those working with leading edge areal densities hustle to obtain semiconductors that are fast enough. A year of new initiatives and tough competition. A normal year.

After publishing the DISK/TREND Report on rigid disk drives in the Autumn for 19 years, the report is being released in May this year, our 20th year. With the rate of change gradually increasing in the industry, we felt it was time to move the publication date forward in the year. The report on disk drive arrays, previously published in the Spring, will now be released in September. As usual, the report on optical disk drives will be available in July, and the report on removable data storage will be published in August. And if you haven't yet done so, we suggest you visit DISK/TREND's Web site (http://www.disktrend.com), which contains information on current industry events and links to every known Web site in the disk drive industry.

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

The product groups have been updated

With areal densities increasing at an average of 60% per year, and with the major disk drive markets moving up just as fast in the average disk capacity utilized, it was necessary to revise the product groups used for fixed disk drives in this year's DISK/TREND Report on rigid disk drives. We avoid any unnecessary changes in the product groups, since we are aware that many companies organize their industry data accordingly, but the time had come to make changes in both the low and high ends of the capacity range.

In view of the rapidly dropping shipments in the lower capacity ranges, we have combined three product groups into a single "less than 300 megabytes" group. Due to the intense product development activity at the high end, the previous top capacity group has been split into "3-5 gigabytes", "5-10 gigabytes" and "more than 10 gigabytes". These changes cover the industry's current range of products, but we fully expect to have to revise the product groups again in a year or two, given the continuing improvements in recording density expected by everyone.

Some data appears in two DISK/TREND Reports

As you may know, we have published a separate report on removable data storage during the two previous years, and will do it again in 1996. 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 the removable data storage 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.

Please note how the DISK/TREND Report counts sales revenues

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/Distributor or OEM/Integrator levels. This is the same method used by individual companies in published financial reports.

SUMMARY: RIGID MAGNETIC DISK DRIVES

Industry size

The growth outlook for the rigid disk drive industry is better than ever, as demand for on-line data storage continues to be enhanced by new applications and new software. Pushed by rapid growth in traditional applications as well as new multimedia and Internet requirements, the personal computer market for disk drives continues to increase and to quickly transition to higher drive capacities. Midrange and mainframe computer markets for disk capacity are growing at a significantly higher rate than the industry anticipated, boosted by mushrooming networks, RAID subsystems and emerging requirements for data warehousing, remote site mirroring and renewed expansion of basic applications.

Driven by the higher shipments which these expanding markets are generating, combined with the strong movement to higher capacities, the disk drive industry's shipments and sales revenues are expected to grow at a higher level than previously anticipated. Worldwide unit shipments reached 89.5 million drives in 1995, and the 1999 total is projected at 170.2 million, an average annual increase of 17.5%. The industry's sales revenues were $26.6 billion in 1995, and the 1999 estimate is $62.2 billion, up an average of 24.0% per year. Underlying the enhanced revenue growth is the increasing disk capacity now in demand for numerous applications, an enhancement in demand which is increasing faster than the industry's expected increases in areal density.

The majority of drives are now shipped in the OEM/Integrator channel, and the OEM share is expected to increase in future years. PCM/Distributor revenues have increased in recent years, claiming 21.6% of the 1995 total. The PCM/Distributor total has been enhanced mainly as personal computer users add disk capacity in order to upgrade software and applications. However, the trend is for system manufacturers to add much larger disk drives, installed at the factory, to their basic PC models. As this trend continues, the PCM/Distributor share of total industry revenues is expected to decline to 16.0% in 1999.

Drive manufacturers headquartered in the U.S. held 85.3% of worldwide sales revenues in 1995, but their 1999 share is projected at only 73.6%, as non-U.S. manufacturers move to more aggressive product development programs and lower cost offshore manufacturing.

TABLE 1

CONSOLIDATED WORLDWIDE REVENUES

RIGID MAGNETIC DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995		Forecast							
	Revenues		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	3,870.6	5,698.8	4,669.6	6,883.2	6,158.1	9,093.4	6,748.1	10,053.1	7,186.2	10,873.0
Other U.S. Captive	353.1	479.5	243.0	268.0	257.4	298.5	373.4	448.7	523.8	630.5
TOTAL U.S. CAPTIVE	4,223.7	6,178.3	4,912.6	7,151.2	6,415.5	9,391.9	7,121.5	10,501.8	7,710.0	11,503.5
PCM/Distributor	2,789.2	5,217.3	2,843.6	5,423.5	3,377.8	5,495.4	4,369.5	6,543.6	5,055.4	7,329.4
OEM/Integrator	7,184.9	11,376.4	6,518.2	11,079.4	8,571.0	12,646.9	14,017.9	18,556.8	20,400.0	27,072.8
TOTAL U.S. NONCAPTIVE	9,974.1	16,593.7	9,361.8	16,502.9	11,948.8	18,142.3	18,387.4	25,100.4	25,455.4	34,402.2
TOTAL U.S. REVENUES	14,197.8	22,772.0	14,274.4	23,654.1	18,364.3	27,534.2	25,508.9	35,602.2	33,165.4	45,905.7
Non-U.S. Manufacturers										
Captive	154.3	1,859.5	207.2	1,750.4	360.4	1,628.1	548.3	2,113.2	702.7	2,237.5
PCM/Distributor	345.9	523.1	645.5	1,057.0	770.0	1,437.6	1,094.5	1,947.9	1,344.1	2,614.7
OEM/Integrator	576.3	1,478.3	1,537.6	3,196.8	2,293.8	4,106.9	3,794.6	6,283.5	6,891.6	11,423.3
TOTAL NON-U.S. REVENUES	1,076.5	3,860.9	2,390.3	6,004.2	3,424.2	7,172.6	5,437.4	10,344.6	8,938.4	16,275.5
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	15,274.3	26,632.9	16,664.7	29,658.3	21,788.5	34,706.8	30,946.3	45,946.8	42,103.8	62,181.2

Marketing channels

For many years the number of rigid disk drive manufacturers active in the industry has continually declined -- except during the last year. One of the industry's major companies, Conner Peripherals, was merged into Seagate Technology earlier this year, but the total number of disk drive manufacturers increased to 26, up two from the previous year. Hyundai Electronics completed the acquisition of Maxtor, and the Micropolis disk drive operations were sold to Singapore Technologies, so two long-standing U.S. disk drive manufacturers became Asian companies during the year. Other newly listed Asian companies include Tottori Sanyo, which continues with the 2.5" drive family originated by Areal Technology, Tae Il Media, an established South Korean disk drive component manufacturer now initiating manufacture of complete disk drives, and Momentum Peripherals, a Singapore firm which has acquired the Singapore plant previously operated by MiniStor Peripherals and started production of 1.8" drives.

Captive drive revenues have continued to decline from the 60% range typical of a decade ago, and provided 30.2% of the 1995 worldwide revenue total. Further long-term decline in share is expected, with 1999 projected at 22.1%, as producers of noncaptive drives continue to set the pace with rapid product evolution and growing sales for personal computers and network servers. Sales revenues for the OEM/Integrator channel are forecasted to grow from 48.2% of the 1995 worldwide total to 81.9% of 1999's sales. PCM/Distributor revenues are expected to decline, as an increasing share of noncaptive drive shipments are purchased directly by system manufacturers.

An understanding of the relative price levels of captive, PCM/Distributor 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/Distributor or OEM/Integrator levels. For example, captive drive revenues for 1995 totaled $8.0 billion, 30.2% of the overall revenue worldwide total. But 1995 captive shipments totaled 8.1 million drives, only 9.0% 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	1995 Revenues $M	1995 Revenues %	1996 $M	1996 %	1997 $M	1997 %	1998 $M	1998 %	1999 $M	1999 %
U.S. Manufacturers										
IBM Captive	5,698.8	21.3%	6,883.2	23.2%	9,093.4	26.2%	10,053.1	21.8%	10,873.0	17.4%
	+10.1%		+20.8%		+32.1%		+10.6%		+8.2%	
Other U.S. Captive	479.5	1.8%	268.0	.9%	298.5	.8%	448.7	.9%	630.5	1.0%
	-54.9%		-44.1%		+11.4%		+50.3%		+40.5%	
PCM/Distributor	5,217.3	19.5%	5,423.5	18.2%	5,495.4	15.8%	6,543.6	14.2%	7,329.4	11.7%
	+34.6%		+4.0%		+1.3%		+19.1%		+12.0%	
OEM/Integrator	11,376.4	42.7%	11,079.4	37.3%	12,646.9	36.4%	18,556.8	40.3%	27,072.8	43.5%
	+17.2%		-2.6%		+14.1%		+46.7%		+45.9%	
Total U.S. Manufacturers	22,772.0	85.3%	23,654.1	79.6%	27,534.2	79.2%	35,602.2	77.2%	45,905.7	73.6%
	+14.9%		+3.9%		+16.4%		+29.3%		+28.9%	
Non-U.S. Manufacturers										
Captive	1,859.5	6.9%	1,750.4	5.9%	1,628.1	4.6%	2,113.2	4.5%	2,237.5	3.5%
	+33.3%		-5.9%		-7.0%		+29.8%		+5.9%	
PCM/Distributor	523.1	1.9%	1,057.0	3.5%	1,437.6	4.1%	1,947.9	4.2%	2,614.7	4.2%
	-42.9%		+102.1%		+36.0%		+35.5%		+34.2%	
OEM/Integrator	1,478.3	5.9%	3,196.8	11.0%	4,106.9	12.1%	6,283.5	14.1%	11,423.3	18.7%
	+35.5%		+116.2%		+28.5%		+53.0%		+81.8%	
Total Non-U.S. Manufacturers	3,860.9	14.7%	6,004.2	20.4%	7,172.6	20.8%	10,344.6	22.8%	16,275.5	26.4%
	+13.5%		+55.5%		+19.5%		+44.2%		+57.3%	
Worldwide Recap										
Captive	8,037.8	30.2%	8,901.6	30.0%	11,020.0	31.8%	12,615.0	27.5%	13,741.0	22.1%
	+5.3%		+10.7%		+23.8%		+14.5%		+8.9%	
PCM/Distributor	5,740.4	21.6%	6,480.5	21.9%	6,933.0	20.0%	8,491.5	18.5%	9,944.1	16.0%
	+19.7%		+12.9%		+7.0%		+22.5%		+17.1%	
OEM/Integrator	12,854.7	48.2%	14,276.2	48.1%	16,753.8	48.2%	24,840.3	54.0%	38,496.1	61.9%
	+19.1%		+11.1%		+17.4%		+48.3%		+55.0%	
Total All Manufacturers	26,632.9	100.0%	29,658.3	100.0%	34,706.8	100.0%	45,946.8	100.0%	62,181.2	100.0%
	+14.7%		+11.4%		+17.0%		+32.4%		+35.3%	

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

Product mix

As computers are utilized for an increasingly diverse list of tasks throughout the world, demand for greater disk storage capacity continues to force rapid changes in the industry's product mix. The current demand for increased storage in individual applications appears to be growing even faster than the disk drive industry's pattern of 60% average annual increases in areal density. In 1990, more than half the drives produced had capacities in the range of 30-60 megabytes, but 500 megabyte - 1 gigabyte drives had taken the shipment lead in 1995, and in 1999 the leading product range is expected to be 5-10 gigabytes.

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.

Another result of continuously increasing areal density has been the obsolescence of all drives with larger disk sizes. After 1996, no drives with disks larger in diameter than 5.25" are expected to remain in production. After initially dominating the desktop personal computer market, 3.5" drives benefited from the disk drive industry's widely discussed pattern of 60% annual increases in recording density during the 1990's, and now have large enough capacities to be the predominant choice for network servers and mainframe data storage requirements. During 1996, 5.25" drives with capacities in the 1 and 2 gigabyte ranges are being offered in competition with 3.5" drives for home computer markets at very competitive prices, but it is currently expected that competitors with 3.5" drives will match the larger drives' prices and hold most of the 3.5" business. In 1990, less than 20 million 3.5" drives were shipped, but 144 million are projected for 1999. A similar pattern of increasing densities has made it possible for 2.5" drives to dominate the notebook computer market, with the one million drives shipped in 1990 expected to grow to almost 20 million in 1999.

The lower fixed disk drive capacity ranges which once dominated the industry are rapidly fading away. Fixed disk drives with capacities below 300 megabytes, which accounted for shipments of 31.8 million drives as recently as 1994, are expected to be down to less than one million drives in 1996, and next year the same situation is expected for all fixed disk drives with less than 500 megabytes capacity. This trend will continue, and by 1999 even drives in the 3-5 gigabyte range will start into shipment decline.

As typical disk storage capacities continue to escalate in personal computer markets, the preponderance of shipments moves up to the higher capacity DISK/TREND Report product groups even faster than expected. The 2-3 gigabyte product group is expected to lead in 1997 unit shipments, and by 1999 the leader will be the 5-10 gigabyte group.

2.5" drives enjoy the same benefits of increasing areal density that 3.5" drives are experiencing, and 2.5" drives have actually utilized the highest areal density found in any production drives during the last two years. It is not expected that 2.5" drives will gain in share of total drive shipments during this forecast period, however, since they are used mostly for notebook computers, which are not increasing in shipments faster than desktop computers. Although the inevitable increases in areal density will probably eventually help 2.5" drives to secure part of the desktop computer disk drive market, significant penetration of that market is not expected through 1999.

Manufacturers of 1.8" drives have been frustrated in their five year campaign to initiate a mass migration to the smaller drives. So far, 1.8" drives have been unsuccessful in the notebook computer market and have had to develop a series of specialized applications with smaller shipment potential. 1996 shipments are estimated at only 370,000, with growth to 1.1 million drives projected for 1999.

Removable media drives have attracted more attention in 1996 than they have enjoyed in many years, with new competitors, new product initiatives and new capacity levels. It appears that established markets for graphics and prepress requirements will joined by a range of applications for video and multimedia editing, plus a variety of personal computer applications, to create new sales momentum. 1995 shipments of 606,300 drives are projected to climb to 6.3 million in 1999.

Figure 1

CHANGING PRODUCT MIX

Worldwide Rigid Disk Drive Revenue

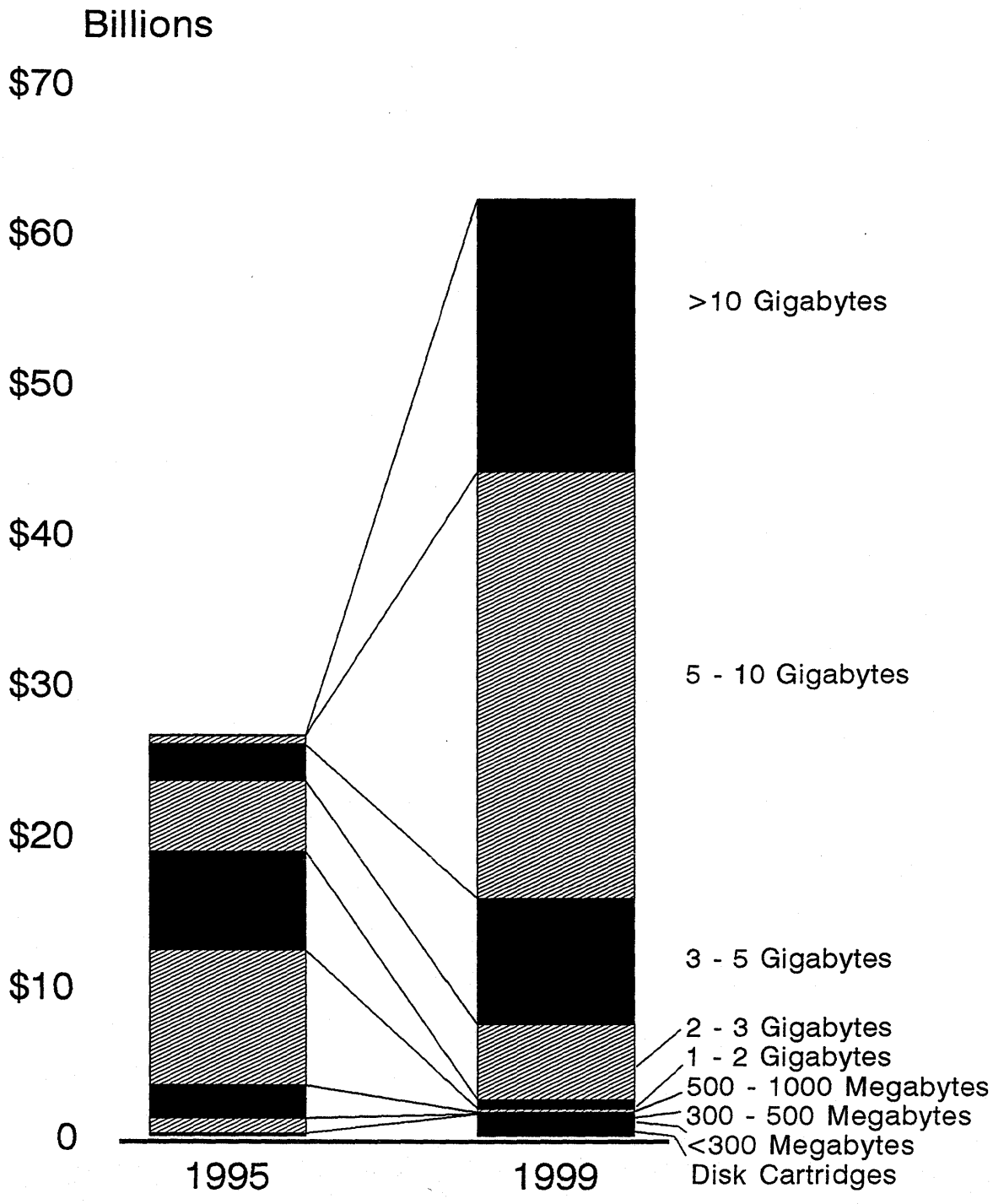


TABLE 3

CONSOLIDATED WORLDWIDE REVENUES
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	1995 Revenues $M	 %	Forecast 1996 $M	 %	 1997 $M	 %	 1998 $M	 %	 1999 $M	 %
CARTRIDGE DISK DRIVES	154.8 +38.3%	.6%	448.4 +189.7%	1.5%	903.6 +101.5%	2.6%	1,220.9 +35.1%	2.7%	1,421.0 +16.4%	2.3%
FIXED DISK DRIVES less than 300 Megabytes	991.1 -80.0%	3.7%	169.3 -82.9%	.6%	44.8 -73.5%	.1%	21.0 -53.1%	--	12.9 -38.6%	--
FIXED DISK DRIVES 300 - 500 Megabytes	2,177.3 -48.3%	8.2%	249.4 -88.5%	.8%	136.7 -45.2%	.4%	120.3 -12.0%	.3%	92.9 -22.8%	.1%
FIXED DISK DRIVES 500 Megabytes - 1 GB	9,004.0 +125.0%	33.8%	5,545.9 -38.4%	18.7%	2,360.0 -57.4%	6.8%	900.1 -61.9%	2.0%	253.0 -71.9%	.4%
FIXED DISK DRIVES 1 - 2 Gigabytes	6,530.4 +66.6%	24.5%	10,848.1 +66.1%	36.6%	5,466.0 -49.6%	15.7%	2,250.6 -58.8%	4.9%	596.7 -73.5%	1.0%
FIXED DISK DRIVES 2 - 3 Gigabytes	4,667.2 +38.0%	17.5%	5,843.4 +25.2%	19.7%	12,068.1 +106.5%	34.8%	6,281.8 -47.9%	13.7%	5,025.8 -20.0%	8.1%
FIXED DISK DRIVES 3 - 5 Gigabytes	2,428.1 +289.8%	9.1%	4,109.7 +69.3%	13.9%	7,681.0 +86.9%	22.1%	14,231.0 +85.3%	31.0%	8,361.2 -41.2%	13.4%
FIXED DISK DRIVES 5 - 10 Gigabytes	626.0 -57.8%	2.4%	2,368.1 +278.3%	8.0%	5,244.4 +121.5%	15.1%	16,481.4 +214.3%	35.9%	28,277.4 +71.6%	45.5%
FIXED DISK DRIVES more than 10 Gigabytes	54.0 -90.0%	.2%	76.0 +40.7%	.2%	802.2 +955.5%	2.3%	4,439.7 +453.4%	9.5%	18,140.3 +308.6%	29.2%
Total Worldwide Revenue	26,632.9 +14.7%	100.0%	29,658.3 +11.4%	100.0%	34,706.8 +17.0%	100.0%	45,946.8 +32.4%	100.0%	62,181.2 +35.3%	100.0%

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

Figure 2

UNIT SHIPMENT SUMMARY

Worldwide Shipments in Millions of Units

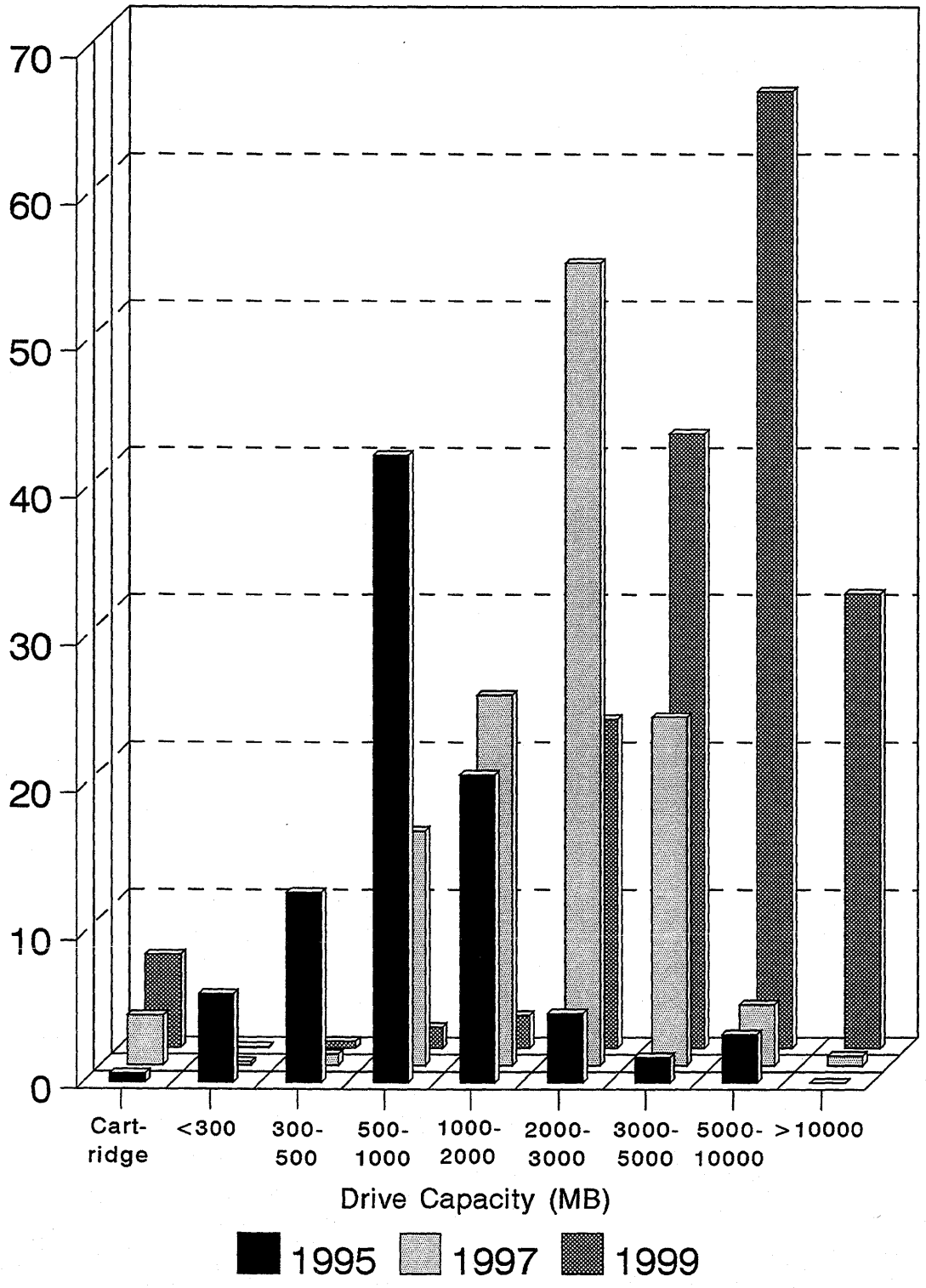


TABLE 4

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	1995 Shipments Units	1995 Shipments %	Forecast 1996 Units	Forecast 1996 %	Forecast 1997 Units	Forecast 1997 %	Forecast 1998 Units	Forecast 1998 %	Forecast 1999 Units	Forecast 1999 %
CARTRIDGE DISK DRIVES	606.3 +29.4%	.7%	1,818.0 +199.9%	1.7%	3,360.0 +84.8%	2.6%	4,940.0 +47.0%	3.3%	6,320.0 +27.9%	3.7%
FIXED DISK DRIVES less than 300 Megabytes	5,970.4 -81.2%	6.7%	865.3 -85.5%	.8%	230.0 -73.4%	.2%	110.0 -52.2%	.1%	70.0 -36.4%	--
FIXED DISK DRIVES 300 - 500 Megabytes	12,863.8 -33.1%	14.4%	1,579.6 -87.7%	1.4%	760.0 -51.9%	.6%	540.0 -28.9%	.4%	450.0 -16.7%	.3%
FIXED DISK DRIVES 500 Megabytes - 1 GB	42,553.7 +289.5%	47.5%	34,104.3 -19.9%	31.2%	15,905.0 -53.4%	12.4%	5,125.0 -67.8%	3.4%	1,430.0 -72.1%	.8%
FIXED DISK DRIVES 1 - 2 Gigabytes	20,859.1 +333.2%	23.3%	47,206.3 +126.3%	43.2%	25,130.0 -46.8%	19.6%	9,245.0 -63.2%	6.2%	2,215.0 -76.0%	1.3%
FIXED DISK DRIVES 2 - 3 Gigabytes	4,674.5 +105.4%	5.2%	18,232.5 +290.0%	16.7%	54,490.0 +198.9%	42.5%	27,580.0 -49.4%	18.5%	22,290.0 -19.2%	13.1%
FIXED DISK DRIVES 3 - 5 Gigabytes	1,698.8 +444.3%	1.9%	3,927.2 +131.2%	3.6%	23,600.0 +500.9%	18.4%	65,100.0 +175.8%	43.6%	41,685.0 -36.0%	24.5%
FIXED DISK DRIVES 5 - 10 Gigabytes	328.8 +205.9%	.3%	1,419.0 +331.6%	1.3%	4,100.0 +188.9%	3.2%	32,210.0 +685.6%	21.6%	64,990.0 +101.8%	38.2%
FIXED DISK DRIVES more than 10 Gigabytes	1.5 -88.4%	--	40.0 --	--	650.0 --	.5%	4,340.0 +567.7%	2.9%	30,795.0 +609.6%	18.1%
Total Worldwide Shipments	89,556.9 +27.9%	100.0%	109,192.2 +21.9%	100.0%	128,225.0 +17.4%	100.0%	149,190.0 +16.4%	100.0%	170,245.0 +14.1%	100.0%
% U.S. Manufacturers	89.3%		81.0%		77.8%		76.2%		73.4%	
Total Capacity (Terabytes)	80,677.2		164,032.6		305,888.8		699,467.8		1,354,581.2	

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

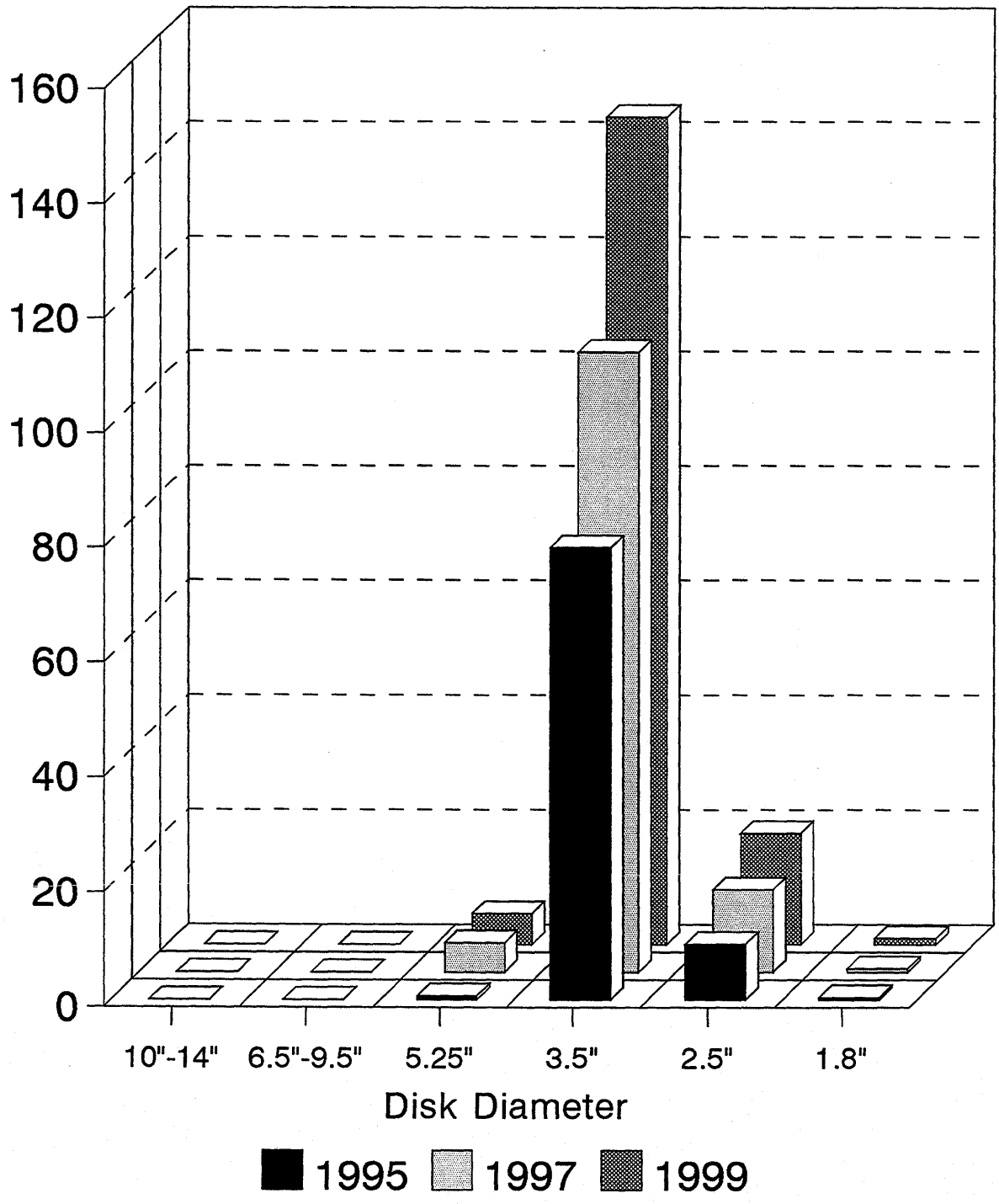


TABLE 5

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
SUMMARY BY DISK DIAMETER

UNIT SHIPMENTS IN THOUSANDS	1995 Shipments Units	%	Forecast 1996 Units	%	1997 Units	%	1998 Units	%	1999 Units	%
10 - 14 INCH	1.9	--	.3	--	--	--	--	--	--	--
	-95.9%		-84.2%		-100.0%		--		--	
6.5 - 9.5 INCH	12.3	--	1.0	--	--	--	--	--	--	--
	-83.7%		-91.9%		-100.0%		--		--	
5.25 INCH	706.8	.8%	4,389.8	4.0%	5,075.0	4.0%	5,425.0	3.6%	5,445.0	3.2%
	-10.7%		+521.1%		+15.6%		+6.9%		+.4%	
3.5 INCH	77,775.8	86.8%	91,895.1	84.2%	108,075.0	84.3%	125,870.0	84.4%	144,265.0	84.7%
	+28.9%		+18.2%		+17.6%		+16.5%		+14.6%	
2.5 INCH	10,637.8	11.9%	12,536.0	11.5%	14,445.0	11.3%	17,030.0	11.4%	19,415.0	11.4%
	+25.0%		+17.8%		+15.2%		+17.9%		+14.0%	
1.8 INCH OR LESS	418.8	.5%	370.0	.3%	630.0	.5%	865.0	.6%	1,120.0	.7%
	+78.0%		-11.7%		+70.3%		+37.3%		+29.5%	
Total Worldwide Shipments	89,553.4	100.0%	109,192.2	100.0%	128,225.0	100.0%	149,190.0	100.0%	170,245.0	100.0%
	+27.9%		+21.9%		+17.4%		+16.4%		+14.1%	

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

Figure 4

CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

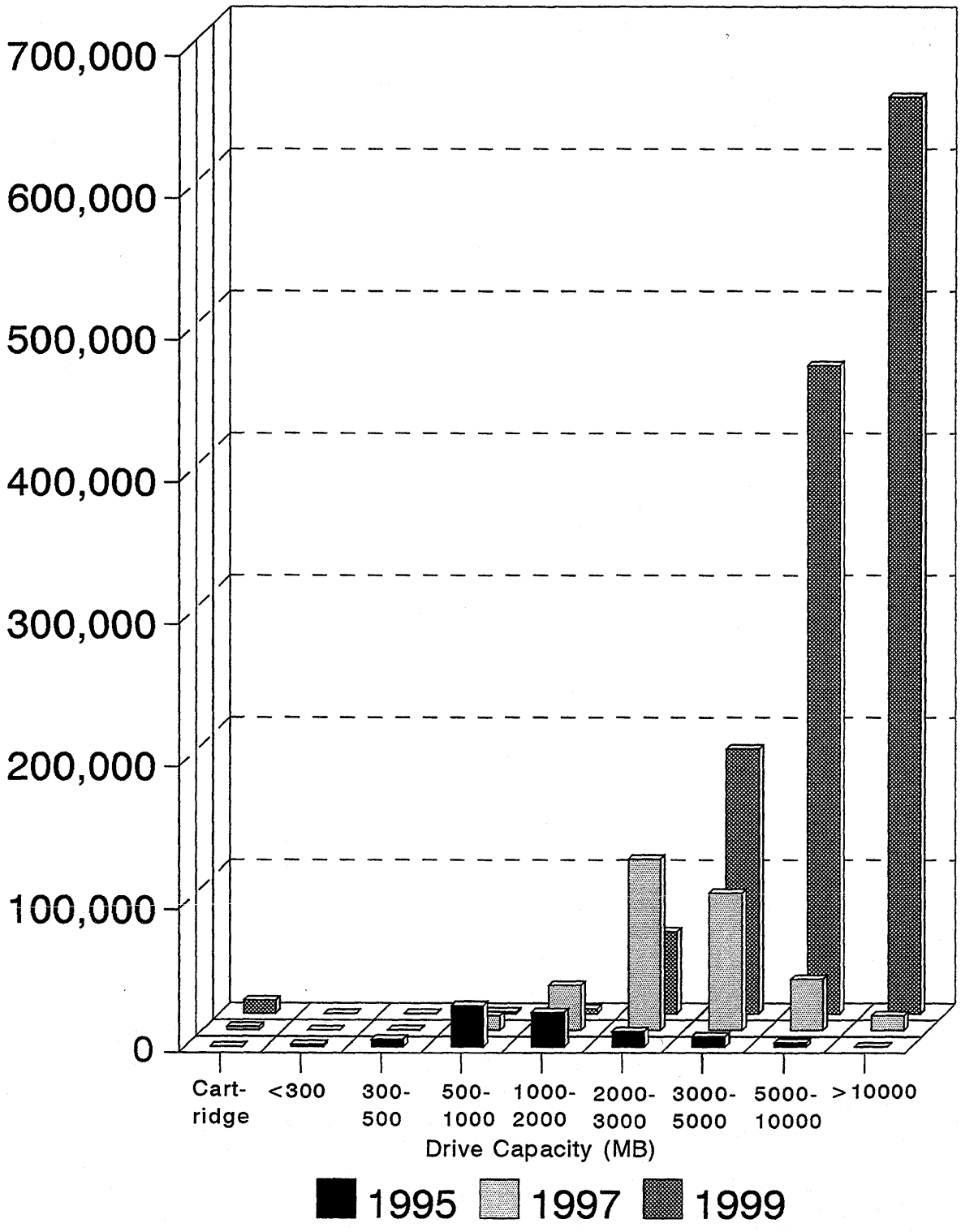


TABLE 6

CONSOLIDATED WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	1995 Shipments Tbytes	1995 Shipments %	1996 Forecast Tbytes	1996 Forecast %	1997 Forecast Tbytes	1997 Forecast %	1998 Forecast Tbytes	1998 Forecast %	1999 Forecast Tbytes	1999 Forecast %
CARTRIDGE DISK DRIVES	104.8 +35.1%	.1%	1,002.0 +856.1%	.6%	2,303.8 +129.9%	.8%	5,134.5 +122.9%	.7%	9,035.0 +76.0%	.7%
FIXED DISK DRIVES less than 300 Megabytes	1,527.2 -81.2%	1.9%	222.6 -85.4%	.1%	59.9 -73.0%	--	28.6 -52.3%	--	18.2 -36.4%	--
FIXED DISK DRIVES 300 - 500 Megabytes	5,170.2 -31.8%	6.4%	653.6 -87.4%	.4%	291.0 -55.5%	.1%	199.8 -31.4%	--	184.5 -7.7%	--
FIXED DISK DRIVES 500 Megabytes - 1 GB	28,860.2 +335.4%	35.8%	27,757.0 -3.8%	16.9%	10,201.7 -63.2%	3.3%	3,717.5 -63.6%	.5%	1,188.2 -68.0%	.1%
FIXED DISK DRIVES 1 - 2 Gigabytes	24,120.8 +324.3%	29.9%	63,259.7 +162.3%	38.6%	31,372.8 -50.4%	10.3%	12,578.5 -59.9%	1.8%	3,359.0 -73.3%	.2%
FIXED DISK DRIVES 2 - 3 Gigabytes	10,774.7 +126.3%	13.4%	41,620.5 +286.3%	25.4%	119,623.1 +187.4%	39.1%	65,560.0 -45.2%	9.4%	57,061.0 -13.0%	4.2%
FIXED DISK DRIVES 3 - 5 Gigabytes	7,119.9 +376.3%	8.8%	16,128.4 +126.5%	9.8%	95,904.6 +494.6%	31.4%	278,258.2 +190.1%	39.8%	185,187.0 -33.4%	13.7%
FIXED DISK DRIVES 5 - 10 Gigabytes	2,973.9 +258.5%	3.7%	12,468.8 +322.1%	7.6%	35,711.8 +186.4%	11.7%	256,613.2 +618.6%	36.7%	454,793.3 +77.2%	33.6%
FIXED DISK DRIVES more than 10 Gigabytes	25.5 -88.4%	--	920.0 --	.6%	10,420.0 --	3.3%	77,377.5 +642.6%	11.1%	643,765.5 +732.0%	47.5%
Total Capacity (Terabytes)	80,677.2 +129.3%	100.0%	164,032.6 +103.3%	100.0%	305,888.8 +86.5%	100.0%	699,467.8 +128.7%	100.0%	1,354,581.2 +93.7%	100.0%

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

Price per megabyte

Noncaptive average prices continue to decline aggressively, as rapidly increasing drive shipments in the higher capacity ranges bring new levels of competition to these product groups. 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.

As shipments of noncaptive 3.5" and 2.5" drives decline in the lower capacity product groups, average prices are expected to increase. The reason for this phenomenon is that the only remaining drives in these groups will be 1.8" drives, which have a higher parts count at each capacity level than the larger diameter disk drives and are produced in smaller quantities, and are priced at higher levels. In the higher capacity ranges, the combination of high individual drive capacities, increasing shipments and intense competition is expected to drop the lowest noncaptive price per megabyte from 19 cents in 1995 to 2 cents in 1999.

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 newer, 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)

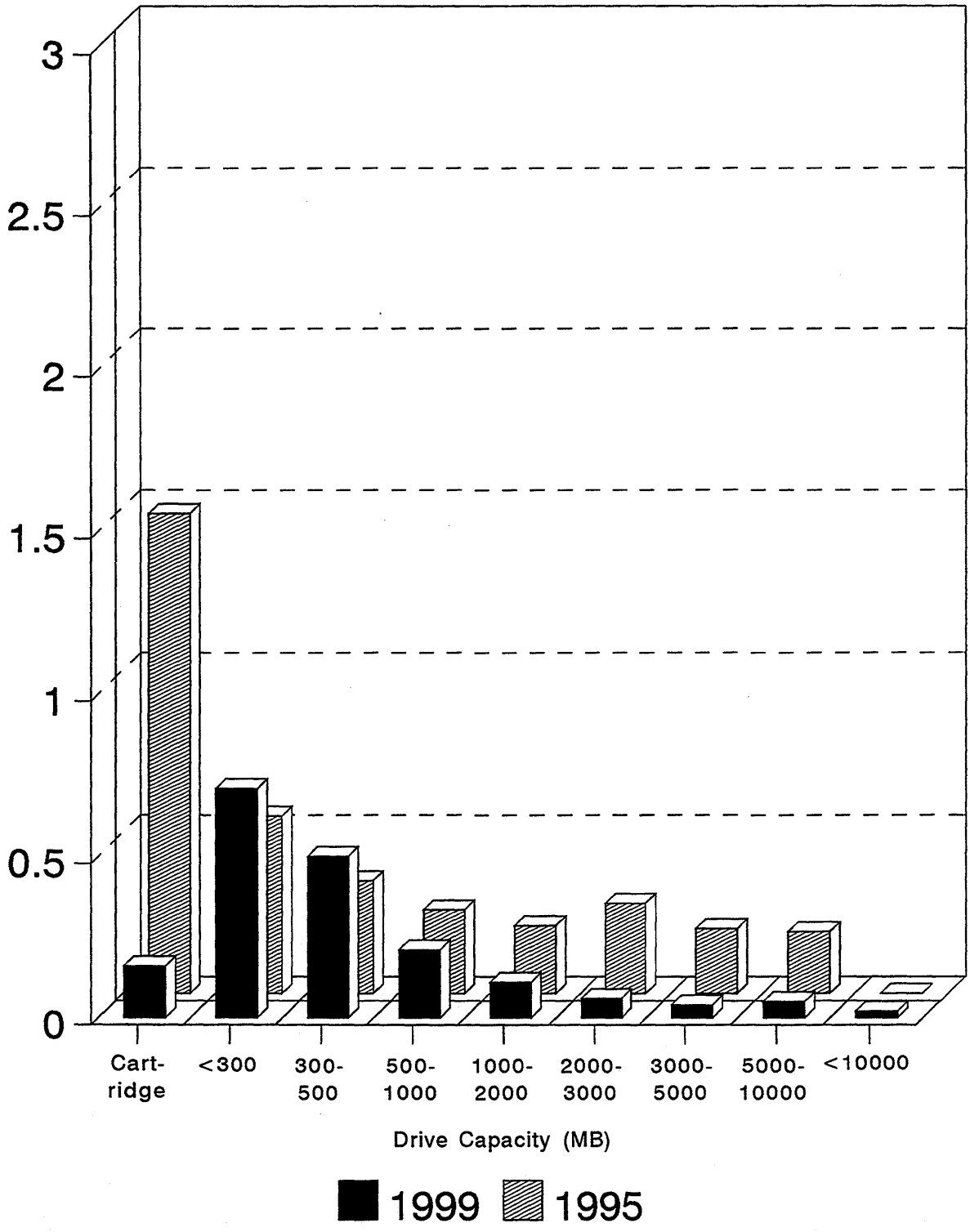


TABLE 7

NONCAPTIVE WORLDWIDE SHIPMENTS
RIGID DISK DRIVES
PRODUCT GROUP REVIEW

PRICE PER MEGABYTE SUMMARY ($/MB)

		Forecast			
	1995	1996	1997	1998	1999
CARTRIDGE DISK DRIVES	1.48 +2.4%	.45 -69.7%	.39 -12.4%	.24 -39.4%	.16 -33.9%
FIXED DISK DRIVES less than 300 Megabytes	.55 +2.5%	.62 +11.3%	.75 +21.4%	.73 -1.7%	.71 -3.5%
FIXED DISK DRIVES 300 - 500 Megabytes	.35 -21.0%	.34 -4.9%	.47 +39.1%	.60 +28.2%	.50 -16.4%
FIXED DISK DRIVES 500 Megabytes - 1 GB	.26 -48.3%	.18 -32.7%	.20 +13.9%	.20 -2.7%	.21 +8.2%
FIXED DISK DRIVES 1 - 2 Gigabytes	.21 -56.5%	.14 -33.3%	.13 -5.3%	.11 -15.6%	.11 -3.1%
FIXED DISK DRIVES 2 - 3 Gigabytes	.28 -37.3%	.11 -61.5%	.09 -19.6%	.07 -18.8%	.06 -11.5%
FIXED DISK DRIVES 3 - 5 Gigabytes	.20 -36.4%	.14 -29.1%	.06 -57.3%	.04 -28.7%	.04 -15.8%
FIXED DISK DRIVES 5 - 10 Gigabytes	.19 -82.7%	.12 -35.9%	.06 -49.7%	.05 -15.8%	.05 --
FIXED DISK DRIVES more than 10 Gigabytes	-- --	.08 --	.06 -21.4%	.04 -45.6%	.02 -31.2%

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			
	1995	1996	1997	1998	1999
CARTRIDGE DISK DRIVES	--	--	--	--	--
	--	--	--	--	--
FIXED DISK DRIVES	2.29	2.30	--	--	--
less than 300 Megabytes	-21.5%	+.2%	--	--	--
FIXED DISK DRIVES	1.67	1.81	--	--	--
300 - 500 Megabytes	-14.5%	+8.5%	--	--	--
FIXED DISK DRIVES	.90	.73	.68	.71	--
500 Megabytes - 1 GB	-38.8%	-18.8%	-6.9%	+4.9%	--
FIXED DISK DRIVES	.80	.58	.44	.33	.26
1 - 2 Gigabytes	-49.2%	-28.4%	-23.0%	-25.1%	-22.3%
FIXED DISK DRIVES	1.34	.36	.27	.22	.19
2 - 3 Gigabytes	-19.3%	-72.9%	-25.8%	-19.8%	-12.9%
FIXED DISK DRIVES	1.37	.73	.27	.15	.10
3 - 5 Gigabytes	+68.6%	-46.4%	-62.6%	-45.5%	-32.5%
FIXED DISK DRIVES	2.99	.63	.52	.34	.24
5 - 10 Gigabytes	--	-78.9%	-17.5%	-35.2%	-28.1%
FIXED DISK DRIVES	2.12	--	.27	.36	.29
more than 10 Gigabytes	-18.0%	--	--	+34.6%	-20.3%

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

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

Noncaptive market

Noncaptive sales revenues provided 69.8% of the disk drive industry's 1995 worldwide total, and the noncaptive share is projected to increase to 77.9% in 1999. The extent of the change in the industry's structure is seen in the fact that 20 years ago sales of captive drives provided 70% of the industry's disk drive revenues. The noncaptive share of worldwide disk drive unit shipments was 91.0% in 1995, and the 1999 share is expected to be the same, indicating expected success for noncaptive producers in holding market share while typical captive prices trend downwards. 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.

Noncaptive disk drive manufacturers have quickly exploited technology advances during the last decade which have enabled them to respond with competitive drives 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	1995 Revenues $M	 %	Forecast 1996 $M	 %	 1997 $M	 %	 1998 $M	 %	 1999 $M	 %
CARTRIDGE DISK DRIVES	154.8 +38.3%	.8%	448.4 +189.7%	2.2%	903.6 +101.5%	3.8%	1,220.9 +35.1%	3.7%	1,421.0 +16.4%	2.9%
FIXED DISK DRIVES less than 300 Megabytes	797.1 -81.2%	4.3%	125.0 -84.3%	.6%	44.8 -64.2%	.2%	21.0 -53.1%	--	12.9 -38.6%	.1%
FIXED DISK DRIVES 300 - 500 Megabytes	1,743.0 -44.9%	9.4%	214.1 -87.7%	1.0%	136.7 -36.2%	.6%	120.3 -12.0%	.4%	92.9 -22.8%	.2%
FIXED DISK DRIVES 500 Megabytes - 1 GB	7,035.4 +130.3%	37.9%	4,732.1 -32.7%	22.9%	1,937.8 -59.0%	8.2%	667.7 -65.5%	2.0%	253.0 -62.1%	.5%
FIXED DISK DRIVES 1 - 2 Gigabytes	4,500.2 +104.1%	24.2%	8,133.1 +80.7%	39.2%	3,560.9 -56.2%	15.1%	966.8 -72.8%	2.9%	193.1 -80.0%	.4%
FIXED DISK DRIVES 2 - 3 Gigabytes	2,525.8 +55.5%	13.6%	3,816.0 +51.1%	18.4%	9,311.4 +144.0%	39.3%	3,703.2 -60.2%	11.1%	2,747.0 -25.8%	5.6%
FIXED DISK DRIVES 3 - 5 Gigabytes	1,272.3 +233.0%	6.9%	1,880.4 +47.8%	9.0%	5,356.5 +184.9%	22.6%	11,293.4 +110.8%	34.0%	5,919.4 -47.6%	12.4%
FIXED DISK DRIVES 5 - 10 Gigabytes	566.5 -19.1%	2.9%	1,331.6 +135.1%	6.4%	1,799.4 +35.1%	7.6%	12,791.8 +610.9%	38.4%	22,386.6 +75.0%	46.2%
FIXED DISK DRIVES more than 10 Gigabytes	-- -100.0%	--	76.0 --	.3%	635.7 +736.4%	2.6%	2,546.7 +300.6%	7.5%	15,414.6 +505.3%	31.7%
Total Worldwide Revenues	18,595.1 +19.3%	100.0%	20,756.7 +11.6%	100.0%	23,686.8 +14.1%	100.0%	33,331.8 +40.7%	100.0%	48,440.5 +45.3%	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	1995 Shipments Units	1995 Shipments %	1996 Forecast Units	1996 Forecast %	1997 Forecast Units	1997 Forecast %	1998 Forecast Units	1998 Forecast %	1999 Forecast Units	1999 Forecast %
CARTRIDGE DISK DRIVES	606.3 +29.4%	.7%	1,818.0 +199.9%	1.8%	3,360.0 +84.8%	2.9%	4,940.0 +47.0%	3.7%	6,320.0 +27.9%	4.1%
FIXED DISK DRIVES less than 300 Megabytes	5,605.0 -81.3%	6.9%	779.8 -86.1%	.8%	230.0 -70.5%	.2%	110.0 -52.2%	.1%	70.0 -36.4%	--
FIXED DISK DRIVES 300 - 500 Megabytes	11,906.5 -31.6%	14.7%	1,497.6 -87.4%	1.5%	760.0 -49.3%	.7%	540.0 -28.9%	.4%	450.0 -16.7%	.3%
FIXED DISK DRIVES 500 Megabytes - 1 GB	39,094.8 +295.9%	48.0%	32,401.0 -17.1%	32.5%	14,895.0 -54.0%	12.9%	4,645.0 -68.8%	3.4%	1,430.0 -69.2%	.9%
FIXED DISK DRIVES 1 - 2 Gigabytes	18,570.6 +384.6%	22.8%	43,529.1 +134.4%	43.5%	21,706.0 -50.1%	18.7%	6,485.0 -70.1%	4.9%	1,215.0 -81.3%	.8%
FIXED DISK DRIVES 2 - 3 Gigabytes	3,907.1 +124.2%	4.8%	15,615.6 +299.7%	15.7%	49,727.0 +218.4%	42.9%	22,470.0 -54.8%	16.8%	17,490.0 -22.2%	11.4%
FIXED DISK DRIVES 3 - 5 Gigabytes	1,456.3 +499.5%	1.8%	3,099.2 +112.8%	3.1%	21,400.0 +590.5%	18.5%	60,375.0 +182.1%	45.0%	36,285.0 -39.9%	23.4%
FIXED DISK DRIVES 5 - 10 Gigabytes	325.3 +342.6%	.3%	1,206.0 +270.7%	1.1%	3,230.0 +167.8%	2.8%	30,720.0 +851.1%	22.8%	61,580.0 +100.5%	39.7%
FIXED DISK DRIVES more than 10 Gigabytes	-- -100.0%	--	40.0 --	--	605.0 --	.4%	3,975.0 +557.0%	2.9%	30,195.0 +659.6%	19.4%
Total Worldwide Shipments	81,471.9 +28.0%	100.0%	99,986.3 +22.7%	100.0%	115,913.0 +15.9%	100.0%	134,260.0 +15.8%	100.0%	155,035.0 +15.5%	100.0%
% U.S. Manufacturers	90.0%		80.9%		77.3%		75.8%		72.6%	
Total Capacity (Terabytes)	73,128.9	100.0%	147,883.7	100.0%	274,998.9	100.0%	647,460.6	100.0%	1,282,851.2	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

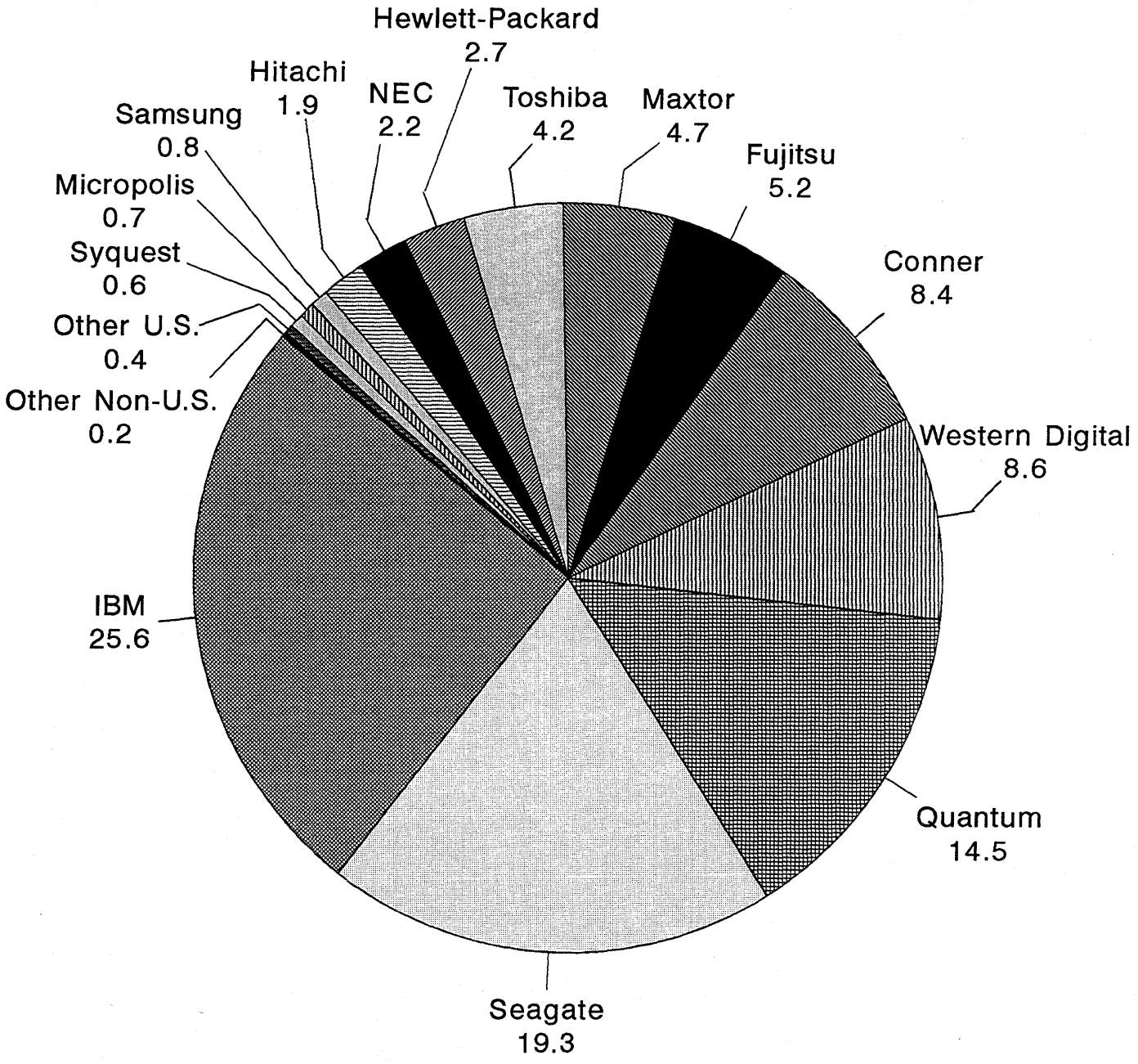
CAPACITY SHIPPED IN TERABYTES	1995 Capacity Units	1995 Capacity %	Forecast 1996 Units	1996 %	1997 Units	1997 %	1998 Units	1998 %	1999 Units	1999 %
CARTRIDGE DISK DRIVES	104.8	.1%	1,002.0	.7%	2,303.8	.8%	5,134.5	.8%	9,035.0	.7%
	+35.1%		+856.1%		+129.9%		+122.9%		+76.0%	
FIXED DISK DRIVES less than 300 Megabytes	1,442.5	2.0%	203.3	.1%	59.9	.1%	28.6	--	18.2	--
	-81.7%		-85.9%		-70.5%		-52.3%		-36.4%	
FIXED DISK DRIVES 300 - 500 Megabytes	4,910.0	6.7%	634.1	.4%	291.0	.1%	199.8	--	184.5	--
	-30.3%		-87.1%		-54.1%		-31.4%		-7.7%	
FIXED DISK DRIVES 500 Megabytes - 1 GB	26,673.0	36.6%	26,642.9	18.2%	9,580.7	3.4%	3,391.5	.6%	1,188.2	.1%
	+345.6%		--		-64.0%		-64.6%		-65.0%	
FIXED DISK DRIVES 1 - 2 Gigabytes	21,597.3	29.5%	58,545.1	39.5%	27,079.2	9.9%	8,714.5	1.3%	1,796.0	.2%
	+369.4%		+171.1%		-53.7%		-67.8%		-79.4%	
FIXED DISK DRIVES 2 - 3 Gigabytes	9,171.4	12.6%	36,017.0	24.4%	109,359.4	39.9%	53,582.0	8.3%	44,908.0	3.5%
	+147.9%		+292.7%		+203.6%		-51.0%		-16.2%	
FIXED DISK DRIVES 3 - 5 Gigabytes	6,277.2	8.6%	13,093.9	8.9%	87,440.0	31.8%	258,642.5	40.0%	161,015.0	12.6%
	+423.6%		+108.6%		+567.8%		+195.8%		-37.7%	
FIXED DISK DRIVES 5 - 10 Gigabytes	2,954.0	3.9%	10,825.6	7.3%	29,089.8	10.5%	245,667.2	38.0%	430,491.3	33.6%
	+368.1%		+266.5%		+168.7%		+744.5%		+75.2%	
FIXED DISK DRIVES more than 10 Gigabytes	--	--	920.0	.5%	9,795.0	3.5%	72,100.0	11.0%	634,215.5	49.3%
	-100.0%		--		+964.7%		+636.1%		+779.6%	
Total Capacity (Terabytes)	73,130.2	100.0%	147,883.9	100.0%	274,998.9	100.0%	647,460.6	100.0%	1,282,851.2	100.0%
	+134.7%		+102.2%		+86.0%		+135.4%		+98.1%	
% U.S. Manufacturers	92.1%		81.6%		76.9%		75.8%		70.9%	

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

Figure 6

1995 ESTIMATED MARKET SHARE

Worldwide Revenue Percentages



1995 Revenues: $26,573,400,000

TABLE 12

1995 ESTIMATED MARKET SHARES

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

	CAPTIVE		PCM/DISTRIBUTOR		OEM/INTEGRATOR		TOTAL INDUSTRY	
	$M	%	$M	%	$M	%	$M	%
U.S. MANUFACTURERS								
Conner Peripherals	--	--	480.1	8.4	1,739.6	13.5	2,219.7	8.3
Hewlett-Packard	479.5	6.0	115.4	2.0	134.9	1.0	729.8	2.7
IBM	5,698.5	70.9	174.1	3.0	986.9	7.7	6,859.5	25.8
Maxtor	--	--	457.4	8.0	783.8	6.1	1,241.2	4.7
Micropolis	--	--	132.5	2.3	50.9	.4	183.4	.7
Quantum	--	--	1,157.6	20.2	2,687.8	20.9	3,845.4	14.4
Seagate Technology	--	--	1,733.3	30.2	3,407.4	26.5	5,140.7	19.3
SyQuest Technology	--	--	150.0	2.6	2.8	--	152.8	.6
Western Digital	--	--	796.9	13.9	1,494.2	11.6	2,291.1	8.6
Other U.S.	.3	--	20.0	.3	88.1	.7	108.4	.4
U.S. Total	6,178.3	76.9	5,217.3	90.9	11,376.4	88.5	22,772.0	85.5
NON-U.S. MANUFACTURERS								
Fujitsu	684.5	8.6	33.5	.6	665.1	5.2	1,383.1	5.2
Hitachi	189.9	2.4	214.5	3.7	111.3	.9	515.7	1.9
NEC	471.0	5.9	--	--	125.8	1.0	596.8	2.2
Samsung Electronics	--	--	208.1	3.6	--	--	208.1	.8
Toshiba	513.9	6.4	62.7	1.1	538.3	4.2	1,114.9	4.2
Other Non-U.S.	.2	--	4.3	.1	37.8	.3	42.3	.2
Non-U.S. Total	1,859.5	23.1	523.1	9.1	1,478.3	11.5	3,860.9	14.5
WORLDWIDE TOTAL	8,037.8	100.0	5,740.4	100.0	12,854.7	100.0	26,632.9	100.0

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

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

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

TABLE 13

CURRENT PRODUCT LINES
MANUFACTURERS OF RIGID MAGNETIC DISK DRIVES

U.S. Manufacturers (13)	DISK/TREND PRODUCT GROUP Type	1 Disk Cartridge Drives	2 Fixed Disk Drives <300 MB	3 Fixed Disk Drives 300-500 MB	4 Fixed Disk Drives 500 MB-1 GB	5 Fixed Disk Drives 1 GB-2 GB	6 Fixed Disk Drives 2 GB-3 GB	7 Fixed Disk Drives 3 GB-5 GB	8 Fixed Disk Drives 5 GB-10 GB	9 Fixed Disk Drives >10 GB
Avatar Systems	O	2								
Gigastorage International	P,O					5	5			
Hewlett-Packard	C,P,O					3	3		3	
IBM	C,P,O				2	2,3	2,3	3	3	
Integral Peripherals	P,O		1.8	1.8	1.8	2				
Iomega	P,O	3								
JTS	P,O				2	2,3	3			
Quantum	P,O		2,3	2,3	2,3	2,3,5	3,5	3	3	
Raymond Engineering	O		3	3						
Seagate Technology	P,O			2,3	2,3	2,3	2,3,5	3	3,5	5
Sequel	O		5	5	5			5		
SyQuest Technology	P,O	3,5								
Western Digital	P,O				3	3	3	3		
Asian Manufacturers (10)										
Fujitsu	C,P,O		2,3	3	2,3	2,3,5	3,5	3	3	
Hitachi	C,P,O		3		2,3	2,3	3,8	3	8	
Maxtor	P,O				2,3	2,3	3			
Micropolis	P,O						3	3	3,5	
Momentum Peripherals	P,O		1.8							
NEC	C,P,O				3	3	3	3		
Samsung Electronics	C,P,O					2,3	3	3		
Tae Il Media	P,O					3				
Toshiba	C,P,O		2	2	2	2	2			
Tottori Sanyo	P,O		2	2	2	2				
European Manufacturers (3)										
Calluna Technology	P,O		1.8	1.8	1.8					
Nomai	P,O	3								
Sagem	O		5							

TECHNICAL REVIEW

Competing technologies

The competitive positioning of the rigid magnetic disk drive industry continues to be bolstered by rapid increases in areal density and the resulting rapid decrease in cost per megabyte. Drive performance has also continued to improve, making it nearly impossible for any competing storage technology to seriously challenge the rigid magnetic disk drive, except in a few niche applications. Manufacturers continue to provide smaller, faster, more reliable, higher capacity, less expensive disk drives, well supported by a magnetic storage industry supplier infrastructure. During the 1990's, the disk drive industry has been able to increase areal density at a 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 remaining on a fast track, 10 gigabit per square inch areal density by the end of the decade continues to appear likely, although some technologists expect the rate of increase in areal density to decline towards the end of the decade as increases in data channel rates required by higher linear bit density become harder to achieve. And as areal densities approach 50 gigabits per square inch, the decreasing size of the resultant magnetic domains may cause intractable stability problems that require the disk drive industry to switch from longitudinal recording to perpendicular recording (or optical recording using a flying optical head) to further increase areal density.

In a few specialized markets and applications, a limited number of alternatives to magnetic disk recording exist, but only where the substitute technology has been significantly better, faster, smaller, less expensive or demonstrated some other overwhelming advantage in that niche.

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 also allow part of main memory to be designated for use as a fast virtual disk.

  Fast semiconductor memory is expensive, ranging up 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 logical and electrical interface for plug-in cards used to expand system memory, emulate a disk drive, or provide other peripheral functions. The associated physical package has been adopted as the PC Card standard.

  Specialized portable computers can use removable semiconductor memory packaged in a flat "credit card" format with PCMCIA interfaces. PC Card 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. Even

smaller form factors for use with industrial equipment, cameras and other consumer applications have appeared in 1995 and 1996.

The PCMCIA/PC Card 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 in PC Card form factors with the capability to be plugged into a PC Card 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.

* Volatile semiconductor memories: DRAM is the most commonly employed form of semiconductor memory. It is used in systems of all sizes for general purpose system memory, video memory, and other applications where its volatility is not a major handicap. It is also used on large systems as a supplement to magnetic storage to provide fast mass storage. DRAM chips are readily available in 4 megabit configurations (shipments seem to have peaked 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.

* Nonvolatile semiconductor memories: Flash memory, a form of EEPROM in which a block of memory cells can be erased by an electrical signal, is

nonvolatile and can be used as fixed or removable storage. Flash memory can provide adequate mass storage where capacity need be only a few megabytes, power limitations are severe, a hostile environment exists, and product price is not a paramount factor.

Flash memory is often discussed as a major competitor to rotating memory, but its more significant computer 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 and 1995. Realistic 1996 flash memory OEM prices remain in the range of 10 to 20 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 cir-

cuitry 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. Ramtron also has a joint development effort with Fujitsu aimed at production of 1 megabit chips, to be followed eventually by 16 megabit chips. National Semiconductor also has a ferroelectric memory development effort. Ramtron is currently in volume 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. NEC has also discussed 4 megabit chips. Symetrix, another U.S. based startup, also has joint FRAM developments with Japanese partners.

Supporters of ferroelectric memories project that in the 1997-1998 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 1998, 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.

* Holographic storage: Holographic storage is a type of storage in which an array of bits is stored in an optically sensitive medium as a pattern scattered throughout the volume of the medium. A scanned laser generated writing (object) beam and reference beam create an interference pattern throughout the storage element, which in turn modifies the index of refraction throughout the storage medium in a similar pattern. Many bit pattern images can be stored in a single piece of storage media, limited largely by the need to maintain an adequate signal to noise ratio. As images are added, there is some tendency for interference between them. The location of the image is determined by the angle at which the reference beam impinges upon the storage medium. When the medium is illuminated by the reference beam only, the data can be projected upon a detector.

  Storage media can be fixed or removable, and both write-once and rewritable forms are possible. Current media designs employ crystals fabricated from iron doped lithium niobate, barium titanate, strontium barium niobate and organic polymer materials. In general, the materials are not interchangeable. While some of these materials permit degradation of stored data due to the effect of read operations, temperature cycling can make the data permanent while still permitting further writing operations. Acousto-optical modulators are used to scan the laser beams. The deflected object beam used for writing is directed through a spatial light modulator (SLM) to create the bit stream to be stored. The SLM is typically a liquid crystal array with the bit pattern imaged upon it. A CCD sensor array is used as an output detector for data readback.

  Because holographic storage systems 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.

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

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

MCC effort included DEC, NCR, Eastman Kodak, General Dynamics and E-Systems. MCC demonstrated working prototypes of holographic memories in a 5.25" form factor in 1992 and established a subsidiary corporation, Tamarack Storage Devices, to commercialize the technology. MCC's 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. However, the storage medium is a write-once medium.

While Tamarack's efforts did not result in a salable product, other companies and universities are working as a consortium on the HDSS (Holographic Data Storage System) to develop prototype holographic storage equipment or required components by the year 2000. Much of this effort is funded by a $32 million program jointly funded by NSIC (National Storage Industry Consortium) and DARPA (Defense Advanced Research Project Agency), which is associated with the U.S. Department of Defense. The goal of HDSS is a capacity of at least a trillion bits and at least a one gigabit per second data transfer rate. A second consortium started in 1994, designated PRISM (Photo Refractive Information Storage Materials) is concentrating upon development of suitable holographic media. Both write-once and rewritable media are anticipated. The consortium is focusing upon creating a storage device with a terabyte of memory (using several media units), one gigabit per second data transfer rate and an access time of less than one millisecond within a single medium unit. A mechanical transport mechanism will switch storage crystals, with a typical transport time of 30 milliseconds anticipated. Packaging of the device within a standard 5.25" form factor is expected. Current cubic storage density is under 50 megabytes/cubic cm., but the target is storage media with 10 gigabytes/cubic cm. capability.

Among the organizations participating in the HDSS consortium are IBM, Optitek, GTE, Eastman Kodak, Rochester Photonics, SDL and several universities, including Stanford, Carnegie Mellon, the University of Arizona and the University of Dayton. PRISM members include IBM, Optitek, GTE, Hughes, Rockwell, SRI and Stanford University. Nonconsortium organizations are also developing holographic memories, including Holoplex and NTT. Consortium members do not expect to have salable products available until at least 1999, although a few evaluation prototypes may be completed sooner. Rockwell and Holoplex have created operating prototypes with limited storage capabilities for evaluating the technology.

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

* Optical disk drives: Optical drives range from 2.5" units with 140 megabyte capacity to 14" drives with up to 25 gigabytes of capacity. With track densities of 18,000 to 25,000 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 announced magnetic disk drives exceeding 1,300 megabits per square inch areal density have more than closed the gap. Because optical recording has been increasing its areal density at "only" an average 40% per year compared to the average 60% annual growth displayed by rigid drives, optical recording will become increasingly disadvantaged compared to rigid drives from a storage density standpoint, at least for the next several years.

  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. 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.

  Although 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. Magnetic disk cartridge products such as the Iomega and SyQuest gigabyte range drives 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. 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 several models of magneto-optic drives without overwrite latencies should be available in 1996 from MOST, Nikon and others. Phase change media can be directly overwritten, but limits the number of write erase cycles, typically to a few hundred thousand. MO media can be rewritten indefinitely, although it is subject to thermal fatigue effects observed after 10-20 million write-erase cycles.

Recent rewritable drives have reached 3,600 RPM spin rates and Fujitsu has announced a 5,400 RPM model. However, average seek times are having difficulty moving below 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 650 megabytes per side, and several drives with over 1.3 gigabytes per side began moving into production in late 1995 and 1996. MOST, Sony, and others have already introduced such a drive, while Pinnacle Micro has announced both 1.3 gigabyte per side and 2.3 gigabyte per side drives. 2.6 gigabyte per side issues are currently under consideration in several standards technical subcommittees. However, the low shipment volumes of MO drives leave them open to competition from lower cost DVD format writable and rewritable drives expected to be shipping in large quantities in the 1998-1999 time frame.

ISO standard 3.5" drives have 128 or 230 megabytes per side, with 640 megabyte and 650 megabyte drives moving into production in 1996. A general increase to the 640 megabyte per side range is anticipated in the 1996 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 to the 1.3 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.

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. The PD drive, a 650 megabyte rewritable phase

change drive with CD-ROM read capability began shipping in 1995 from Matsushita and NEC. While inferior to rigid magnetic drives in performance, it appears to be winning a role as an auxiliary storage and data exchange and backup device. Companies producing CD format drives have indicated that they expect to ship rewritable drives (CD-E) 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. Recordable CD format drives (CD-R) using dye based media have been in production since 1992.

Individual firms working on other proposed reversible optical recording technologies have yet to overcome technical problems that include slow completion of the reversal cycle, degradation of stored data with the passage of time, sensitivity to ambient light, limitations on the number of reversals which may be accomplished before degradation, temperature sensitivity, expensive optical or laser components, poor shelf life, 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 mainstream, but will be replaced by 8X drives now being introduced by several firms. The next generation of CD-ROM drives, DVD drives, will extend capacity to the multigigabyte range in late 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 in 1998 or later as additional technical, copyright and other legal 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. Rewritable CD format drives could take

the place of some rigid disk drives in an auxiliary storage or data exchange and distribution role. 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 serious threats to magnetic rigid drives in the near term.

* High capacity flexible disk drives: The 5.25" Bernoulli disk drives offered by Iomega reached 230 megabytes in capacity and competed for a while with removable 5.25" rigid cartridge disk drives, but are now phasing out. Iomega and licensee Seiko Epson are producing the highly successful 100 megabyte Zip drive, and this technology is potentially extendible to the 200 megabyte range and beyond.

  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 limited acceptance, especially in the aftermarket. The older floptical 20 megabyte drive is now being displaced 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 will be backward compatible with 1.44 megabyte floppy drives. Other firms are also expected to offer high capacity flexible drives in 1996.

  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

Ever since 1956, when the RAMAC, the first moving head rigid magnetic disk drive, was shipped by IBM, the highly competitive rigid disk drive industry has been characterized by continuous and rapid improvement in product technology. IBM provided disk drive product development 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 product leader in the late 1980's, with new families of 2.5", 3.5" and 5.25" drives. IBM has maintained a leading position in early implementation of high recording densities in new drive models. The "Scorpion" series of high-end 3.5" disk drives set the

pattern for the current generation of high-end 3.5" drives, and during the last few years IBM's 2.5" drives have utilized the industry's highest areal densities. The current champion is the "Crescendo" 2.5" drive at 1,316 megabits per square inch. 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 are discussed below.

* Head flying height: Because head flying height determines the achievable areal density, reductions are of critical importance. Head flying height is in the 2 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. However, this technique appears costly and has not been well accepted by drive manufacturers.

IBM's "tail dragging" approach suspended 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. The tail dragger has evolved into a series of virtual contact heads, variously called "Tri-pad" or "Proximity recording heads" by various manufacturers. These heads, which fly at 1.5 microinches or less, are extending the product life of inductive thin film heads.

* 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, but ferrite heads are phasing out as areal density increases favor the use of 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 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. A limited use of sub-30% sliders is anticipated to begin in 1996. 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. The very low flying heights now required also required improvements in head wear resistance. A diamond like carbon overcoating for the head first used by IBM is now used by many producers to improve head life and reduce stiction.

  Head suspensions have become a challenging design area as slider form factors continue to shrink and MR heads, which require more wires, become increasingly prevalent. Expected improvements include the incorporation of connecting leads and head bonding pads within the structure of the suspension itself. While stainless steel remains the current

material of choice for suspensions, other materials such as ceramics or silicon are being investigated.

The ability of inductive and magnetoresistive 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.

Magnetoresistive heads are now in use in both high performance and small form factor drives. While internally generated noise, vulnerability to electrostatic discharge and low yield still remain challenges, MR heads are now available from at least 9 vendors, with many also produced by drive manufacturers such as IBM, Quantum, Fujitsu and Seagate.

IBM introduced the first 3.5" disk drives using MR heads in 1991, using them 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. 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 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. 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. Hydrogenated carbon is the most favored overcoat material. The emergence of virtual contact recording has created pressure to improve the durability of the thin overcoatings.

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 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.

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 also 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, 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. (3.5" and larger drives have continued to use aluminum substrates.) 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, aluminum-boron-carbide 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 7,000 TPI. IBM's "Crescendo" 2.5" drive operates at 8,600 TPI, while the 3.5" "Aquarius" 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" "Crescendo" operates at 153,000 BPI, approximately the same as IBM's 1989 laboratory demo. 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. It is interesting to note that the areal densities of IBM's newer 2.5" drives exceed the areal densities of IBM's 3.5" drive family.

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. As areal densities of longitudinal recording approach the superparamagnetic limit (expected to be reached between 2000 and 2005), interest in perpendicular recording is likely to revive because it appears to be able to support higher areal densities than longitudinal 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. Disk drive arrays are usually implemented with specialized controllers and software, but some arrays achieve low cost by using software to control array functionality and minimize hardware content. This approach lowers cost, but performance usually suffers. Arrays are available for a variety of systems, ranging from PC's serving as file servers to 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-6. The RAID nomenclature, which derives from papers published by the University of California, Berkeley, has been formally defined only up to the RAID-6 level, but various firms offer advanced redundant architectures informally defined with RAID designations of their own invention. 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 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 $7 billion 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.

  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 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 megahertz in read channel bandwidth. One of the fastest read channels is offered by Silicon Systems, which specifies operation at up to 200 megahertz. As areal densities approach 10 gigabits per second, channel data rates are expected to require 400 to 500 megahertz data channels. While PRML channels are fast, they also require significant power, making them less desirable in small drives destined for use in notebook computers, although aggressive power management strategies can minimize the average power required.

  The use of parallel data 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. In 1995 Gigastorage International announced a single platter 1.1 gigabyte 5.25" drive, and in 1996 Quantum announced "Bigfoot", a family of one and two platter 5.25" drives with capacities of a 1.2 and 2.2 gigabytes, taking advantage of minimal parts count and the larger surface area of the disk to obtain a lower cost per megabyte. Depending on the ferocity of the competitive response, such drives may have the potential to be shipped in large numbers over the next few 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 functions may also be shut down when the drive is inactive. A related need is for the drive to quickly come up to operating speed when needed. A few designs incorporate ramp loading of heads, enabling removal of the heads from disk contact when the drive spins down. The removal of head drag on the disk enables the drive to spin up faster with less power demand and lessens the danger of a stiction caused malfunction.

  The voltage required by the drive is also a factor. In 1996, 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 trans-

fer 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 beginning to appear in product announcements. (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 interface 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, supported by IBM, Conner, Micropolis, Dell, Adaptec and many others seemed destined for a major role in large and midrange systems, but the market has been reluctant to perceive 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, while Apple and video equipment producers have been the most visible supporters of P1394. SSA, which was earliest to appear in drives and controllers, and FC-AL were announced in 1995, with the choice made by the

system integrator dependent upon the application and processing platform selected. With the acquisition of Conner by Seagate Technology and the sale of the Micropolis disk drive operation to Singapore Technologies, wide industry support for SSA has been called into question, and Fibre Channel now appears to be the serial interface of choice for most system producers.

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. Intelligent controllers can also provide indications of impending drive failure to a system, permitting an orderly replacement of the drive with minimum disruption to operations.

* 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 are expected to 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/Distributor 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/Distributor 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 Fujitsu 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/Distributor shipments are included in the noncaptive sales channel.

Examples:

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

* Shipments made by Quantum or Western Digital are noncaptive.

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

Examples:

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

* On an arbitrary basis, disk drives manufactured by Fujitsu or Hitachi and resold in the PCM/Distributor market by other companies are included in PCM/Distributor 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 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 Seagate or Western Digital 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: Disk drive 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 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/Distributor or OEM/Integrator levels. All prices are in 1996 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 which are 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/midrange 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.

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DISK CARTRIDGE DRIVES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

SyQuest Technology	SQ5200C

3.5" disk diameter

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

2.5" disk diameter

Avatar Systems	AR-2170

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

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

Avatar Systems' 2.5" disk cartridge drives, including models combining removable disk drives with floppy drives, have been available in limited production quantities since 1993, with volume production now under way at the company's new Thailand plant. SyQuest also initiated a 2.5" disk cartridge drive program, with initial shipments in 1993, but has since discontinued the product. In

addition, SyQuest placed considerable emphasis on development of an 80 megabyte drive in a PCMCIA Type III PC Card format, using 1.8" disks in a cartridge which could be removed from the removable drive. However, the 1.8" project was dropped in early 1996.

Market status

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

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

There is also a vigorous contest between 3.5" rigid disk cartridge drives and 3.5" magneto-optic drives, but the 3.5" rigid disk cartridge drives appear to be holding their own in this contest. Both types of drives are experiencing excellent growth in shipments, but rigid disk cartridge drives remain at higher shipment

levels, due to lower prices and continuing increases in the disk capacities available. 3.5" MO drives, however, have made progress in displacing 5.25" rigid disk cartridge drives in some professional and business applications, with increasing capacities and more competitive prices.

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

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

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

Marketing trends

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

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

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

of the planned new high capacity rigid disk cartridge drives may have a similar opportunity to develop specialized OEM markets.

Technical trends

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

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

Forecasting assumptions

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

TABLE 14

CARTRIDGE DISK DRIVES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast							
	1996		1997		1998		1999			
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	98.1	150.1	232.9	318.0	480.8	686.1	634.8	905.1	723.5	1,030.8
OEM/Integrator	2.2	3.5	26.8	77.9	74.4	140.4	110.5	201.6	139.0	246.4
TOTAL U.S. NONCAPTIVE	100.3	153.6	259.7	395.9	555.2	826.5	745.3	1,106.7	862.5	1,277.2
TOTAL U.S. REVENUES	100.3	153.6	259.7	395.9	555.2	826.5	745.3	1,106.7	862.5	1,277.2
Non-U.S. Manufacturers										
PCM/Distributor	--	1.2	21.0	52.5	20.9	70.8	36.8	102.9	44.7	127.4
OEM/Integrator	--	--	--	--	--	6.3	1.4	11.3	3.8	16.4
TOTAL NON-U.S. REVENUES	--	1.2	21.0	52.5	20.9	77.1	38.2	114.2	48.5	143.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	100.3	154.8	280.7	448.4	576.1	903.6	783.5	1,220.9	911.0	1,421.0
OEM Average Price ($000)		.291		.230		.232		.219		.202

TABLE 15

CARTRIDGE DISK DRIVES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
PCM/Distributor	387.2	592.3	975.0	1,355.0	1,760.0	2,510.0	2,540.0	3,620.0	3,195.0	4,550.0
OEM/Integrator	7.5	12.0	115.0	338.0	310.0	610.0	490.0	930.0	675.0	1,235.0
TOTAL U.S. NONCAPTIVE	394.7	604.3	1,090.0	1,693.0	2,070.0	3,120.0	3,030.0	4,550.0	3,870.0	5,785.0
TOTAL U.S. SHIPMENTS	394.7	604.3	1,090.0	1,693.0	2,070.0	3,120.0	3,030.0	4,550.0	3,870.0	5,785.0
Non-U.S. Manufacturers										
PCM/Distributor	--	2.0	50.0	125.0	65.0	220.0	125.0	350.0	165.0	470.0
OEM/Integrator	--	--	--	--	--	20.0	5.0	40.0	15.0	65.0
TOTAL NON-U.S. SHIPMENTS	--	2.0	50.0	125.0	65.0	240.0	130.0	390.0	180.0	535.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	394.7	606.3	1,140.0	1,818.0	2,135.0	3,360.0	3,160.0	4,940.0	4,050.0	6,320.0
Total Capacity (Terabytes)	67.8	104.8	719.8	1,002.0	1,535.3	2,303.8	3,438.7	5,134.5	5,996.7	9,035.0
Cumulative Shipments (Units in millions)										
WORLDWIDE TOTAL	2.5	4.1	3.7	5.9	5.8	9.3	9.0	14.2	13.0	20.5

TABLE 16

CARTRIDGE DISK DRIVES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

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

TABLE 17

CARTRIDGE DISK DRIVES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

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

TABLE 18

CARTRIDGE DISK DRIVES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS				
Business and professional, single user	406.5	67.1	5,245.6	83.0
WORKSTATIONS				
Engineering and office, single user	199.0	32.8	1,061.8	16.8
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	.6	.1	12.6	.2
Total	606.3	99.9	6,320.0	100.0

TABLE 19

CARTRIDGE DISK DRIVES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

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

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

TABLE 20

CARTRIDGE DISK DRIVES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
SyQuest Technology	172.0	221.0	--	393.0	99.6	264.0	338.0	--	602.0	99.3
Other U.S.	--	.2	1.5	1.7	.4	--	.3	2.0	2.3	.4
Other Non-U.S.	--	--	--	--	--	--	2.0	--	2.0	.3
TOTAL	172.0	221.2	1.5	394.7	100.0	264.0	340.3	2.0	606.3	100.0

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Sagem	MSA 252-200
Sequel	XT-1140, XT-4170

3.5" disk diameter

Fujitsu	M2681S/T**
Hitachi	DK312C-25*
Quantum	270A/S Maverick**
Raymond Engineering	8440

2.5" disk diameter

Areal Technology	A130****, A260***
Fujitsu	M2637S/T***
Quantum	256A/S Daytona****
Toshiba	MK-1724FCV****

1.8" disk diameter

Calluna Technology	CT-260*****
Integral Peripherals	8260PA*****
Momentum Peripherals	130*****, 170*****

*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)

Although numerous manufacturers shipped fixed disk drives with less than 300 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 has forced the withdrawal of drives with larger disks from the market. In the last few years, 3.5" and 2.5" drives also found rapidly shrinking markets below 300 megabytes, due to the current demand for the higher capacities required for most applications, and the continually dropping prices for disk drives with higher capacities. 1996 is expected to be the last year of shipments for 3.5" disk drives in this product group,

and with production of 2.5" drives ending in 1997. 1.8" disk drives are the only group forecasted to remain in production through 1999, but with declining shipments.

This product group represents the consolidation of the three groups utilized in last year's DISK/TREND Report for fixed disk drives with less than 300 megabytes. Unit shipments for this product group peaked in 1994, as the personal computer market's continually increasing requirements for higher storage capacities created a new market for 3.5" 200-300 megabyte drives at the beginning of the 1990's, while the notebook computer market stimulated the introduction of 2.5" drives in this capacity range in 1992. Most major drive manufacturers offered 3.5" drives using two disks in this capacity range until three 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

Fixed disk drives with capacities less than 300 megabytes dominated 1994 worldwide disk drive shipments, with 31.8 million units, but since last year the group's shipment level has been down sharply. 1995 shipments were down 81.2%, at less than 6 million drives, and the total for 1996 is expected to be less than one million drives.

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 variety of applications, including graphics, games, multimedia, and downloads from the Internet. The result of falling shipments has been a rapid decline in revenues for drives with less than 300 megabytes capacity, with 1996 estimated at only $169.3 million.

Business personal computers, including notebook computers, produced 86.5% of 1995's worldwide unit shipments, trailed by 12.6% of shipments for consumer computer applications. Applications for the product group in 1999 are expected to reflect the fact that 1.8" drives are forecasted to provide all of the 1999 shipments for this product group. In 1999, the personal computer market is expected to consume only 18% of the group's shipments, while consumer computers take 25%, and 52% are used in other specialized applications.

Quantum again increased its share of the noncaptive shipments of drives with less than 300 megabytes capacity in 1995, with 36.3% of the worldwide total. Seagate Technology held second with 16.3%, and Conner Peripherals dropped to third with 14.2%.

Marketing trends

As shipments of 3.5" drives end in 1996 and 2.5" drives reach the end of life in 1997, 1.8" drives are expected to be the only survivors in the less than 300 megabyte product group by the end of the forecast period.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
5.25"	7.6	2.0	--	--	--
	.1%	.2%	--	--	--
3.5"	4,406.7	438.8	--	--	--
	73.8%	50.7%	--	--	--
2.5"	1,163.3	190.0	35.0	--	--
	19.5%	22.0%	15.2%	--	--
1.8" or less	392.8	235.0	195.0	110.0	70.0
	6.6%	27.0%	84.8%	100.0%	100.0%
Total	5,970.4	865.3	230.0	110.0	70.0

The rapid movement to higher capacities for 3.5" and 2.5" drives, combined with more demanding software and enhanced user appetite for new applications, have prompted both manufacturers and users of notebook computers and desktop personal computers to abandon the 3.5" and 2.5" disk drives in this product group. The only remaining participants in the product group are expected to be 1.8" PC Card drives.

1.8" drives with disks 1.8" or less enjoyed increasing shipments in the less than 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 392,800 drives (including close-out shipments of 1.3" drives) are expected to drop to 235,000 1.8" drives in 1996, with the decline continuing, down to 70,000 in 1999.

Clearly, the market currently available to 1.8" drives has been 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 1996, the average OEM/Integrator price per megabyte for 1.8" drives in this product group is estimated at 83 cents, while the average for 2.5" drives is 60 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 capacities in the group's range, 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 1996, as the industry's recording densities move up. At one time, it was expected that the manufacturers of 1.8" drives would undertake the investment required to move to 5 millimeter thick Type II PC Card drives. However, with the notebook computer market demanding higher capacities than it is practical to offer in 1.8"

PC Card formats in the next few years, drive manufacturer's plans for Type II cards have apparently been shelved for now.

Forecasting assumptions

1. Shipments of 3.5" drives in this capacity group will end in 1996, and shipments of 2.5" drives will end in 1997.
2. Shipments of 1.8" Type III PC Card drives will peak in 1996, 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 expected that they will be introduced.

TABLE 21

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	33.3	48.1	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	33.3	48.1	--	--	--	--	--	--	--	--
PCM/Distributor	64.6	164.4	9.4	16.5	4.4	7.7	2.0	4.0	1.6	3.0
OEM/Integrator	275.2	534.5	29.4	65.1	11.1	22.7	5.5	10.1	2.6	4.3
TOTAL U.S. NONCAPTIVE	339.8	698.9	38.8	81.6	15.5	30.4	7.5	14.1	4.2	7.3
TOTAL U.S. REVENUES	373.1	747.0	38.8	81.6	15.5	30.4	7.5	14.1	4.2	7.3
Non-U.S. Manufacturers										
Captive	23.2	145.9	10.0	44.3	--	--	--	--	--	--
PCM/Distributor	3.1	10.3	2.8	8.8	.7	4.5	.4	3.1	.4	2.9
OEM/Integrator	11.5	87.9	1.1	34.6	1.0	9.9	.6	3.8	.4	2.7
TOTAL NON-U.S. REVENUES	37.8	244.1	13.9	87.7	1.7	14.4	1.0	6.9	.8	5.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	410.9	991.1	52.7	169.3	17.2	44.8	8.5	21.0	5.0	12.9
OEM Average Price ($000)		.143		.158		.186		.185		.175

TABLE 22

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	90.0	130.0	--	--	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	90.0	130.0	--	--	--	--	--	--	--	--
PCM/Distributor	456.0	1,197.0	48.0	95.0	20.0	35.0	10.0	20.0	8.0	15.0
OEM/Integrator	1,999.3	3,851.8	187.9	436.0	57.0	120.0	30.0	55.0	15.0	25.0
TOTAL U.S. NONCAPTIVE	2,455.3	5,048.8	235.9	531.0	77.0	155.0	40.0	75.0	23.0	40.0
TOTAL U.S. SHIPMENTS	2,545.3	5,178.8	235.9	531.0	77.0	155.0	40.0	75.0	23.0	40.0
Non-U.S. Manufacturers										
Captive	40.0	235.4	20.0	85.5	--	--	--	--	--	--
PCM/Distributor	22.0	65.0	24.0	54.0	3.0	20.0	2.0	15.0	2.0	15.0
OEM/Integrator	66.7	491.2	5.0	194.8	5.0	55.0	3.0	20.0	2.0	15.0
TOTAL NON-U.S. SHIPMENTS	128.7	791.6	49.0	334.3	8.0	75.0	5.0	35.0	4.0	30.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	2,674.0	5,970.4	284.9	865.3	85.0	230.0	45.0	110.0	27.0	70.0
Total Capacity (Terabytes)	681.7	1,525.9	74.4	222.4	22.1	59.9	11.7	28.6	7.0	18.2
Cumulative Shipments (Units in millions)										
IBM	16.1	23.6	16.1	23.6	16.1	23.6	16.1	23.6	16.1	23.6
Non-IBM	116.2	217.3	116.5	218.1	116.6	218.4	116.6	218.5	116.6	218.5
WORLDWIDE TOTAL	132.3	240.9	132.6	241.8	132.7	242.0	132.7	242.1	132.7	242.2

TABLE 23

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues				Forecast							
					1996				1997		1998	1999
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	2.5"	<=1.8"	<=1.8"	<=1.8"
U.S. MANUFACTURERS												
IBM Captive	--	28.1	20.0	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	120.6	34.6	9.2	--	4.9	2.0	9.6	--	7.7	4.0	3.0
OEM/Integrator	5.0	372.5	80.4	76.6	1.0	29.5	5.5	29.1	2.0	20.7	10.1	4.3
TOTAL U.S. REVENUES	5.0	521.2	135.0	85.8	1.0	34.4	7.5	38.7	2.0	28.4	14.1	7.3
NON-U.S. MANUFACTURERS												
Captive	.2	70.1	75.4	.2	--	8.9	35.0	.4	--	--	--	--
PCM/Distributor	--	3.1	4.2	3.0	--	1.3	2.3	5.2	--	4.5	3.1	2.9
OEM/Integrator	1.3	46.1	39.1	1.4	1.3	17.0	8.6	7.7	2.8	7.1	3.8	2.7
TOTAL NON-U.S. REVENUES	1.5	119.3	118.7	4.6	1.3	27.2	45.9	13.3	2.8	11.6	6.9	5.6
WORLDWIDE RECAP												
Captive	.2	98.2	95.4	.2	--	8.9	35.0	.4	--	--	--	--
	-92.3%	-77.7%	-63.9%	-60.0%	--	-90.9%	-63.3%	+100.0%	--	--	--	--
PCM/Distributor	--	123.7	38.8	12.2	--	6.2	4.3	14.8	--	12.2	7.1	5.9
	--	-87.5%	-39.6%	+90.6%	--	-95.0%	-88.9%	+21.3%	--	-17.6%	-41.8%	-16.9%
OEM/Integrator	6.3	418.6	119.5	78.0	2.3	46.5	14.1	36.8	4.8	27.8	13.9	7.0
	-55.0%	-82.2%	-84.7%	+67.4%	-63.5%	-88.9%	-88.2%	-52.8%	-66.0%	-24.5%	-50.0%	-49.6%
Total Revenues	6.5	640.5	253.7	90.4	2.3	61.6	53.4	52.0	4.8	40.0	21.0	12.9
	-63.5%	-83.0%	-77.1%	+69.0%	-64.6%	-90.4%	-79.0%	-42.5%	-91.0%	-23.1%	-47.5%	-38.6%
ANNUAL SHARE, BY DIAMETER	.7%	64.7%	25.6%	9.0%	1.4%	36.5%	31.5%	30.6%	10.7%	89.3%	100.0%	100.0%

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

TABLE 24

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments				Forecast							
					1996				1997		1998	1999
	5.25"	3.5"	2.5"	<=1.8"	5.25"	3.5"	2.5"	<=1.8"	2.5"	<=1.8"	<=1.8"	<=1.8"
U.S. MANUFACTURERS												
IBM Captive	--	80.0	50.0	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	941.0	217.0	39.0	--	40.0	15.0	40.0	--	35.0	20.0	15.0
OEM/Integrator	6.3	2,990.0	521.5	334.0	1.0	260.0	40.0	135.0	15.0	105.0	55.0	25.0
TOTAL U.S. SHIPMENTS	6.3	4,011.0	788.5	373.0	1.0	300.0	55.0	175.0	15.0	140.0	75.0	40.0
NON-U.S. MANUFACTURERS												
Captive	.1	104.8	130.0	.5	--	14.5	70.0	1.0	--	--	--	--
PCM/Distributor	--	28.0	25.0	12.0	--	15.0	15.0	24.0	--	20.0	15.0	15.0
OEM/Integrator	1.2	262.9	219.8	7.3	1.0	108.8	50.0	35.0	20.0	35.0	20.0	15.0
TOTAL NON-U.S. SHIPMENTS	1.3	395.7	374.8	19.8	1.0	138.3	135.0	60.0	20.0	55.0	35.0	30.0
WORLDWIDE RECAP												
Captive	.1	184.8	180.0	.5	--	14.5	70.0	1.0	--	--	--	--
	-92.3%	-85.6%	-66.0%	-58.3%	--	-92.2%	-61.1%	+100.0%	--	--	--	--
PCM/Distributor	--	969.0	242.0	51.0	--	55.0	30.0	64.0	--	55.0	35.0	30.0
	--	-86.9%	-27.1%	+86.8%	--	-94.3%	-87.6%	+25.5%	--	-14.1%	-36.4%	-14.3%
OEM/Integrator	7.5	3,252.9	741.3	341.3	2.0	368.8	90.0	170.0	35.0	140.0	75.0	40.0
	-68.1%	-82.0%	-81.3%	+65.0%	-73.3%	-88.7%	-87.9%	-50.2%	-61.1%	-17.6%	-46.4%	-46.7%
Total Shipments	7.6	4,406.7	1,163.3	392.8	2.0	438.3	190.0	235.0	35.0	195.0	110.0	70.0
	-75.0%	-83.5%	-75.9%	+66.9%	-73.7%	-90.1%	-83.7%	-40.2%	-81.6%	-17.0%	-43.6%	-36.4%
ANNUAL SHARE, BY DIAMETER	.1%	73.9%	19.5%	6.5%	.2%	50.8%	22.0%	27.0%	15.2%	84.8%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	.5	1,179.5	283.5	62.4	.1	116.9	46.8	58.6	9.3	50.7	28.6	18.2

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

TABLE 25

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS				
Business and professional, single user	5,166.8	86.5	12.6	18.0
WORKSTATIONS				
Engineering and office, single user	17.9	.3	4.2	6.0
CONSUMER, GAME AND HOBBY COMPUTERS	749.9	12.6	16.8	24.0
OTHER APPLICATIONS	35.8	.6	36.4	52.0
Total	5,970.4	100.0	70.0	100.0

TABLE 26

FIXED DISK DRIVES, LESS THAN 300 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
5.25"	--	--	--	--	--
3.5"	2.16	2.78	--	--	--
2.5"	2.42	2.17	--	--	--
1.8" or less	--	--	--	--	--
Captive Average	2.28	2.29	--	--	--
PCM/Distributor					
5.25"	--	--	--	--	--
3.5"	.46	.42	--	--	--
2.5"	.61	.56	--	--	--
1.8" or less	1.52	1.03	.85	.78	.75
PCM/Distributor Average	.51	.69	.85	.78	.75
OEM/Integrator					
5.25"	3.51	7.66	--	--	--
3.5"	.48	.47	--	--	--
2.5"	.65	.60	.51	--	--
1.8" or less	1.43	.83	.76	.70	.66
OEM/Integrator Average	.56	.59	.71	.70	.66

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 300 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	3.5"	2.5"	<=1.8"	Total		5.25"	3.5"	2.5"	<=1.8"	Total	
Quantum	--	672.0	140.0	--	812.0	31.9	--	1687.0	348.0	--	2035.0	36.3
Seagate Technology	--	236.0	123.0	--	359.0	14.1	--	567.0	348.0	--	915.0	16.3
Conner Peripherals	--	415.0	--	--	415.0	16.3	--	794.0	2.5	--	796.5	14.2
Maxtor	--	247.0	--	18.0	265.0	10.4	--	450.0	--	29.0	479.0	8.5
Western Digital	--	365.0	29.0	--	394.0	15.5	--	413.0	40.0	--	453.0	8.1
Integral Peripherals	--	--	--	132.0	132.0	5.2	--	--	--	240.0	240.0	4.3
Fujitsu	--	--	.7	--	.7	--	1.1	213.3	16.8	--	231.2	4.1
Toshiba	--	--	52.0	--	52.0	2.0	--	--	155.0	--	155.0	2.8
Other U.S.	5.3	10.0	--	63.0	78.3	3.1	6.3	20.0	--	104.0	130.3	2.3
Other Non-U.S.	--	10.0	26.0	--	36.0	1.5	.1	77.6	73.0	19.3	170.0	3.1
TOTAL	5.3	1955.0	370.7	213.0	2544.0	100.0	7.5	4221.9	983.3	392.3	5605.0	100.0

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

FIXED DISK DRIVES, 300 - 500 MEGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, 300 - 500 MEGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Sequel	XT-4380E/S

3.5" disk diameter

Fujitsu	M2622S/T*, MK2682S/T**
Quantum	365A/S**, 420A/S**
Raymond Engineering	84300
Seagate Technology	ST3491A**

2.5" disk diameter

Areal Technology	A345L****, A340***
Quantum	341A/S Daytona***
Seagate Technology	ST9420AG****
Toshiba	MK-1824****

1.8" disk diameter

Calluna Technology	CT-390MC*****
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" disk 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

Shipments in the 300-500 megabyte disk drive product group peaked in 1994, with 19.2 million drives. This group never became the industry leader in unit shipments, as the personal computer industry's ravenous appetite for disk storage was so great that leadership in disk drive shipments jumped in one year from the 200-300 megabyte product group to the 500 megabyte-1 gigabyte range, skipping over this product group. 1995 worldwide shipments were 12.9 million drives, a decline of 33.1%, and 1996 total shipments are projected to drop to 1.6 million drives. 1995 sales revenues were down 48.3%, at $2.1 billion, and are forecasted to reach a total of only $249.4 million in 1996, a further decline of 88.5%.

In addition to the sharp drop in shipments caused by changing personal computer markets, the group's sales revenues were also undercut by declining prices. The OEM/Integrator average price per megabyte for 3.5" drives, currently the group's dominant product, sagged from $1.69 in 1992 to 79 cents in 1993, to 46 cents in 1994, to 32 cents in 1995, and to an estimated 29 cents in 1996. 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 1995, 99.8% of the disk drives in the 300-500 megabyte capacity range were used for business personal computers or home 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 1999, the continuing movement to higher capacities for 3.5" and 2.5" drives used for personal computer, home computer and notebook computer applications will leave 1.8" drives with all of the remaining shipments for the product group. In 1999, business personal computers and home computers will decline to 58% of overall 300-500 megabyte drive shipments, with the rest in a variety of workstation and specialized industrial applications.

The market for 300-500 megabyte drives was dominated in recent years by desktop personal computer applications, with the result that 3.5" drives led the product group's shipments. During the 1995-96 period, 3.5" drives are still in the lead, but shipments are in a free-fall status: 1995 3.5" drive shipments dropped 40.2%, to 10.1 million drives, and the 1996 total is projected at only 1.3 million units, down another 86.9%. Shipments of 2.5" drives were still increasing in 1995, up 15.2%, with 2.9 million units. However, the trend to higher capacities has also affected the notebook computer market, the application in which most 2.5" drives are used. 2.5" drive shipments in this capacity range are collapsing in 1996, with the total forecasted at 132,000 drives, down 95.3%. Only 1.8" drives are currently enjoying growth in shipments in this capacity range, up from 26,000 in 1995 to 130,000 in 1996.

Seagate Technology assumed the lead in noncaptive 1995 shipments in this product group with 23.7% of the worldwide total, combining shipments of both 3.5" and 2.5" drives. Quantum rose to second place with 21.3%, and Conner Peripherals dropped to third with 20.4%.

Marketing trends

As 3.5" single disk drives with 540 megabytes capacity achieved high production levels in the product lines of all major disk drive manufacturers in 1995, it

became inevitable that shipments in the 300-500 megabyte product group would have to drop. 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. 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)	1995	1996	1997	1998	1999
5.25"	4.1	1.5	--	--	--
		.1%	--	--	--
3.5"	10,053.2	1,316.1	375.0	--	--
	78.2%	83.3%	49.3%	--	--
2.5"	2,780.5	132.0	15.0	--	--
	21.6%	8.4%	2.0%	--	--
1.8" PCMCIA Type III	26.0	130.0	370.0	540.0	450.0
	.2%	8.2%	48.7%	100.0%	100.0%
Total	12,863.8	1,579.6	760.0	540.0	450.0

1997 is expected to be the last year of shipments for 3.5" and 2.5" drives in this product group, as both are replaced in all of their applications by drives with higher capacities. On the other hand, 1.8" drive shipments are not being driven by either the desktop personal computer or notebook computer markets, but by a variety of specialized applications ranging from Japanese word processors to pen-based computers. Since the total storage requirements for these markets is still growing, 1.8" drives are expected to enjoy continued growth through 1998, reaching a projected level of 540,000 drives. By 1999, the appetite for higher capacities is expected to affect even the markets for 1.8" drives, with a shipment decline to 450,000 units forecasted.

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 next year or two. 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" and 2.5" drives will be shipped for the last time in 1997, as desktop personal computers and notebook computers move to higher disk drive capacities.
2. Shipments of 1.8" drives will continue to grow through 1998, with negligible penetration of notebook computer markets, plus a variety of workstation and industrial applications.

TABLE 28

FIXED DISK DRIVES, 300 - 500 MEGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	156.3	232.1	12.9	21.5	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	156.3	232.1	12.9	21.5	--	--	--	--	--	--
PCM/Distributor	183.3	431.6	27.4	59.5	12.2	21.5	8.4	10.8	6.8	9.1
OEM/Integrator	628.3	1,065.1	75.3	138.1	62.7	107.4	58.3	96.8	44.7	74.1
TOTAL U.S. NONCAPTIVE	811.6	1,496.7	102.7	197.6	74.9	128.9	66.7	107.6	51.5	83.2
TOTAL U.S. REVENUES	967.9	1,728.8	115.6	219.1	74.9	128.9	66.7	107.6	51.5	83.2
Non-U.S. Manufacturers										
Captive	24.0	202.2	2.1	13.8	--	--	--	--	--	--
PCM/Distributor	15.0	32.2	--	--	--	1.4	.5	2.5	.7	1.9
OEM/Integrator	84.8	214.1	1.6	16.5	1.4	6.4	4.5	10.2	3.2	7.8
TOTAL NON-U.S. REVENUES	123.8	448.5	3.7	30.3	1.4	7.8	5.0	12.7	3.9	9.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,091.7	2,177.3	119.3	249.4	76.3	136.7	71.7	120.3	55.4	92.9
OEM Average Price ($000)		.146		.143		.182		.220		.203

TABLE 29

FIXED DISK DRIVES, 300 - 500 MEGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995		Forecast							
	Shipments		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	350.0	520.0	30.0	50.0	--	--	--	--	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	350.0	520.0	30.0	50.0	--	--	--	--	--	--
PCM/Distributor	1,242.7	2,915.2	180.4	420.5	65.0	130.0	35.0	45.0	30.0	40.0
OEM/Integrator	4,423.0	7,484.0	530.0	976.0	340.0	590.0	265.0	440.0	220.0	365.0
TOTAL U.S. NONCAPTIVE	5,665.7	10,399.2	710.4	1,396.5	405.0	720.0	300.0	485.0	250.0	405.0
TOTAL U.S. SHIPMENTS	6,015.7	10,919.2	740.4	1,446.5	405.0	720.0	300.0	485.0	250.0	405.0
Non-U.S. Manufacturers										
Captive	50.0	437.3	5.0	32.0	--	--	--	--	--	--
PCM/Distributor	112.0	237.0	--	--	--	5.0	2.0	10.0	3.0	8.0
OEM/Integrator	521.1	1,270.3	12.5	101.1	7.0	35.0	20.0	45.0	15.0	37.0
TOTAL NON-U.S. SHIPMENTS	683.1	1,944.6	17.5	133.1	7.0	40.0	22.0	55.0	18.0	45.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	6,698.8	12,863.8	757.9	1,579.6	412.0	760.0	322.0	540.0	268.0	450.0
Total Capacity (Terabytes)	2,710.7	5,170.2	314.2	653.6	156.3	291.0	119.1	199.8	109.8	184.5
Cumulative Shipments (Units in millions)										
IBM	2.6	3.8	2.7	3.9	2.7	3.9	2.7	3.9	2.7	3.9
Non-IBM	20.8	39.3	21.5	40.9	21.9	41.6	22.2	42.2	22.5	42.6
WORLDWIDE TOTAL	23.5	43.2	24.2	44.8	24.6	45.5	25.0	46.1	25.2	46.5

TABLE 30

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues				1996 Forecast				1997 Forecast			1998 Forecast	1999 Forecast
	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS													
IBM Captive	--	42.0	190.1	--	--	--	21.5	--	--	--	--	--	--
PCM/Distributor	2.6	348.8	79.2	1.0	.6	49.7	1.6	7.6	11.0	--	10.5	10.8	9.1
OEM/Integrator	--	912.5	145.6	7.0	--	103.0	6.2	28.9	31.3	1.4	74.7	96.8	74.1
TOTAL U.S. REVENUES	2.6	1,303.3	414.9	8.0	.6	152.7	29.3	36.5	42.3	1.4	85.2	107.6	83.2
NON-U.S. MANUFACTURERS													
Captive	--	111.3	90.9	--	--	5.4	8.4	--	--	--	--	--	--
PCM/Distributor	--	24.0	8.2	--	--	--	--	--	--	--	1.4	2.5	1.9
OEM/Integrator	2.8	54.5	156.8	--	1.5	12.6	2.4	--	1.7	1.0	3.7	10.2	7.8
TOTAL NON-U.S. REVENUES	2.8	189.8	255.9	--	1.5	18.0	10.8	--	1.7	1.0	5.1	12.7	9.7
WORLDWIDE RECAP													
Captive	--	153.3	281.0	--	--	5.4	29.9	--	--	--	--	--	--
	--	-72.9%	-40.5%	--	--	-96.5%	-89.4%	--	--	--	--	--	--
PCM/Distributor	2.6	372.8	87.4	1.0	.6	49.7	1.6	7.6	11.0	--	11.9	13.3	11.0
	+30.0%	-57.7%	+251.0%	--	-76.9%	-86.7%	-98.2%	+660.0%	-77.9%	--	+56.6%	+11.8%	-17.3%
OEM/Integrator	2.8	967.0	302.4	7.0	1.5	115.6	8.6	28.9	33.0	2.4	78.4	107.0	81.9
	-80.6%	-47.7%	-22.9%	--	-46.4%	-88.0%	-97.2%	+312.9%	-71.5%	-72.1%	+171.3%	+36.5%	-23.5%
Total Revenues	5.4	1,493.1	670.8	8.0	2.1	170.7	40.1	36.5	44.0	2.4	90.3	120.3	92.9
	-73.1%	-54.7%	-24.6%	--	-61.1%	-88.6%	-94.0%	+356.3%	-74.2%	-94.0%	+147.4%	+33.2%	-22.8%
ANNUAL SHARE, BY DIAMETER	.2%	68.7%	30.8%	.3%	.8%	68.5%	16.1%	14.6%	32.3%	1.8%	65.9%	100.0%	100.0%

TABLE 31

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments				Forecast 1996				1997			1998	1999
	5.25"	3.5"	2.5"	1.8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	1.8"	1.8"
U.S. MANUFACTURERS													
IBM Captive	--	120.0	400.0	--	--	--	50.0	--	--	--	--	--	--
PCM/Distributor	2.2	2,496.0	414.0	3.0	.5	385.0	10.0	25.0	90.0	--	40.0	45.0	40.0
OEM/Integrator	--	6,655.0	806.0	23.0	--	831.0	40.0	105.0	270.0	10.0	310.0	440.0	365.0
TOTAL U.S. SHIPMENTS	2.2	9,271.0	1,620.0	26.0	.5	1,216.0	100.0	130.0	360.0	10.0	350.0	485.0	405.0
NON-U.S. MANUFACTURERS													
Captive	--	250.5	186.8	--	--	12.0	20.0	--	--	--	--	--	--
PCM/Distributor	--	192.0	45.0	--	--	--	--	--	--	--	5.0	10.0	8.0
OEM/Integrator	1.9	339.7	928.7	--	1.0	88.1	12.0	--	15.0	5.0	15.0	45.0	37.0
TOTAL NON-U.S. SHIPMENTS	1.9	782.2	1,160.5	--	1.0	100.1	32.0	--	15.0	5.0	20.0	55.0	45.0
WORLDWIDE RECAP													
Captive	--	370.5	586.8	--	--	12.0	70.0	--	--	--	--	--	--
	--	-65.7%	-22.6%	--	--	-96.8%	-88.1%	--	--	--	--	--	--
PCM/Distributor	2.2	2,688.0	459.0	3.0	.5	385.0	10.0	25.0	90.0	--	45.0	55.0	48.0
	+4.8%	-47.1%	+378.1%	--	-77.3%	-85.7%	-97.8%	+733.3%	-76.6%	--	+80.0%	+22.2%	-12.7%
OEM/Integrator	1.9	6,994.7	1,734.7	23.0	1.0	919.1	52.0	105.0	285.0	15.0	325.0	485.0	402.0
	-85.9%	-34.3%	+11.2%	--	-47.4%	-86.9%	-97.0%	+356.5%	-69.0%	-71.2%	+209.5%	+49.2%	-17.1%
Total Shipments	4.1	10,053.2	2,780.5	26.0	1.5	1,316.1	132.0	130.0	375.0	15.0	370.0	540.0	450.0
	-75.4%	-40.2%	+15.2%	--	-63.4%	-86.9%	-95.3%	+400.0%	-71.5%	-88.6%	+184.6%	+45.9%	-16.7%
ANNUAL SHARE, BY DIAMETER	--	78.3%	21.6%	.1%	.1%	83.4%	8.4%	8.1%	49.4%	2.0%	48.6%	100.0%	100.0%
TOTAL CAPACITY (Terabytes)	1.5	4,240.7	919.2	8.8	.4	570.4	38.6	44.2	159.4	5.9	125.8	199.8	184.5

TABLE 32

FIXED DISK DRIVES, 300 - 500 MEGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	--	--
PERSONAL COMPUTERS				
Business and professional, single user	11,101.6	86.3	144.0	32.0
WORKSTATIONS				
Engineering and office, single user	25.7	.2	63.0	14.0
CONSUMER, GAME AND HOBBY COMPUTERS	1,731.5	13.5	117.0	26.0
OTHER APPLICATIONS	--	--	126.0	28.0
Total	12,863.9	100.0	450.0	100.0

TABLE 33

FIXED DISK DRIVES, 300 - 500 MEGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
5.25"	--	--	--	--	--
3.5"	1.19	1.28	--	--	--
2.5"	2.13	1.95	--	--	--
1.8"	--	--	--	--	--
Captive Average	1.66	1.80	--	--	--
PCM/Distributor					
5.25"	3.30	6.00	--	--	--
3.5"	.32	.29	.28	--	--
2.5"	.58	.40	--	--	--
1.8"	.99	.89	.77	.65	.55
PCM/Distributor Average	.35	.32	.42	.65	.55
OEM/Integrator					
5.25"	4.01	5.00	--	--	--
3.5"	.32	.29	.27	--	--
2.5"	.47	.44	.40	--	--
1.8"	.89	.80	.71	.59	.49
OEM/Integrator Average	.35	.34	.48	.59	.49

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, 300 - 500 MEGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	5.25"	3.5"	2.5"	1.8"	Total		5.25"	3.5"	2.5"	1.8"	Total	
Seagate Technology	--	1347.0	297.0	--	1644.0	26.1	--	2318.0	499.0	--	2817.0	23.7
Quantum	--	935.0	52.0	--	987.0	15.7	--	2343.0	192.0	--	2535.0	21.3
Conner Peripherals	--	1233.0	111.0	--	1344.0	21.3	--	2199.0	229.0	--	2428.0	20.4
Western Digital	--	1188.0	--	--	1188.0	18.9	--	1621.0	--	--	1621.0	13.6
Toshiba	--	--	237.0	--	237.0	3.8	--	--	685.0	--	685.0	5.8
Maxtor	--	295.0	--	--	295.0	4.7	--	540.0	--	--	540.0	4.5
IBM	--	60.0	120.0	--	180.0	2.9	--	130.0	300.0	--	430.0	3.6
Fujitsu	--	39.3	--	--	39.3	.6	1.3	288.1	--	--	289.4	2.4
Hitachi	--	--	224.5	--	224.5	3.6	--	1.0	265.7	--	266.7	2.2
Samsung Electronics	--	95.0	--	--	95.0	1.5	--	192.0	--	--	192.0	1.6
Other U.S.	1.7	--	--	26.0	27.7	.4	2.2	--	--	26.0	28.2	.2
Other Non-U.S.	--	34.3	3.0	--	37.3	.5	.6	50.6	23.0	--	74.2	.7
TOTAL	1.7	5226.6	1044.5	26.0	6298.8	100.0	4.1	9682.7	2193.7	26.0	11906.5	100.0

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

1996 DISK/TREND REPORT

FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Sequel	XT-8760SH

3.5" disk diameter

Fujitsu	M2684S/T**
Hitachi	DK325C-57**
Maxtor	7850AV**, 7541AP/A**
NEC	D3743**, DSE850A/S**
Quantum	540A/S Lightning**, 540A/S Fireball**
Seagate Technology	ST3660A**, ST3852A***
Western Digital	AC2850**

2.5" - 3" disk diameter

Areal Technology	A520F***
Fujitsu	M2713TAM****
Hitachi	DK211A***, DK222A-54****
IBM	DPRS-20810***, DSOA-20810****
JTS	N0810-2AF/AR*****
Maxtor	250837****
Quantum	540AT Europa****, 810AT Europa***
Seagate Technology	ST9840A****, ST9816AG***
Toshiba	MK-2628***, MK-1926****

1.8" disk diameter

Calluna Technology	CT-520MC*****
Integral Peripherals	8510PA*****

*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 pro-

ducts 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 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, and the IBM Sonata series used only one disk for 540 megabytes, also with a 12.5 millimeter drive height. A new type of disk drive competitor for the notebook computer market 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

As expected, the 500 megabyte - 1 gigabyte capacity range assumed a dominant position in the disk drive industry in 1995 -- the product group's 42.5 million drives constituted 47.5% of the industry's worldwide unit shipments. This achievement provided one of the industry's more remarkable success stories, in that shipments of drives in this capacity range didn't reach a million drives until 1992. However, in the disk drive industry capacity ranges which lead in shipments can normally expect to be succeeded within a year, and that is happening to this product group. Total shipments for the group are forecasted to be down 19.9% in 1996, falling to 34.1 million units. Sales revenues also peaked last year at $9.0 billion, and are projected to decline to $5.5 billion in 1996.

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 all contributing to 1995's notable increase in drive shipments in the 500 megabyte - 1 giga-

byte 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 in this product group dropped from 92 cents in 1993, to 52 cents in 1994, then to 24 cents in 1995, with an average for 1996 projected at only 16 cents.

Shipments of 3.5" drives for desktop personal computer markets were the dominant contributing factor in the product group's 1995 sales success. With the availability of 1" high drives in this capacity range starting in 1992, shipments ramped up rapidly starting in 1994. The same phenomenon started to occur with 2.5" drives in 1995, as drives with 12.5 or 12.7 millimeter heights became available in the product lines of most 2.5" drive manufacturers. 1995 shipments of 2.5" drives in this capacity range jumped 393.9%, reaching 6.3 million units, with the majority 12.7 millimeters or less in height. But the growth period for both 3.5" and 2.5" drives is over in 1996, as the inevitable upward trend in the market's demand for disk capacity continues for both desktop personal computers and for notebook computers.

The combination of business personal computers and consumer computer applications consumed 98.6% of the disk drives shipped in this product group in 1995, with network servers, midrange systems and workstations utilizing only 1.4% of total shipments. The mix of applications will undergo marked changes in 1999, as 3.5" and 2.5" drive shipments decline to modest levels, and 1.8" drive shipments increase to comparable levels. In 1999, business and home personal computers are expected to hold 82.0% of worldwide shipments, with workstations at 4.0%, and a variety of specialized applications at 14.0%.

Quantum retained leadership in noncaptive drive shipments for the product group in 1995, with 27% of the worldwide total, mostly 3.5" models. Western Digital was again in second place with 17.5% of the total, all 3.5" drives, and Seagate Technology moved into third place with 16%, also mostly 3.5" drives.

Marketing trends

The downhill pattern for disk drive product groups which have peaked in shipments is now becoming almost standardized. As areal densities move up

aggressively, making possible rapid drive capacity increases, and as computer system markets steadily modify software and broaden applications, increasing demand for on-line data storage, the upward capacity migration never stops. The expectation for this product group is no exception. Total shipments for the product group are projected to decline an average of 64.4% per year through 1999, dropping to 1.4 million. A similar pattern is forecasted for sales revenues, dropping an average of 63.7%, with the 1999 revenue total down to only $235 million.

Shipments of all drives with disk diameters larger than 3.5" are expected to end in 1996, and the only growth pattern expected in the product group will be derived from shipments of 1.8" drives, for which production is expected to start in 1996.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
8"-14"	1.4	.3	--	--	--
	--	--	--	--	--
5.25"	4.3	1.5	--	--	--
	--	--	--	--	--
3.5"	36,265.6	29,435.5	13,085.0	2,715.0	405.0
	85.3%	86.4%	82.4%	53.1%	28.4%
2.5"	6,282.4	4662.0	2,755.0	2,195.0	545.0
	14.7%	13.6%	17.3%	42.8%	38.1%
1.8" PCMCIA Type III	--	5.0	65.0	215.0	480.0
	--	--	.3%	4.1%	33.5%
Total	42,553.7	34,104.3	15,905.0	5,125.0	1,430.0

The shipment levels for 3.5" drives in this product group are expected to drop off the most rapidly during the next few years, due to the nature of the desktop personal computer market, and the established pattern of immediate movement to new disk capacity levels by system manufacturers. The notebook computer market which consumes most of the current generation of 2.5" drives follows the same pattern, with a timetable a bit slower. The anticipated market for 1.8" drives in this capacity range will follow a different set of rules. The 1.8" market will probably consist of a variety of specialized applications, similar to the pattern already established by lower capacity 1.8" drives.

Technical trends

Little effort by disk drive manufacturers will be expended to develop new 3.5" or 2.5" drives in this capacity range. Any new products which appear in the group will be mere "depopulated" versions of drives developed for higher capacity ranges. Most of the 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. While the current intent of most of these development programs is to produce drives in capacity ranges higher than this product group, low cost single disk models will probably be introduced in this capacity range.

The development programs for 1.8" drives will follow similar product family strategies, except that the main product planning targets will frequently be in this product group, considering the drive capacity ranges now practical with the industry's current areal density levels. This capacity range is still a demanding target for 1.8" drive development programs, with the same head, disk and semiconductor limitations which exist with larger diameter drives, but complicated by the special considerations developers of 1.8" drives must place on power requirements and shock and vibration specifications.

Forecasting assumptions

1. 5.25" and larger drives will be produced for the last time in 1996.
2. Shipments of 3.5" drives for personal computer markets and other applications will start to decline in 1996, then drop rapidly in following years, displaced by higher capacity drives. 2.5" disk drives will follow a similar pattern.
3. Shipments of 1.8" drives will start in 1996, and maintain a pattern of continuous growth through 1999.

TABLE 35

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	990.5	1,496.5	283.2	439.8	112.2	176.5	16.3	27.2	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	990.5	1,496.5	283.2	439.8	112.2	176.5	16.3	27.2	--	--
PCM/Distributor	910.5	2,000.6	650.4	1,472.2	213.8	496.0	44.4	101.0	10.6	22.6
OEM/Integrator	2,246.1	4,171.2	1,056.6	2,389.8	461.1	1,004.1	161.2	322.1	76.4	130.7
TOTAL U.S. NONCAPTIVE	3,156.6	6,171.8	1,707.0	3,862.0	674.9	1,500.1	205.6	423.1	87.0	153.3
TOTAL U.S. REVENUES	4,147.1	7,668.3	1,990.2	4,301.8	787.1	1,676.6	221.9	450.3	87.0	153.3
Non-U.S. Manufacturers										
Captive	105.0	472.1	108.0	374.0	73.1	245.7	62.1	205.2	--	--
PCM/Distributor	75.6	188.0	99.2	182.0	71.9	141.9	28.7	66.1	10.7	24.2
OEM/Integrator	226.0	675.6	318.2	688.1	142.0	295.8	81.7	178.5	31.9	75.5
TOTAL NON-U.S. REVENUES	406.6	1,335.7	525.4	1,244.1	287.0	683.4	172.5	449.8	42.6	99.7
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	4,553.7	9,004.0	2,515.6	5,545.9	1,074.1	2,360.0	394.4	900.1	129.6	253.0
OEM Average Price ($000)		.183		.147		.130		.147		.178

TABLE 36

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995		Forecast							
	Shipments		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,910.0	2,900.0	765.0	1,190.0	375.0	590.0	60.0	100.0	--	--
Other U.S. Captive	--	--	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,910.0	2,900.0	765.0	1,190.0	375.0	590.0	60.0	100.0	--	--
PCM/Distributor	5,316.0	11,644.0	4,535.0	10,265.0	1,708.0	3,970.0	355.0	825.0	65.0	150.0
OEM/Integrator	12,682.7	23,506.5	7,475.8	16,976.0	3,640.0	7,980.0	1,120.0	2,315.0	400.0	720.0
TOTAL U.S. NONCAPTIVE	17,998.7	35,150.5	12,010.8	27,241.0	5,348.0	11,950.0	1,475.0	3,140.0	465.0	870.0
TOTAL U.S. SHIPMENTS	19,908.7	38,050.5	12,775.8	28,431.0	5,723.0	12,540.0	1,535.0	3,240.0	465.0	870.0
Non-U.S. Manufacturers										
Captive	120.0	558.9	150.0	513.3	125.0	420.0	115.0	380.0	--	--
PCM/Distributor	430.0	1,060.0	686.0	1,213.0	530.0	985.0	200.0	420.0	60.0	125.0
OEM/Integrator	956.7	2,884.3	1,896.0	3,947.0	960.0	1,960.0	505.0	1,085.0	190.0	435.0
TOTAL NON-U.S. SHIPMENTS	1,506.7	4,503.2	2,732.0	5,673.3	1,615.0	3,365.0	820.0	1,885.0	250.0	560.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	21,415.4	42,553.7	15,507.8	34,104.3	7,338.0	15,905.0	2,355.0	5,125.0	715.0	1,430.0
Total Capacity (Terabytes)	14,724.5	28,860.2	12,597.5	27,757.0	4,708.2	10,201.7	1,707.7	3,717.5	595.2	1,188.2
Cumulative Shipments (Units in millions)										
IBM	2.9	4.5	3.7	5.7	4.0	6.3	4.1	6.4	4.1	6.4
Non-IBM	27.9	54.9	42.7	87.8	49.6	103.2	51.9	108.2	52.6	109.6
WORLDWIDE TOTAL	30.9	59.4	46.4	93.6	53.7	109.5	56.1	114.6	56.8	116.0

TABLE 37

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues				Forecast													
					1996					1997			1998			1999		
	>=8"	5.25"	3.5"	2.5"	>=8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	--	672.0	824.5	--	--	144.0	295.8	--	32.0	144.5	--	--	27.2	--	--	--	--
PCM/Distributor	--	--	1,956.2	44.4	--	--	1,436.1	36.1	--	478.5	15.8	1.7	86.7	9.8	4.5	11.3	1.8	9.5
OEM/Integrator	--	5.3	3,526.6	639.3	--	2.3	2,115.7	271.8	--	841.4	150.7	12.0	153.7	129.2	39.2	20.6	30.4	79.7
TOTAL U.S. REVENUES	--	5.3	6,154.8	1,508.2	--	2.3	3,695.8	603.7	--	1,351.9	311.0	13.7	240.4	166.2	43.7	31.9	32.2	89.2
NON-U.S. MANUFACTURERS																		
Captive	21.3	--	100.8	350.0	7.5	--	6.5	360.0	--	--	245.7	--	--	205.2	--	--	--	--
PCM/Distributor	--	--	139.6	48.4	--	--	139.7	42.3	--	98.8	41.4	1.7	28.4	33.2	4.5	5.0	6.8	12.4
OEM/Integrator	--	1.6	232.3	441.7	--	1.0	303.1	382.2	1.8	141.0	150.2	4.6	33.3	134.1	11.1	5.8	50.4	19.3
TOTAL NON-U.S. REVENUES	21.3	1.6	472.7	840.1	7.5	1.0	449.3	784.5	1.8	239.8	437.3	6.3	61.7	372.5	15.6	10.8	57.2	31.7
WORLDWIDE RECAP																		
Captive	21.3	--	772.8	1,174.5	7.5	--	150.5	655.8	--	32.0	390.2	--	--	232.4	--	--	--	--
	-63.3%	--	+77.0%	+182.7%	-64.8%	--	-80.5%	-44.2%	--	-78.7%	-40.5%	--	--	-40.4%	--	--	--	--
PCM/Distributor	--	--	2,095.8	92.8	--	--	1,575.8	78.4	--	577.3	57.2	3.4	115.1	43.0	9.0	16.3	8.6	21.9
	--	--	+143.8%	+421.3%	--	--	-24.8%	-15.5%	--	-63.4%	-27.0%	--	-80.1%	-24.8%	+164.7%	-85.8%	-80.0%	+143.3%
OEM/Integrator	--	6.9	3,758.9	1,081.0	--	3.3	2,418.8	654.0	1.8	982.4	300.9	16.6	187.0	263.3	50.3	26.4	80.8	99.0
	--	-76.8%	+102.0%	+293.4%	--	-52.2%	-35.7%	-39.5%	--	-59.4%	-54.0%	+822.2%	-81.0%	-12.5%	+203.0%	-85.9%	-69.3%	+96.8%
Total Revenues	21.3	6.9	6,627.5	2,348.3	7.5	3.3	4,145.1	1,388.2	1.8	1,591.7	748.3	20.0	302.1	538.7	59.3	42.7	89.4	120.9
	-67.4%	-90.2%	+109.9%	+231.7%	-64.8%	-52.2%	-37.5%	-40.9%	--	-61.6%	-46.1%	--	-81.0%	-28.0%	+196.5%	-85.9%	-83.4%	+103.9%
ANNUAL SHARE, BY DIAMETER	.2%	.1%	73.7%	26.0%	.1%	.1%	74.8%	25.0%	--	67.5%	31.7%	.8%	33.7%	59.8%	6.5%	16.9%	35.4%	47.7%

Note: ">=" indicates "greater than or equal to".

TABLE 38

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments				Forecast 1996					1997			1998			1999		
	>=8"	5.25"	3.5"	2.5"	>=8"	5.25"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"	3.5"	2.5"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	--	960.0	1,940.0	--	--	320.0	870.0	--	100.0	490.0	--	--	100.0	--	--	--	--
PCM/Distributor	--	--	11,494.0	150.0	--	--	10,110.0	155.0	--	3,890.0	75.0	5.0	760.0	50.0	15.0	105.0	10.0	35.0
OEM/Integrator	--	3.5	21,367.0	2,136.0	--	1.0	15,660.0	1,315.0	--	7,130.0	810.0	40.0	1,410.0	760.0	145.0	200.0	195.0	325.0
TOTAL U.S. SHIPMENTS	--	3.5	33,821.0	4,226.0	--	1.0	26,090.0	2,340.0	--	11,120.0	1,375.0	45.0	2,170.0	910.0	160.0	305.0	205.0	360.0
NON-U.S. MANUFACTURERS																		
Captive	1.4	--	157.5	400.0	.3	--	13.0	500.0	--	--	420.0	--	--	380.0	--	--	--	--
PCM/Distributor	--	--	900.0	160.0	--	--	1,038.0	175.0	--	790.0	190.0	5.0	245.0	160.0	15.0	45.0	35.0	45.0
OEM/Integrator	--	.8	1,387.1	1,496.4	--	.5	2,294.5	1,647.0	5.0	1,175.0	770.0	15.0	300.0	745.0	40.0	55.0	305.0	75.0
TOTAL NON-U.S. SHIPMENTS	1.4	.8	2,444.6	2,056.4	.3	.5	3,345.5	2,322.0	5.0	1,965.0	1,380.0	20.0	545.0	1,285.0	55.0	100.0	340.0	120.0
WORLDWIDE RECAP																		
Captive	1.4	--	1,117.5	2,340.0	.3	--	333.0	1,370.0	--	100.0	910.0	--	--	480.0	--	--	--	--
	-62.2%	--	+99.4%	+396.6%	-78.6%	--	-70.2%	-41.5%	--	-70.0%	-33.6%	--	--	-47.3%	--	--	--	--
PCM/Distributor	--	--	12,394.0	310.0	--	--	11,148.0	330.0	--	4,680.0	265.0	10.0	1,005.0	210.0	30.0	150.0	45.0	80.0
	--	--	+350.9%	+588.9%	--	--	-10.1%	+6.5%	--	-58.0%	-19.7%	--	-78.5%	-20.8%	+200.0%	-85.1%	-78.6%	+166.7%
OEM/Integrator	--	4.3	22,754.1	3,632.4	--	1.5	17,954.5	2,962.0	5.0	8,305.0	1,580.0	55.0	1,710.0	1,505.0	185.0	255.0	500.0	400.0
	--	-79.4%	+261.1%	+380.5%	--	-65.1%	-21.1%	-18.5%	--	-53.7%	-46.7%	+1,000.0%	-79.4%	-4.7%	+236.4%	-85.1%	-66.8%	+116.2%
Total Shipments	1.4	4.3	36,265.6	6,282.4	.3	1.5	29,435.5	4,662.0	5.0	13,085.0	2,755.0	65.0	2,715.0	2,195.0	215.0	405.0	545.0	480.0
	-73.1%	-88.7%	+277.4%	+393.9%	-78.6%	-65.1%	-18.8%	-25.8%	--	-55.5%	-40.9%	--	-79.3%	-20.3%	+230.8%	-85.1%	-75.2%	+123.3%
ANNUAL SHARE, BY DIAMETER	--	--	85.3%	14.7%	--	--	86.4%	13.6%	--	82.4%	17.3%	.3%	53.1%	42.8%	4.1%	28.4%	38.1%	33.5%
TOTAL CAPACITY (Terabytes)	.9	2.8	24,869.2	3,987.3	.2	.9	24,697.2	3,056.1	2.6	8,515.3	1,653.0	33.5	2,036.3	1,526.5	154.8	344.3	436.0	408.0

Note: ">=" indicates "greater than or equal to".

TABLE 39

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	451.1	1.1	--	--
PERSONAL COMPUTERS				
Business and professional, single user	37,621.7	88.4	1,058.2	74.0
WORKSTATIONS				
Engineering and office, single user	123.4	.3	57.2	4.0
CONSUMER, GAME AND HOBBY COMPUTERS	4,353.2	10.2	114.4	8.0
OTHER APPLICATIONS	--	--	200.2	14.0
Total	42,553.7	100.0	1,430.0	100.0

TABLE 40

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
>=8"	23.68	37.50	--	--	--
5.25"	--	--	--	--	--
3.5"	.96	.60	.42	--	--
2.5"	.85	.75	.71	.71	--
Captive Average	.90	.73	.68	.71	--
PCM/Distributor					
>=8"	--	--	--	--	--
5.25"	--	--	--	--	--
3.5"	.24	.16	.19	.15	.12
2.5"	.47	.35	.36	.29	.24
PCM/Distributor Average	.24	.17	.19	.17	.15
OEM/Integrator					
>=8"	--	--	--	--	--
5.25"	2.44	3.66	--	--	--
3.5"	.24	.16	.18	.14	.12
2.5"	.44	.33	.31	.25	.20
OEM/Integrator Average	.27	.18	.20	.19	.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.

">=" indicates "greater than or equal to".

TABLE 41

FIXED DISK DRIVES, 500 MEGABYTES - 1 GIGABYTE

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
Drive Manufacturers	5.25"	3.5"	2.5"	Total		5.25"	3.5"	2.5"	Total	
Quantum	--	4150.0	45.0	4195.0	21.6	--	10377.0	166.0	10543.0	27.0
Western Digital	--	4663.0	--	4663.0	24.1	--	6833.0	--	6833.0	17.5
Seagate Technology	--	2135.0	169.0	2304.0	11.9	--	5810.0	460.0	6270.0	16.0
Conner Peripherals	--	2964.0	--	2964.0	15.3	--	4941.0	--	4941.0	12.6
Maxtor	--	2645.0	--	2645.0	13.6	--	4270.0	--	4270.0	10.9
IBM	--	310.0	840.0	1150.0	5.9	--	540.0	1660.0	2200.0	5.6
Toshiba	--	--	455.0	455.0	2.3	--	--	1470.0	1470.0	3.8
Fujitsu	--	292.0	11.7	303.7	1.6	.8	1081.9	17.4	1100.1	2.8
Samsung Electronics	--	370.0	--	370.0	1.9	--	900.0	--	900.0	2.3
NEC	--	130.0	--	130.0	.7	--	266.0	--	266.0	.7
Hitachi	--	--	119.0	119.0	.6	--	4.0	152.0	156.0	.4
Other U.S.	2.7	75.0	--	77.7	.4	3.5	90.0	--	93.5	.3
Other Non-U.S.	--	5.0	4.0	9.0	.1	--	35.2	17.0	52.2	.1
TOTAL	2.7	17739.0	1643.7	19385.4	100.0	4.3	35148.1	3942.4	39094.8	100.0

FIXED DISK DRIVES, 1 - 2 GIGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, 1 - 2 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	F6429H
Gigastorage International	B5108A**, B5128A**
Quantum	1.2 Bigfoot

3.5" disk diameter

Fujitsu	M2694*, M1623TAU**
Hewlett-Packard	C3724S**, C5271A**
Hitachi	DK315C-14*, DK326C-10**
IBM	DJAA-31270**, DJAA-31700**
JTS	P1000-2AF****, P1600-3AF***
Maxtor	71626AP**, 71260A**
NEC	D3845**, DSE1700A/S**
Quantum	1280A/S Fireball**, 1400S Empire**
Samsung	PLS-31084A**, WNR-31601A**
Seagate Technology	ST51080A***, ST31720A**
Tae II Media	TM-3G12-3**
Western Digital	AC21000**, AC21600**

2.5" - 3" disk diameter

Fujitsu	M2714TAM****
Hitachi	DK212A-10***
IBM	DPRA-21215***, DMCA-21440****
Integral Peripherals	21080****, 21200****
JTS	N1080-2AR*****, N1620-3AR****
Maxtor	251340****
Quantum	1080AT Europa***
Samsung	ACB-21202A****
Seagate Technology	ST91350AG****, ST91685AG***
Toshiba	MK-2720FC***, MK-1301MAV****
Tottori Sanyo	S3403***, S3404***

*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.

There are still drives in this product group that were designed for mainframe computers, but shipments are now negligible. IBM's 3380 was the core of this 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 provided 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 appeared in the product lines of 7 manufacturers in 1995, and the capacities now available in 2.5" drives now exceed 1.6 gigabytes. Many 2.5" drives in this capacity range are now available with heights less than 12.7 millimeters.

Competing for the same markets is the 3" drive family announced by JTS, with the intention of capturing notebook computer sales by using the additional recording area offered by 3" disks to reduce prices at each capacity level. The industry is also seeing the reincarnation of the 5.25" form factor, first with a new drive from Gigastorage International, designed to provide very low cost disk storage for personal computers, followed by the Quantum Bigfoot, a single disk 5.25" drive with 1.2 gigabyte capacity and also designed to provide a pricing edge.

Market status

Shipments of drives in the 1-2 gigabyte range are expected to be higher than for any other product group in 1996, at 47.2 million units. Despite falling prices, sales revenues for the product group are projected to rise from 1995's $6.5 billion to a 1996 total of $10.8 billion.

Incessant growth in the personal computer market's craving for more disk storage capacity has forced the rapid growth of shipments in this capacity range. 3.5" drives have been the primary beneficiaries of storage demand for desktop personal computers, with 38.3 million drives forecasted for 1996 shipment, up 87.4% over the previous year. The notebook computer market has seen a similar upward swing in demand for disk storage, with the result that 1995's shipments of 409,600 2.5" drives are projected to rise to 6.2 million in 1996. Shipments of 3" drives address the same markets as 2.5" drives and are included in the same group for the purpose of measuring shipments and sales revenues.

The advent of single disk 5.25" drives in this capacity range will create a new competitive struggle, with 1.2 gigabyte 5.25" drives offered at lower prices than 3.5" drives of the same capacity, a sales tactic prompted by the drives' lower parts count and presumably lower cost. The current DISK/TREND forecast assumes that 5.25" drives will achieve some sales momentum in 1996 but that competitive countermeasures will hold 5.25" drive shipments to 2.7 million units.

Average unit prices have fallen 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 fell to 50 cents in 1994. By 1995, it was down to 20 cents, and the average for 1996 is projected at 13 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 disappeared completely in 1995. Shipments for networks and midrange systems had been as high as 54% of the total in previous years, but were down to only 4.6% of the 1995 total, with the expectation that they will be gone by 1999. Workstation applications held 2.8% of the 1995 total and are expected to grow to 6.0% in 1999. The combination of business personal computer and consumer computer applications had risen to 92.4% of the 1995 total and is expected to retain 91.0% of the 1999 total shipments.

In 1995, Quantum moved up to the lead in noncaptive unit shipments for the product group, with 22.2% of the worldwide total, mostly 3.5" drives. Western Digital captured second place with 18.2%, and Seagate Technology was third with 17.4%.

Marketing trends

In the modern disk drive industry, the current year's shipment leadership for a capacity range cannot be expected to continue into next year. As shipment

leadership passes to higher capacity product groups, total shipments in the 1-2 gigabyte range will start downward in 1997. It is projected that the group's total shipments will decline at an annual average of 62.0% through 1999, with the total for that year estimated at 2.2 million drives. An average annual sales revenue decline of 60.6% will lower revenues to a forecasted $596.7 million in 1999.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
8"-14"	8.3 --	.3 --	-- --	-- --	-- --
5.25"	22.3 .1%	2,722.0 5.8%	2,910.0 11.6%	1,730.0 18.7%	185.0 8.4%
3.5"	20,418.9 98.0%	38,267.0 81.2%	15,550.0 62.0%	2,905.0 31.5%	665.0 30.1
2.5"	409.6 1.9%	6,217.0 13.0%	6,670.0 26.4%	4,610.0 49.8%	1,245.0 56.2%
1.8"	-- --	-- --	-- --	-- --	120.0 5.3%
Total	20,859.1	47,206.3	25,130.0	9,245.0	2,215.0

Total shipments for this product group are projected to decline 46.8% in 1997, but 3.5" drives will be the only type expected to actually suffer a drop in shipments during 1997. The quick reaction of the desktop personal computer industry to availability of drives at higher capacities at the right price is expected to drop shipments of 3.5" drives in 1997 to less than half of the previous year's level. It is inevitable that drastic reductions in 3.5" drive shipments will continue, and the 1999 total is forecasted to be only 665,000 units.

The new low-cost 5.25" drives being introduced in 1996 are expected to enjoy modest growth in 1997 shipments, but poor sales in following years, as even the low-end segments of the personal computer market move on to disk capacities higher than this product group offers. 2.5" disk drives are also expected to see modest continuing growth in 1997, but declining shipments in the following years, as higher capacity drive models at competitive prices penetrate the notebook computer market. The industry's nonstop growth in areal density will also make it possible to introduce 1.8" drives in the 1-2 gigabyte capacity

range before the end of this forecast period, with the starting point forecasted for 1999.

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.

For most drive designers the remaining problems involve chips with adequate data rates, adoption of more efficient encoding schemes, 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.

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.
2. Low-cost 5.25" drives will peak in shipments in 1997, due to 3.5" price competition and demand for higher capacities for personal computers.
3. Shipments of 3.5" drives will decline rapidly after 1996, displaced by higher capacity drives in the personal computer market.
4. 2.5" drives shipments will decline after 1997, impacted by the continuing movement to higher disk capacities for notebook computers.
5. The first shipments of 1.8" drives will occur in 1999.

TABLE 42

FIXED DISK DRIVES, 1 - 2 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	926.3	1,306.6	1,331.9	1,948.8	912.4	1,377.4	558.3	855.7	179.4	279.3
Other U.S. Captive	18.0	22.5	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	944.3	1,329.1	1,331.9	1,948.8	912.4	1,377.4	558.3	855.7	179.4	279.3
PCM/Distributor	793.1	1,420.9	1,024.9	2,150.2	373.1	751.7	73.7	136.4	14.3	24.6
OEM/Integrator	1,550.7	2,646.0	2,194.4	4,285.3	1,087.9	1,995.6	330.1	587.3	70.6	118.5
TOTAL U.S. NONCAPTIVE	2,343.8	4,066.9	3,219.3	6,435.5	1,461.0	2,747.3	403.8	723.7	84.9	143.1
TOTAL U.S. REVENUES	3,288.1	5,396.0	4,551.2	8,384.3	2,373.4	4,124.7	962.1	1,579.4	264.3	422.4
Non-U.S. Manufacturers										
Captive	2.1	701.1	58.3	766.2	88.3	527.7	102.7	428.1	31.8	124.3
PCM/Distributor	23.2	43.4	189.6	325.4	69.3	124.6	9.4	20.1	1.5	3.4
OEM/Integrator	213.3	389.9	601.9	1,372.2	291.9	689.0	91.6	223.0	20.0	46.6
TOTAL NON-U.S. REVENUES	238.6	1,134.4	849.8	2,463.8	449.5	1,341.3	203.7	671.2	53.3	174.3
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	3,526.7	6,530.4	5,401.0	10,848.1	2,822.9	5,466.0	1,165.8	2,250.6	317.6	596.7
OEM Average Price ($000)		.241		.186		.165		.152		.161

TABLE 43

FIXED DISK DRIVES, 1 - 2 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1,450.0	2,040.0	2,185.0	3,190.0	1,745.0	2,630.0	1,260.0	1,930.0	470.0	730.0
Other U.S. Captive	20.0	25.0	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,470.0	2,065.0	2,185.0	3,190.0	1,745.0	2,630.0	1,260.0	1,930.0	470.0	730.0
PCM/Distributor	3,204.5	5,745.0	5,468.0	11,463.0	2,330.0	4,695.0	555.0	1,035.0	95.0	170.0
OEM/Integrator	6,426.3	10,962.5	11,795.0	23,248.0	6,710.0	12,406.0	2,230.0	4,005.0	425.0	740.0
TOTAL U.S. NONCAPTIVE	9,630.8	16,707.5	17,263.0	34,711.0	9,040.0	17,101.0	2,785.0	5,040.0	520.0	910.0
TOTAL U.S. SHIPMENTS	11,100.8	18,772.5	19,448.0	37,901.0	10,785.0	19,731.0	4,045.0	6,970.0	990.0	1,640.0
Non-U.S. Manufacturers										
Captive	2.0	223.5	75.0	487.2	135.0	794.0	185.0	830.0	65.0	270.0
PCM/Distributor	134.0	249.0	1,051.0	1,790.0	435.0	765.0	70.0	140.0	12.0	25.0
OEM/Integrator	905.1	1,614.1	3,110.0	7,028.1	1,645.0	3,840.0	540.0	1,305.0	120.0	280.0
TOTAL NON-U.S. SHIPMENTS	1,041.1	2,086.6	4,236.0	9,305.3	2,215.0	5,399.0	795.0	2,275.0	197.0	575.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	12,141.9	20,859.1	23,684.0	47,206.3	13,000.0	25,130.0	4,840.0	9,245.0	1,187.0	2,215.0
Total Capacity (Terabytes)	14,000.3	24,120.8	31,855.6	63,259.7	16,230.5	31,372.8	6,577.0	12,578.5	1,791.0	3,359.0
Cumulative Shipments (Units in millions)										
IBM	2.5	3.7	4.7	6.9	6.4	9.5	7.7	11.4	8.2	12.1
Non-IBM	16.1	26.9	37.6	70.9	48.8	93.4	52.4	100.8	53.1	102.2
WORLDWIDE TOTAL	18.6	30.6	42.3	77.8	55.3	103.0	60.2	112.2	61.3	114.4

TABLE 44

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues				Forecast													
	1996				1997			1998			1999			
	>=8"	5.25"	3.5"	2.5"	>=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"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	--	1,081.6	225.0	--	--	486.8	1,462.0	--	258.7	1,118.7	--	129.2	726.5	--	65.1	214.2	--
Other U.S. Captive	--	--	22.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	--	1,418.9	2.0	--	54.7	2,050.4	45.1	59.4	652.8	39.5	42.7	73.7	20.0	5.2	10.8	3.3	5.3
OEM/Integrator	--	1.1	2,636.8	8.1	--	299.7	3,402.0	583.6	320.6	1,158.3	516.7	164.8	168.1	254.4	15.7	26.6	48.1	28.1
TOTAL U.S. REVENUES	--	1.1	5,159.8	235.1	--	354.4	5,939.2	2,090.7	380.0	2,069.8	1,674.9	207.5	371.0	1,000.9	20.9	102.5	265.6	33.4
NON-U.S. MANUFACTURERS																		
Captive	75.2	279.0	336.4	10 5	4.5	128.0	439.4	194.3	60.0	173.4	294.3	--	84.0	344.1	--	21.6	102.7	--
PCM/Distributor	--	--	41.4	2.0	--	--	305.6	19.8	--	109.9	14.7	--	12.5	7.6	--	1.8	1.6	--
OEM/Integrator	1.8	6.4	355.1	26.6	.2	3.6	969.3	399.1	--	333.7	355.3	--	47.2	175.8	--	7.2	32.6	6.8
TOTAL NON-U.S. REVENUES	77.0	285.4	732.9	39.1	4.7	131.6	1,714.3	613.2	60.0	617.0	664.3	--	143.7	527.5	--	30.6	136.9	6.8
WORLDWIDE RECAP																		
Captive	75.2	279.0	1,440.5	235.5	4.5	128.0	926.2	1,656.3	60.0	432.1	1,413.0	--	213.2	1,070.6	--	86.7	316.9	--
	-68.4%	-14.9%	+25.4%	--	-94.0%	-54.1%	-35.7%	+603.3%	-53.1%	-53.3%	-14.7%	--	-50.7%	-24.2%	--	-59.3%	-70.4%	--
PCM/Distributor	--	--	1,460.3	4.0	--	54.7	2,356.0	64.9	59.4	762.7	54.2	42.7	86.2	27.6	5.2	12.6	4.9	5.3
	--	--	+188.6%	--	--	--	+61.3%	--	+8.6%	-67.6%	-16.5%	-28.1%	-88.7%	-49.1%	-87.8%	-85.4%	-82.2%	--
OEM/Integrator	1.8	7.5	2,991.9	34.7	.2	303.3	4,371.3	982.7	320.6	1,492.0	872.0	164.8	215.3	430.2	15.7	33.8	80.7	34.9
	-10.0%	-87.4%	+83.7%	--	-88.9%	--	+46.1%	--	+5.7%	-65.9%	-11.3%	-48.6%	-85.6%	-50.7%	-90.5%	-84.3%	-81.2%	--
Total Revenues	77.0	286.5	5,892.7	274.2	4.7	486.0	7,653.5	2,703.9	440.0	2,686.8	2,339.2	207.5	514.7	1,528.4	20.9	133.1	402.5	40.2
	-67.9%	-27.6%	+79.5%	--	-93.9%	+69.6%	+29.9%	+886.1%	-9.5%	-64.9%	-13.5%	-52.8%	-80.8%	-34.7%	-89.9%	-74.1%	-73.7%	--
ANNUAL SHARE, BY DIAMETER	1.2%	4.4%	90.3%	4.1%	--	4.5%	70.7%	24.8%	8.0%	49.3%	42.7%	9.2%	23 0%	67.8%	3.5%	22.4%	67.5%	6.6%

Note: ">=" indicates "greater than or equal to".

TABLE 45

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments				Forecast 1996				1997			1998			1999			
	>=8"	5.25"	3.5"	2.5"	>=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"	1.8"
U.S. MANUFACTURERS																		
IBM Captive	--	--	1,740.0	300.0	--	--	1,040.0	2,150.0	--	650.0	1,980.0	--	410.0	1,520.0	--	220.0	510.0	--
Other U.S. Captive	--	--	25.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	--	5,740.0	5.0	--	405.0	10,898.0	160.0	440.0	4,080.0	175.0	345.0	585.0	105.0	45.0	90.0	20.0	15.0
OEM/Integrator	--	1.0	10,941.5	20.0	--	2,305.0	18,813.0	2,130.0	2,466.0	7,570.0	2,370.0	1,385.0	1,245.0	1,375.0	140.0	220.0	295.0	85.0
TOTAL U.S. SHIPMENTS	--	1.0	18,446.5	325.0	--	2,710.0	30,751.0	4,440.0	2,906.0	12,300.0	4,525.0	1,730.0	2,240.0	3,000.0	185.0	530.0	825.0	100.0
NON-U.S. MANUFACTURERS																		
Captive	7.6	15.5	190.4	10.0	.2	8.0	229.0	250.0	4.0	340.0	450.0	--	210.0	620.0	--	60.0	210.0	--
PCM/Distributor	--	--	244.0	5.0	--	--	1,725.0	65.0	--	700.0	65.0	--	100.0	40.0	--	15.0	10.0	--
OEM/Integrator	.7	5.8	1,538.0	69.6	.1	4.0	5,562.0	1,462.0	--	2,210.0	1,630.0	--	355.0	950.0	--	60.0	200.0	20.0
TOTAL NON-U.S. SHIPMENTS	8.3	21.3	1,972.4	84.6	.3	12.0	7,516.0	1,777.0	4.0	3,250.0	2,145.0	--	665.0	1,610.0	--	135.0	420.0	20.0
WORLDWIDE RECAP																		
Captive	7.6	15.5	1,955.4	310.0	.2	8.0	1,269.0	2,400.0	4.0	990.0	2,430.0	--	620.0	2,140.0	--	280.0	720.0	--
	-61.6%	-74.4%	+116.7%	--	-97.4%	-48.4%	-35.1%	+674.2%	-50.0%	-22.0%	+1.3%	--	-37.4%	-11.9%	--	-54.8%	-66.4%	--
PCM/Distributor	--	--	5,984.0	10.0	--	405.0	12,623.0	225.0	440.0	4,780.0	240.0	345.0	685.0	145.0	45.0	105.0	30.0	15.0
	--	--	+567.6%	--	--	--	+110.9%	--	+8.6%	-62.1%	+6.7%	-21.6%	-85.7%	-39.6%	-87.0%	-84.7%	-79.3%	--
OEM/Integrator	.7	6.8	12,479.5	89.6	.1	2,309.0	24,375.0	3,592.0	2,466.0	9,780.0	4,000.0	1,385.0	1,600.0	2,325.0	140.0	280.0	495.0	105.0
	+40.0%	-84.3%	+332.4%	--	-85.7%	--	+95.3%	--	+6.8%	-59.9%	+11.4%	-43.8%	-83.6%	-41.9%	-89.9%	-82.5%	-78.7%	--
Total Shipments	8.3	22.3	20,418.9	409.6	.3	2,722.0	38,267.0	6,217.0	2,910.0	15,550.0	6,670.0	1,730.0	2,905.0	4,610.0	185.0	665.0	1,245.0	120.0
	-59.1%	-79.7%	+335.8%	--	-96.4%	--	+87.4%	--	+6.9%	-59.4%	+7.3%	-40.5%	-81.3%	-30.9%	-89.3%	-77.1%	-73.0%	--
ANNUAL SHARE, BY DIAMETER	--	.1%	98.0%	1.9%	--	5.8%	81.2%	13.0%	11.6%	62.0%	26.4%	18.7%	31.5%	49.8%	8.4%	30.1%	56.2%	5.3%
TOTAL CAPACITY (Terabytes)	15.7	31.5	23,573.7	499.9	.5	3,268.8	52,341.2	7,649.2	3,492.8	20,345.0	7,535.0	2,076.0	4,357.5	6,145.0	222.0	1,086.5	1,918.5	132.0

Note: ">=" indicates "greater than or equal to"

TABLE 46

FIXED DISK DRIVES, 1 - 2 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	--	--	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	963.7	4.6	--	--
PERSONAL COMPUTERS				
Business and professional, single user	18,364.3	88.0	1,838.4	83.0
WORKSTATIONS				
Engineering and office, single user	577.8	2.8	132.9	6.0
CONSUMER, GAME AND HOBBY COMPUTERS	917.8	4.4	177.2	8.0
OTHER APPLICATIONS	31.3	.2	66.5	3.0
Total	20,859.2	100.0	2,215.1	100.0

TABLE 47

FIXED DISK DRIVES, 1 - 2 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER	1995	Forecast 1996	1997	1998	1999
Captive					
>=8"	5.26	14.86	--	--	--
5.25"	12.85	11.42	10.71	--	--
3.5"	.68	.51	.30	.22	.20
2.5"	.63	.56	.49	.36	.28
1.8"	--	--	--	--	--
Captive Average	.80	.57	.44	.33	.25
PCM/Distributor					
>=8"	--	--	--	--	--
5.25"	--	.11	.11	.10	.09
3.5"	.20	.13	.12	.08	.07
2.5"	.32	.22	.20	.14	.11
1.8"	--	--	--	--	.31
PCM/Distributor Average	.20	.13	.12	.09	.09
OEM/Integrator					
>=8"	1.25	1.10	--	--	--
5.25"	.76	.10	.10	.09	.09
3.5"	.20	.13	.11	.09	.07
2.5"	.30	.22	.19	.14	.10
1.8"	--	--	--	--	.30
OEM/Integrator Average	.21	.14	.13	.11	.11

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.

">=" indicates "greater than or equal to".

TABLE 48

FIXED DISK DRIVES, 1 - 2 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	>=8"	5.25"	3.5"	2.5"	Total		>=8"	5.25"	3.5"	2.5"	Total	
Quantum	--	--	1639.0	7.0	1646.0	15.4	--	--	4101.0	25.0	4126.0	22.2
Western Digital	--	--	2540.0	--	2540.0	23.8	--	--	3386.0	--	3386.0	18.2
Seagate Technology	--	--	1795.0	--	1795.0	16.8	--	1.0	3224.0	--	3225.0	17.4
Conner Peripherals	--	--	1835.0	--	1835.0	17.2	--	--	3165.0	--	3165.0	17.0
Maxtor	--	--	1040.0	--	1040.0	9.7	--	--	1680.0	--	1680.0	9.0
Fujitsu	.3	--	627.3	--	627.6	5.9	.7	2.8	1203.0	.1	1206.6	6.5
IBM	--	--	675.0	--	675.0	6.3	--	--	950.0	--	950.0	5.2
NEC	--	--	252.0	--	252.0	2.4	--	--	320.0	--	320.0	1.7
Samsung Electronics	--	--	132.0	--	132.0	1.2	--	--	244.0	--	244.0	1.3
Other U.S.	--	--	99.8	--	99.8	.9	--	--	175.5	--	175.5	.9
Other Non-U.S.	--	2.0	3.0	22.5	27.5	.4	--	3.0	15.0	74.5	92.5	.6
TOTAL	.3	2.0	10638.1	29.5	10669.9	100.0	.7	6.8	18463.5	99.6	18570.6	100.0

Note: ">=" indicates "greater than or equal to".

FIXED DISK DRIVES, 2 - 3 GIGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, 2 - 3 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Fujitsu	F6429K
Gigastorage International	B5256A**
Quantum	2.4 Bigfoot
Seagate Technology	ST42400N, ST43200N

3.5" disk diameter

Fujitsu	M2932*, M1638TAU**
Hewlett-Packard	C3325A**
Hitachi	DK328C-21**
IBM	DORS-32160**, DAQA-32160**
Maxtor	72004AP/A**
Micropolis	4221**
NEC	D3896**
Quantum	2550S/A Sirocco**, 2.1S Viking**
Samsung Electronics	WNR-32502A**
Seagate Technology	ST-32430N/W**, ST52520A***
Western Digital	AC32100**, AC52500**

2.5" disk diameter

IBM	DCRA-22160***
Seagate Technology	ST92255AG***
Toshiba	MK-2101MAN***

*Maximum 41.3 mm height, or less.
**Maximum 25.4 mm height, or less.
***Maximum 19 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 were intended

for mainframe and supermini applications similar to IBM's, and most used standard industry technology, but generally more conservatively, to facilitate reliable production. Other 8" and 9" drives, now mostly out of production, were used typically in small mainframe, supermini and imaging applications.

5.25" drives above 2 gigabytes were shipped for the first time in 1991, and were once available from seven manufacturers, now down to four. The early 5.25" drives offered in this capacity range were intended for midrange and mainframe systems, but most of the drives now in the market will be sold as low cost substitutes for 3.5" drives in the personal computer market.

3.5" drives first became available in late 1992, with the introduction of IBM's 2 gigabyte 1.625" high Allicat series, since retired in favor of newer drives with lower parts counts. The initial 3.5" drives in this product group were intended for midrange and mainframe computer system applications. In 1996, the midrange system markets for 3.5" disk drives still exist, but they've been dwarfed by the rapid growth of demand for higher disk capacities in the desktop personal computer market, and the newer generation of low cost 3.5" drive families. Eleven disk drive manufacturers have joined the very competitive contest to secure customers among the leading personal computer makers for 3.5" 1" high drives. Three disk drive manufacturers also now offer 2.5" drives in this capacity range, targeting the inevitable enlargement of demand for disk capacity for notebook computers which always follows each upward step in the typical capacities used with desktop personal computers.

Market status

With continuing growth in network and midrange computer system markets for drives in this product group, combined with early adoption of drives in the 2 gigabyte range for desktop personal computer applications, 1995 shipments of 2-3 gigabyte drives increased 105.4% in 1995, with 4.7 million drives. But that was only the beginning of a sales surge which will carry this product group to leadership in the industry's sales in the near future. 1996 worldwide shipments are forecasted at 18.2 million drives, up another 290.0%. Due to the changing nature of the disk drive products and applications for this product group, the increase in sales revenues will be more modest. 1996's projected sales revenue

total of $5.8 billion represents an increase of only 25.2% over the previous year despite the major increase in shipments, as low price drives targeted at the personal computer market replace older high-end drives.

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 have faded, with final production expected this year. At the same time many network server and midrange system requirements are transitioning to higher capacities, and existing applications with the same capacity requirements are moving 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 1996 shipments of 3.5" drives are expected to top 16 million units, as desktop personal computers become the dominant application for the product group.

The reemergence of significant shipments of 5.25" drives in 1996 is the result of the new programs by Quantum and Gigastorage International to divert sales from standard 3.5" drives designed for personal computers to new low-cost 5.25" models. A moderate level of success for these efforts is expected, but market penetration will be limited by the reluctance of other drive manufacturers to surrender customers to the manufacturers of the new 5.25" drives, and their expected feisty response at the bargaining table. The other type of new product program for 1996 in this capacity range is the 2.5" disk drive, available for the first time this year in the 2-3 gigabyte capacity group. The upward transition to higher disk capacities for notebook computers is inevitable, and the level of sales success to be achieved during 1996 will be controlled primarily by product availability.

Mainframe computers utilized 11.6% of the product group's 1995 shipments, and network and midrange applications consumed 49.9%. Underlining the ongoing changes in this capacity range, the mainframe applications will be nonexistent in 1999, and network/midrange requirements will be only 2.0% of the total. Drives used with workstations will decline from 11.3% in 1995 to 4.0% in 1999. Business personal computer applications utilized 26.1% of 1995's drives and consumer computers only 0.2%, but in 1999 business personal computers are expected to require 79.0% of drive shipments, and consumer computers will take 15.0%.

Seagate Technology continued to hold the lion's share of noncaptive shipments in 1995, with 59.1% of the worldwide total, mostly 3.5" drives. Quantum's 17.5% earned second place, and IBM held third place with 6.8%.

Marketing trends

Rapid growth in demand for 2-3 gigabyte drives will continue, boosting 1997 shipments for this product group to a projected 54.5 million drives, as a result of the expanding hunger for more disk capacity on personal computers. After peaking in 1997, shipments are expected to drop rapidly as the typical capacities for personal computers continue to move up, beyond the range offered by this product group. By 1999, both sales revenues and shipments are expected to decline to only about 40% of their 1997 peak levels. The decline in total shipments during the 1997-99 period will be sharp, but the reduction will apply only to 3.5" drives.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
8"	3.0 .1%	.7 --	-- --	-- --	-- --
5.25"	68.1 1.5%	1,167.6 6.4%	1,720.0 3.2%	2,175.0 7.9%	2,210.0 9.9%
3.5"	4,603.4 98.4%	16,064.2 88.2%	49,680.0 91.3%	19,085.0 69.3%	11,810.0 53.1%
2.5"	-- --	1,000.0 5.4%	3,030.0 5.5%	6,320.0 22.8%	8,270.0 37.0%
Total	4,674.5	18,232.5	54,490.0	27,580.0	22,290.0

Partially hidden by the general decline in the product group's shipments, both 5.25" and 2.5" drives are expected to benefit from continuing growth. The increases for low cost 5.25" drives are forecasted to be modest, held down by a shrinking market for desktop PC storage in this capacity range and competitive rearguard actions by 3.5" drive producers. More aggressive growth is expected for 2.5" drives, as 2.5" shipments in this capacity range become larger than for any other product group in 1999, reaching 8.3 million drives.

Technical trends

Low manufacturing cost has become the prime product development objective for the majority of 2-3 gigabyte drives, 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.

Areal density improvements will be the largest influence on 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 1998, the industry probably will be able to manufacture 2 gigabyte 3.5" drives for the desktop personal computer market with a single platter, and by 1999 similar 2.5" drives for the notebook computer market will be introduced with only one disk. The leading edge high-end drives introduced in the same years will use much higher areal densities, but 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.

Forecasting assumptions

1. All shipments of drives larger than 5.25" will end in 1996, and the remaining network/midrange disk drive market in this capacity range will be served by newer 3.5" high performance drives in this product group designed for low parts count.
2. Low cost 5.25" drives will stay in production through 1999, but sales growth will be held down by competitive action and declining markets.
3. 3.5" drive shipments will peak in 1997, then drop rapidly as personal computer markets move to higher disk drive capacities.
4. 2.5" drives will increase shipments through 1999, as notebook computer demand continues to increase.

TABLE 49

FIXED DISK DRIVES, 2 - 3 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995		Forecast							
	Revenues		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	892.6	1,353.0	1,020.7	1,481.6	1,617.1	2,408.3	1,424.7	2,168.6	1,132.9	1,752.0
Other U.S. Captive	335.1	457.0	68.0	82.5	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	1,227.7	1,810.0	1,088.7	1,564.1	1,617.1	2,408.3	1,424.7	2,168.6	1,132.9	1,752.0
PCM/Distributor	311.5	505.7	445.9	780.0	1,208.7	2,011.2	393.3	651.5	240.2	395.5
OEM/Integrator	1,444.4	1,774.6	1,431.0	2,040.5	3,433.9	4,981.1	1,400.9	2,080.4	1,052.9	1,586.7
TOTAL U.S. NONCAPTIVE	1,755.9	2,280.3	1,876.9	2,820.5	4,642.6	6,992.3	1,794.2	2,731.9	1,293.1	1,982.2
TOTAL U.S. REVENUES	2,983.6	4,090.3	2,965.6	4,384.6	6,259.7	9,400.6	3,218.9	4,900.5	2,426.0	3,734.2
Non-U.S. Manufacturers										
Captive	--	331.4	28.8	463.3	36.0	348.4	86.8	410.0	132.3	526.8
PCM/Distributor	162.1	176.1	151.5	268.1	334.0	611.3	104.9	198.8	63.5	130.1
OEM/Integrator	23.6	69.4	399.2	727.4	998.7	1,707.8	377.7	772.5	270.6	634.7
TOTAL NON-U.S. REVENUES	185.7	576.9	579.5	1,458.8	1,368.7	2,667.5	569.4	1,381.3	466.4	1,291.6
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	3,169.3	4,667.2	3,545.1	5,843.4	7,628.4	12,068.1	3,788.3	6,281.8	2,892.4	5,025.8
OEM Average Price ($000)		.609		.243		.186		.165		.158

TABLE 50

FIXED DISK DRIVES, 2 - 3 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	342.0	505.0	1,455.0	2,115.0	2,805.0	4,190.0	2,840.0	4,330.0	2,415.0	3,740.0
Other U.S. Captive	163.0	222.0	50.0	60.0	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	505.0	727.0	1,505.0	2,175.0	2,805.0	4,190.0	2,840.0	4,330.0	2,415.0	3,740.0
PCM/Distributor	525.5	856.8	1,818.0	3,155.0	6,340.0	10,545.0	2,430.0	4,025.0	1,610.0	2,650.0
OEM/Integrator	2,382.5	2,925.7	5,893.0	8,576.0	18,585.0	27,042.0	8,585.0	12,845.0	6,760.0	10,290.0
TOTAL U.S. NONCAPTIVE	2,908.0	3,782.5	7,711.0	11,731.0	24,925.0	37,587.0	11,015.0	16,870.0	8,370.0	12,940.0
TOTAL U.S. SHIPMENTS	3,413.0	4,509.5	9,216.0	13,906.0	27,730.0	41,777.0	13,855.0	21,200.0	10,785.0	16,680.0
Non-U.S. Manufacturers										
Captive	--	40.4	30.0	441.9	50.0	573.0	140.0	780.0	245.0	1,060.0
PCM/Distributor	24.7	26.7	615.0	1,087.2	1,820.0	3,325.0	670.0	1,245.0	430.0	850.0
OEM/Integrator	37.6	97.9	1,566.0	2,797.4	5,190.0	8,815.0	2,230.0	4,355.0	1,675.0	3,700.0
TOTAL NON-U.S. SHIPMENTS	62.3	165.0	2,211.0	4,326.5	7,060.0	12,713.0	3,040.0	6,380.0	2,350.0	5,610.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	3,475.3	4,674.5	11,427.0	18,232.5	34,790.0	54,490.0	16,895.0	27,580.0	13,135.0	22,290.0
Total Capacity (Terabytes)	8,120.9	10,774.7	26,264.6	41,620.5	76,379.5	119,623.1	40,184.5	65,560.0	33,653.0	57,061.0
Cumulative Shipments (Units in millions)										
IBM	.7	1.1	2.1	3.2	5.0	7.4	7.8	11.7	10.2	15.4
Non-IBM	5.2	7.1	15.2	23.2	47.2	73.5	61.2	96.8	72.0	115.3
WORLDWIDE TOTAL	6.0	8.2	17.4	26.5	52.2	80.9	69.1	108.5	82.2	130.8

TABLE 51

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues			Forecast												
				1996				1997			1998			1999		
	8"	5.25"	3.5"	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	--	--	1,353.0	--	--	1,052.6	429.0	--	1,018.3	1,390.0	--	733.4	1,435.2	--	441.2	1,310.8
Other U.S. Captive	--	--	457.0	--	--	82.5	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	--	505.7	--	28.9	751.1	--	43.0	1,955.8	12.4	50.0	562.1	39.4	46.8	297.4	51.3
OEM/Integrator	--	38.4	1,736.2	--	163.3	1,850.8	26.4	233.1	4,614.7	133.3	271.9	1,381.7	426.8	253.8	771.3	561.6
TOTAL U.S. REVENUES	--	38.4	4,051.9	--	192.2	3,737.0	455.4	276.1	7,588.8	1,535.7	321.9	2,677.2	1,901.4	300.6	1,509.9	1,923.7
NON-U.S. MANUFACTURERS																
Captive	66.0	227.3	38.1	13.7	116.6	237.0	96.0	36.0	190.0	122.4	--	124.8	285.2	--	84.0	442.8
PCM/Distributor	--	175.0	1.1	--	1.4	253.3	13.4	--	603.0	8.3	--	172.5	26.3	--	95.9	34.2
OEM/Integrator	.7	12.5	56.2	--	1.1	643.1	83.2	--	1,618.7	89.1	--	485.8	286.7	--	267.0	367.7
TOTAL NON-U.S. REVENUES	66.7	414.8	95.4	13.7	119.1	1,133.4	192.6	36.0	2,411.7	219.8	--	783.1	598.2	--	446.9	844.7
WORLDWIDE RECAP																
Captive	66.0	227.3	1,848.1	13.7	116.6	1,372.1	525.0	36.0	1,208.3	1,512.4	--	858.2	1,720.4	--	525.2	1,753.6
	-68.8%	-2.5%	+40.7%	-79.2%	-48.7%	-25.8%	--	-69.1%	-11.9%	+188.1%	--	-29.0%	+13.8%	--	-38.8%	+1.9%
PCM/Distributor	--	175.0	506.8	--	30.3	1,004.4	13.4	43.0	2,558.8	20.7	50.0	734.6	65.7	46.8	393.3	85.5
	--	+361.7%	+60.3%	--	-82.7%	+98.2%	--	+41.9%	+154.8%	+54.5%	+16.3%	-71.3%	+217.4%	-6.4%	-46.5%	+30.1%
OEM/Integrator	.7	50.9	1,792.4	--	164.4	2,493.9	109.6	233.1	6,233.4	222.4	271.9	1,867.5	713.5	253.8	1,038.3	929.3
	-96.0%	-75.3%	+71.3%	--	+223.0%	+39.1%	--	+41.8%	+149.9%	+102.9%	+16.6%	-70.0%	+220.8%	-6.7%	-44.4%	+30.2%
Total Revenues	66.7	453.2	4,147.3	13.7	311.3	4,870.4	648.0	312.1	10,000.5	1,755.5	321.9	3,460.3	2,499.6	300.6	1,956.8	2,768.4
	-70.8%	-5.0%	+55.0%	-79.5%	-31.3%	+17.4%	--	+.3%	+105.3%	+170.9%	+3.1%	-65.4%	+42.4%	-6.6%	-43.4%	+10.8%
ANNUAL SHARE, BY DIAMETER	1.4%	9.7%	88.9%	.2%	5.3%	83.4%	11.1%	2.6%	83.0%	14.4%	5.1%	55.2%	39.7%	6.0%	39.0%	55.0%

TABLE 52

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments			Forecast												
				1996				1997			1998			1999		
	8"	5.25"	3.5"	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	--	--	505.0	--	--	1,595.0	520.0	--	2,190.0	2,000.0	--	1,930.0	2,400.0	--	1,290.0	2,450.0
Other U.S. Captive	--	--	222.0	--	--	60.0	--	--	--	--	--	--	--	--	--	--
PCM/Distributor	--	--	856.8	--	175.0	2,980.0	--	260.0	10,240.0	45.0	325.0	3,535.0	165.0	330.0	2,080.0	240.0
OEM/Integrator	--	24.0	2,901.7	--	985.0	7,511.0	80.0	1,457.0	25,080.0	505.0	1,850.0	9,090.0	1,905.0	1,880.0	5,630.0	2,780.0
TOTAL U.S. SHIPMENTS	--	24.0	4,485.5	--	1,160.0	12,146.0	600.0	1,717.0	37,510.0	2,550.0	2,175.0	14,555.0	4,470.0	2,210.0	9,000.0	5,470.0
NON-U.S. MANUFACTURERS																
Captive	2.8	11.9	25.7	.7	7.0	334.2	100.0	3.0	400.0	170.0	--	320.0	460.0	--	240.0	820.0
PCM/Distributor	--	25.0	1.7	--	.2	1,047.0	40.0	--	3,295.0	30.0	--	1,135.0	110.0	--	690.0	160.0
OEM/Integrator	.2	7.2	90.5	--	.4	2,537.0	260.0	--	8,475.0	340.0	--	3,075.0	1,280.0	--	1,880.0	1,820.0
TOTAL NON-U.S. SHIPMENTS	3.0	44.1	117.9	.7	7.6	3,918.2	400.0	3.0	12,170.0	540.0	--	4,530.0	1,850.0	--	2,810.0	2,800.0
WORLDWIDE RECAP																
Captive	2.8	11.9	752.7	.7	7.0	1,989.2	620.0	3.0	2,590.0	2,170.0	--	2,250.0	2,860.0	--	1,530.0	3,270.0
	-64.6%	-76.2%	+58.2%	-75.0%	-41.2%	+164.3%	--	-57.1%	+30.2%	+250.0%	--	-13.1%	+31.8%	--	-32.0%	+14.3%
PCM/Distributor	--	25.0	858.5	--	175.2	4,027.0	40.0	260.0	13,535.0	75.0	325.0	4,670.0	275.0	330.0	2,770.0	400.0
	--	+5.9%	+142.4%	--	+600.8%	+369.1%	--	+48.4%	+236.1%	+87.5%	+25.0%	-65.5%	+266.7%	+1.5%	-40.7%	+45.5%
OEM/Integrator	.2	31.2	2,992.2	--	985.4	10,048.0	340.0	1,457.0	33,555.0	845.0	1,850.0	12,165.0	3,185.0	1,880.0	7,510.0	4,600.0
	-93.7%	-73.5%	+140.5%	--	--	+235.8%	--	+47.9%	+233.9%	+148.5%	+27.0%	-63.7%	+276.9%	+1.6%	-38.3%	+44.4%
Total Shipments	3.0	68.1	4,603.4	.7	1,167.6	16,064.2	1,000.0	1,720.0	49,680.0	3,090.0	2,175.0	19,085.0	6,320.0	2,210.0	11,810.0	8,270.0
	-73.0%	-64.4%	+122.0%	-76.7%	--	+249.0%	--	+47.3%	+209.3%	+209.0%	+26.5%	-61.6%	+104.5%	+1.6%	-38.1%	+30.9%
ANNUAL SHARE, BY DIAMETER	.1%	1.5%	98.4%	--	6.4%	88.2%	5.4%	3.2%	91.3%	5.5%	7.9%	69.3%	22.8%	9.9%	53.1%	37.0%
TOTAL CAPACITY (Terabytes)	8.6	197.0	10,569.1	2.1	2,808.6	36,649.8	2,160.0	3,838.1	109,296.0	6,489.0	5,220.0	45,804.0	14,536.0	5,680.0	30,706.0	20,675.0

TABLE 53

FIXED DISK DRIVES, 2 - 3 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	6.5	.1	--	--
MAINFRAME SYSTEMS				
General purpose	543.2	11.6	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	2,331.2	49.9	445.8	2.0
PERSONAL COMPUTERS				
Business and professional, single user	1,219.1	26.1	17,609.1	79.0
WORKSTATIONS				
Engineering and office, single user	530.1	11.3	891.6	4.0
CONSUMER, GAME AND HOBBY COMPUTERS	7.0	.2	3,343.5	15.0
OTHER APPLICATIONS	37.4	.8	--	--
Total	4,674.5	100.0	22,290.0	100.0

TABLE 54

FIXED DISK DRIVES, 2 - 3 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
8"	8.25	6.52	--	--	--
5.25"	7.70	6.55	4.13	--	--
3.5"	1.18	.32	.21	.15	.13
2.5"	--	.39	.33	.26	.21
Captive Average	1.33	.36	.26	.21	.18
PCM/Distributor					
8"	--	--	--	--	--
5.25"	2.53	.07	.06	.06	.05
3.5"	.25	.10	.08	.06	.05
2.5"	--	.15	.13	.10	.08
PCM/Distributor Average	.33	.10	.08	.06	.05
OEM/Integrator					
8"	1.16	--	--	--	--
5.25"	.51	.06	.07	.06	.05
3.5"	.25	.10	.08	.06	.05
2.5"	--	.14	.12	.09	.08
OEM/Integrator Average	.25	.10	.08	.07	.06

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

TABLE 55

FIXED DISK DRIVES, 2 - 3 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
Drive Manufacturers	8"	5.25"	3.5"	2.5"	Total		8"	5.25"	3.5"	2.5"	Total	
Seagate Technology	--	19.0	1973.0	--	1992.0	67.1	--	24.0	2284.0	--	2308.0	59.1
Quantum	--	--	453.0	--	453.0	15.3	--	--	682.0	--	682.0	17.5
IBM	--	--	165.0	--	165.0	5.6	--	--	265.0	--	265.0	6.8
Hewlett-Packard	--	--	127.0	--	127.0	4.3	--	--	262.0	--	262.0	6.7
Conner Peripherals	--	--	135.0	--	135.0	4.5	--	--	198.0	--	198.0	5.1
Other U.S.	--	--	36.0	--	36.0	1.2	--	--	67.5	--	67.5	1.7
Other Non-U.S.	--	23.1	39.2	--	62.3	2.0	.2	32.2	92.2	--	124.6	3.1
TOTAL	--	42.1	2928.2	--	2970.3	100.0	.2	56.2	3850.7	--	3907.1	100.0

FIXED DISK DRIVES, 3 - 5 GIGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, 3 - 5 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Sequel	5400

3.5" disk diameter

Fujitsu	M2934*, M2954**
Hitachi	DK306-45, DK328C-43**
IBM	DCHS-34550**, DAQA-33240**
Micropolis	3243*, 3343**
NEC	DVF4400S**
Quantum	XP34361S Atlas II**, 4.3S Viking**
Seagate Technology	ST34371W/FC**, ST-34250A*
Western Digital	AC33100**

*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. In 1991, the IBM 3390 series moved to capacities above 5 gigabytes.

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.

5.25" drives above 3 gigabytes appeared for the first time in 1992, and for a few years were offered by most manufacturers active in the markets for high-end disk drives. This product activity was short-lived, as some 5.25" drive manufac-

turers quickly moved to higher capacities and others developed 3.5" drives for this capacity range. The last production of 5.25" drives in the 3-5 gigabyte capacity range is expected this year.

IBM utilized magnetoresistive heads and PRML encoding with the firm's Starfire 4.3 gigabyte 1.625" high 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 4.5 gigabyte Starfire models for delivery in 1995, and also announced 4.5 gigabyte 1" high Scorpion 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 1" high 4.3 and 4.5 gigabyte models. The industry has had a difficult start-up period with these drives, but production is increasing. Despite the initial high degree of technical difficulty, IBM is expected to introduce a 2.5" drive in the 3-5 gigabyte range, probably by the end of 1996.

Market status

Total shipments in the 3-5 gigabyte capacity range achieved a major boost in 1995, up 444.3%, with 1.7 million drives. The upward trend continues in 1996, with the total forecasted at 3.9 million drives, up 131.2%, with midrange and mainframe applications driving demand in both years. Sales revenues rose to $2.4 billion in 1995 and are expected to reach $4.1 billion in 1996.

The mainframe computer market again became a major market for drives in this capacity range in the Autumn of 1995, when IBM introduced the second generation of its RAMAC disk drive array family using Starfire 4.3 gigabyte 3.5" drives. IBM's requirements for the mainframe array program (see Table 74 in the product group for drives with more than 10 gigabytes capacity) have provided a major market for 3.5" drives in this product group. Independent storage subsystem vendors active in the mainframe market have also started to use significant quantities of 3.5 gigabyte disk drives, and both IBM and the independent vendors have also produced growing shipments of disk drives used in scores of arrays and other disk subsystems sold in the network server and midrange system markets.

Mainframe and midrange markets have provided almost all of the growth to date for shipments in this product group, but that's due to change as lower cost drives start to become available for the desktop personal computer market. In 1995, mainframe systems were the application which consumed 22.8% of the product group's shipments, but zero shipments are forecasted for this application in 1999. Networks/midrange systems received 68.9% of 1995 unit shipments, but the 1999 share for this application is expected to be only 4.0%. Workstations received 7.5% of 1995 shipments, but will be down to an estimated 1.9% in 1999. Obviously, the big growth area will be business personal computers, only 0.7% of 1995 shipments, but projected to account for 88.0% of the 1999 total. Consumer computers, which received no significant shipments in 1995, are forecasted to use 6.0% of the total for 1999.

Seagate Technology continues to dominate the noncaptive shipments for this product group, capturing 64.3% in 1995, with all 3.5" drives. Quantum rose to second place with 12.8%, and IBM slumped to third place with 6.9%.

Marketing trends

The mushrooming disk storage requirements of the desktop personal computer market have overwhelmed all of the DISK/TREND product groups in the capacity ranges below 3 gigabytes, and the same thing will happen to this product group. Total shipments are projected to increase 500% in 1997, with shipments of 23.6 million drives, and to jump another 175% in 1998, reaching 65.1 million drives. That's expected to be the peak year, and 1999 is forecasted to drop to 41.7 million units, as typical capacities move up to an even higher capacity range. Sales revenues are also projected to peak in 1998 at $14.2 billion, then decline in 1999 to $8.4 billion.

The changing nature of the products produced and the markets served by this product group can be clearly seen in the evolution of typical unit prices during the forecast period. In 1995, the average OEM unit price for drives in the 3-5 gigabyte capacity range was $842, and the level is declining in 1996 to an estimated $571. In both years, the 3.5" drives involved are almost entirely high-end models. With the advent of high shipment levels for 3.5" drives used in personal computers starting next year, the average unit price is forecasted to

drop to $250 in 1997, sinking to $163 in 1999. The same change in product mix will drive the average price per megabyte from 19 cents in 1995 to 3 cents in 1999. The advent of 3.5" drives with very competitive pricing for the personal computer market is also expected to prompt the introduction of low cost 5.25" drives for the same market. These drives will be an extension of similar programs now in existence at lower capacity levels, and are forecasted to start in 1998.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
5.25"	11.4 .7%	.2 --	-- --	1,215.0 1.9%	2,925.0 7.0%
3.5"	1,687.4 99.3%	3,877.0 98.8%	22,180.0 94.1%	60,950.0 93.7%	32,530.0 78.1%
2.5"	-- --	50.0 1.2%	1,420.0 5.9%	2,935.0 4.4%	6,230.0 14.9%
Total	1,698.8	3,927.2	23,600.0	65,100.0	41,685.0

The industry's highest areal densities have been utilized in 2.5" drives developed by IBM since 1994, and IBM has already moved areal densities up to 1.3 gigabits per square inch with drives below the capacity level of this product group which are scheduled for first shipment in June, 1996. IBM also has a project to introduce, by the end of this year, 2.5" drives with slightly higher areal densities, using more disks, with drive capacities in this product group. It is expected that IBM's lead will be followed by the other leading 2.5" drive manufacturers next year, and the notebook computer market will be able to move up to another disk capacity level. By 1999, 2.5" drive shipments are projected at 6.2 million units.

Technical trends

It is expected that the high performance disk drives which remain in this product group will be improved, but that the highest priority will be placed on improvements designed to lower product costs. Well before the end of the this forecast period, 3.5" drives for high-end applications will be available with only one disk, reducing parts count to a minimum. Such drives will be priced signifi-

cantly lower than today's high-end models, with higher reliability, and they may provide performance enhancements not yet in today's production drives. One such enhancement will probably be rotation speeds in the 10,000 RPM range, offering major improvement to today's latencies and transfer rates, with the first availability expected within a year.

Another type of product development effort will be devoted to the 3.5" and 2.5" drives targeted at the desktop personal computer and the notebook computer markets. With low product cost as the overriding objective, these programs will stress attempts to achieve the lowest possible drive parts count consistent with areal densities which can be manufactured with high yields. The new drives will also utilize performance levels which can be produced at high yields with readily available components.

Forecasting assumptions

1. IBM and other manufacturers of high-end drives will be successful in improving areal density utilized in drives by an average of 60% per year, and most high-end drives will be single disk models before 1999.
2. Production of high-end 3.5" drives in this capacity range will continue through 1999, but starting in 1997 a high proportion of 3.5" drives will be designed for lower cost personal computer applications.
3. Shipment of existing 5.25" drives will end in 1996. Shipments of low-cost 5.25" drives intended to compete with 3.5" drives for personal computer applications will commence in 1998.
4. The first 2.5" drives in this product group will be shipped by IBM by the end of 1996, with other manufacturers commencing shipments in 1997, resulting in continuing growth through 1999.

TABLE 56

FIXED DISK DRIVES, 3 - 5 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	796.5	1,149.0	1,429.8	2,140.5	1,437.9	2,076.2	1,630.8	2,430.6	1,271.6	1,939.1
Other U.S. Captive	--	--	--	--	15.0	20.0	16.4	28.7	15.3	24.5
TOTAL U.S. CAPTIVE	796.5	1,149.0	1,429.8	2,140.5	1,452.9	2,096.2	1,647.2	2,459.3	1,286.9	1,963.6
PCM/Distributor	237.0	328.1	240.6	344.7	773.1	1,106.7	1,568.2	2,413.1	683.5	1,130.0
OEM/Integrator	728.7	853.4	856.2	1,114.4	2,081.8	2,775.9	4,397.8	5,932.7	2,280.3	3,251.8
TOTAL U.S. NONCAPTIVE	965.7	1,181.5	1,096.8	1,459.1	2,854.9	3,882.6	5,966.0	8,345.8	2,963.8	4,381.8
TOTAL U.S. REVENUES	1,762.2	2,330.5	2,526.6	3,599.6	4,307.8	5,978.8	7,613.2	10,805.1	4,250.7	6,345.4
Non-U.S. Manufacturers										
Captive	--	6.8	--	88.8	8.0	228.3	48.8	478.3	89.9	478.2
PCM/Distributor	44.4	49.4	158.8	189.4	200.9	369.7	431.9	790.8	194.2	365.5
OEM/Integrator	17.1	41.4	133.0	231.9	678.2	1,104.2	1,358.0	2,156.8	652.0	1,172.1
TOTAL NON-U.S. REVENUES	61.5	97.6	291.8	510.1	887.1	1,702.2	1,838.7	3,425.9	936.1	2,015.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	1,823.7	2,428.1	2,818.4	4,109.7	5,194.9	7,681.0	9,451.9	14,231.0	5,186.8	8,361.2
OEM Average Price ($000)		.842		.571		.250		.186		.163

TABLE 57

FIXED DISK DRIVES, 3 - 5 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	165.0	240.0	530.0	780.0	1,300.0	1,880.0	2,605.0	3,890.0	2,935.0	4,460.0
Other U.S. Captive	--	--	--	--	15.0	20.0	20.0	35.0	25.0	40.0
TOTAL U.S. CAPTIVE	165.0	240.0	530.0	780.0	1,315.0	1,900.0	2,625.0	3,925.0	2,960.0	4,500.0
PCM/Distributor	267.5	369.0	415.0	595.0	3,110.0	4,450.0	8,325.0	12,810.0	4,275.0	7,075.0
OEM/Integrator	869.8	1,015.0	1,505.2	1,955.2	8,580.0	11,440.0	24,165.0	32,610.0	14,180.0	20,320.0
TOTAL U.S. NONCAPTIVE	1,137.3	1,384.0	1,920.2	2,550.2	11,690.0	15,890.0	32,490.0	45,420.0	18,455.0	27,395.0
TOTAL U.S. SHIPMENTS	1,302.3	1,624.0	2,450.2	3,330.2	13,005.0	17,790.0	35,115.0	49,345.0	21,415.0	31,895.0
Non-U.S. Manufacturers										
Captive	--	2.5	--	48.0	10.0	300.0	65.0	800.0	145.0	900.0
PCM/Distributor	22.2	24.7	112.0	147.0	795.0	1,460.0	2,242.0	4,095.0	1,180.0	2,195.0
OEM/Integrator	20.1	47.6	232.0	402.0	2,500.0	4,050.0	6,905.0	10,860.0	3,885.0	6,695.0
TOTAL NON-U.S. SHIPMENTS	42.3	74.8	344.0	597.0	3,305.0	5,810.0	9,212.0	15,755.0	5,210.0	9,790.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1,344.6	1,698.8	2,794.2	3,927.2	16,310.0	23,600.0	44,327.0	65,100.0	26,625.0	41,685.0
Total Capacity (Terabytes)	5,656.0	7,119.9	11,494.0	16,128.4	66,324.9	95,904.6	189,673.5	278,258.2	118,658.0	185,187.0
Cumulative Shipments (Units in millions)										
IBM	.4	.6	.9	1.4	2.2	3.3	4.8	7.2	7.8	11.6
Non-IBM	1.4	1.7	3.6	4.9	18.6	26.6	60.4	87.8	84.1	125.0
WORLDWIDE TOTAL	1.8	2.4	4.6	6.3	20.9	29.9	65.2	95.0	91.9	136.7

TABLE 58

FIXED DISK DRIVES, 3 - 5 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues		Forecast											
			1996			1997		1998			1999			
	5.25"	3.5"	5.25"	3.5"	2.5"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS														
IBM Captive	--	1,149.0	--	2,091.5	49.0	1,795.0	281.2	--	1,366.6	1,064.0	--	731.6	1,207.5
Other U.S. Captive	--	--	--	--	--	20.0	--	--	28.7	--	--	24.5	--
PCM/Distributor	3.5	324.6	--	344.7	--	1,091.2	15.5	33.3	2,363.2	16.6	66.4	1,020.7	42.9
OEM/Integrator	7.5	845.9	.2	1,114.2	--	2,613.6	162.3	182.3	5,565.6	184.8	367.8	2,420.5	463.5
TOTAL U.S. REVENUES	11.0	2,319.5	.2	3,550.4	49.0	5,519.8	459.0	215.6	9,324.1	1,265.4	434.2	4,197.3	1,713.9
NON-U.S. MANUFACTURERS														
Captive	--	6.8	--	88.8	--	196.3	32.0	--	313.2	165.1	--	180.6	297.6
PCM/Distributor	--	49.4	--	189.4	--	360.3	9.4	--	778.6	12.2	--	337.0	28.5
OEM/Integrator	1.3	40.1	--	231.9	--	993.6	110.6	--	2,031.9	124.9	--	856.0	316.1
TOTAL NON-U.S. REVENUES	1.3	96.3	--	510.1	--	1,550.2	152.0	--	3,123.7	302.2	--	1,373.6	642.2
WORLDWIDE RECAP														
Captive	--	1,155.8	--	2,180.3	49.0	2,011.3	313.2	--	1,708.5	1,229.1	--	936.7	1,505.1
	--	+435.1%	--	+88.6%	--	-7.8%	+539.2%	--	-15.1%	+292.4%	--	-45.2%	+22.5%
PCM/Distributor	3.5	374.0	--	534.1	--	1,451.5	24.9	33.3	3,141.8	28.8	66.4	1,357.7	71.4
	-97.8%	+335.4%	--	+42.8%	--	+171.8%	--	--	+116.5%	+15.7%	+99.4%	-56.8%	+147.9%
OEM/Integrator	8.8	886.0	.2	1,346.1	--	3,607.2	272.9	182.3	7,597.5	309.7	367.8	3,276.5	779.6
	-26.7%	+767.8%	-97.7%	+51.9%	--	+168.0%	--	--	+110.6%	+13.5%	+101.8%	-56.9%	+151.7%
Total Revenues	12.3	2,415.8	.2	4,060.5	49.0	7,070.0	611.0	215.6	12,447.8	1,567.6	434.2	5,570.9	2,356.1
	-93.8%	+498.0%	-98.4%	+68.1%	--	+74.1%	--	--	+76.1%	+156.6%	+101.4%	-55.2%	+50.3%
ANNUAL SHARE, BY DIAMETER	.5%	99.5%	--	98.9%	1.1%	92.1%	7.9%	1.5%	87.6%	10.9%	5.2%	66.7%	28.1%

TABLE 59

FIXED DISK DRIVES, 3 - 5 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments		Forecast										
			1996			1997		1998			1999		
	5.25"	3.5"	5.25"	3.5"	2.5"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS													
IBM Captive	--	240.0	--	730.0	50.0	1,500.0	380.0	--	2,370.0	1,520.0	--	2,360.0	2,100.0
Other U.S. Captive	--	--	--	--	--	20.0	--	--	35.0	--	--	40.0	--
PCM/Distributor	3.5	365.5	--	595.0	--	4,400.0	50.0	185.0	12,570.0	55.0	440.0	6,460.0	175.0
OEM/Integrator	7.5	1,007.5	.2	1,955.0	--	10,890.0	550.0	1,030.0	30,920.0	660.0	2,485.0	15,820.0	2,015.0
TOTAL U.S. SHIPMENTS	11.0	1,613.0	.2	3,280.0	50.0	16,810.0	980.0	1,215.0	45,895.0	2,235.0	2,925.0	24,680.0	4,290.0
NON-U.S. MANUFACTURERS													
Captive	--	2.5	--	48.0	--	260.0	40.0	--	580.0	220.0	--	420.0	480.0
PCM/Distributor	--	24.7	--	147.0	--	1,430.0	30.0	--	4,055.0	40.0	--	2,080.0	115.0
OEM/Integrator	.4	47.2	--	402.0	--	3,680.0	370.0	--	10,420.0	440.0	--	5,350.0	1,345.0
TOTAL NON-U.S. SHIPMENTS	.4	74.4	--	597.0	--	5,370.0	440.0	--	15,055.0	700.0	--	7,850.0	1,940.0
WORLDWIDE RECAP													
Captive	--	242.5	--	778.0	50.0	1,780.0	420.0	--	2,985.0	1,740.0	--	2,820.0	2,580.0
	--	+304.2%	--	+220.8%	--	+128.8%	+740.0%	--	+67.7%	+314.3%	--	-5.5%	+48.3%
PCM/Distributor	3.5	390.2	--	742.0	--	5,830.0	80.0	185.0	16,625.0	95.0	440.0	8,540.0	290.0
	-95.1%	+451.9%	--	+90.2%	--	+685.7%	--	--	+185.2%	+18.8%	+137.8%	-48.6%	+205.3%
OEM/Integrator	7.9	1,054.7	.2	2,357.0	--	14,570.0	920.0	1,030.0	41,340.0	1,100.0	2,485.0	21,170.0	3,360.0
	-16.0%	--	-97.5%	+123.5%	--	+518.2%	--	--	+183.7%	+19.6%	+141.3%	-48.8%	+205.5%
Total Shipments	11.4	1,687.4	.2	3,877.0	50.0	22,180.0	1,420.0	1,215.0	60,950.0	2,935.0	2,925.0	32,530.0	6,230.0
	-87.4%	+664.9%	-98.2%	+129.8%	--	+472.1%	--	--	+174.8%	+106.7%	+140.7%	-46.6%	+112.3%
ANNUAL SHARE, BY DIAMETER	.7%	99.3%	--	98.8%	1.2%	94.1%	5.9%	1.9%	93.7%	4.4%	7.0%	78.1%	14.9%
TOTAL CAPACITY (Terabytes)	36.9	7,083.0	.7	15,940.1	187.6	90,527.6	5,377.0	4,374.0	261,861.2	12,023.0	10,530.0	146,629.0	28,028.0

TABLE 60

FIXED DISK DRIVES, 3 - 5 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	.8	.1	41.7	.1
MAINFRAME SYSTEMS				
General purpose	388.0	22.8	--	--
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	1,170.7	68.9	1,667.4	4.0
PERSONAL COMPUTERS				
Business and professional, single user	11.6	.7	36,682.8	88.0
WORKSTATIONS				
Engineering and office, single user	127.4	7.5	792.0	1.9
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	2,501.1	6.0
OTHER APPLICATIONS	--	--	--	--
Total	1,698.7	100.0	41,685.0	100.0

TABLE 61

FIXED DISK DRIVES, 3 - 5 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
5.25"	--	--	--	--	--
3.5"	1.37	.76	.29	.13	.07
2.5"	--	.26	.19	.17	.13
Captive Average	1.37	.73	.27	.15	.10
PCM/Distributor					
5.25"	.33	--	--	.05	.04
3.5"	.22	.17	.06	.04	.03
2.5"	--	--	.08	.07	.05
PCM/Distributor Average	.22	.17	.06	.04	.03
OEM/Integrator					
5.25"	.33	.28	--	.04	.04
3.5"	.19	.13	.06	.04	.03
2.5"	--	--	.07	.06	.05
OEM/Integrator Average	.19	.13	.06	.04	.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.

TABLE 62

FIXED DISK DRIVES, 3 - 5 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	5.25"	3.5"	Total		5.25"	3.5"	Total	
Seagate Technology	--	834.0	834.0	70.7	--	937.0	937.0	64.3
Quantum	--	126.0	126.0	10.7	--	186.0	186.0	12.8
IBM	--	63.0	63.0	5.3	--	100.0	100.0	6.9
Conner Peripherals	--	70.0	70.0	5.9	--	92.0	92.0	6.3
Micropolis	5.5	36.0	41.5	3.5	8.0	58.0	66.0	4.5
Other U.S.	2.8	--	2.8	.2	3.0	--	3.0	.2
Other Non-U.S.	--	42.3	42.3	3.7	.4	71.9	72.3	5.0
TOTAL	8.3	1171.3	1179.6	100.0	11.4	1444.9	1456.3	100.0

FIXED DISK DRIVES, 5 - 10 GIGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, 5 - 10 GIGABYTES

Coverage

5.25" disk diameter

Micropolis	1991
Seagate Technology	ST410800N/W

3.5" disk diameter

Fujitsu	M2948S*, M2949S*
Hewlett-Packard	C3653*
IBM	DCHS-39100*
Micropolis	3391*
Quantum	XP39100S Atlas II*
Seagate Technology	ST19171N/FC*

*Maximum 41.3 mm height, or less.

Established as a separate DISK/TREND product group for the first time this year, the 5-10 gigabyte capacity range didn't exist as a disk drive industry product area until IBM introduced the 3390-3 in 1991, using 10.8" disks, with 5,676 megabytes capacity. The 3390-3 stayed in production until 1995, and during most of that period was IBM's primary disk drive for the mainframe computer market. IBM's introduction in Autumn, 1994, of the company's first disk drive array subsystem for mainframe applications under the recycled RAMAC name effectively replaced IBM's older large diameter disk drives with arrays of lower capacity 3.5" drives.

A major share of the sales activity in this capacity range during the last two years has been generated by 9 gigabyte 5.25" drives, the Seagate Elite 9 and the Micropolis Scorpio 9. These drives appeared in mid-1994, and have been widely used in arrays and other storage subsystems for mainframe, midrange and network file server applications, offering the most competitive price per megabyte available. IBM skipped 5.25" drives in this range and preannounced an 8.7 gigabyte 3.5" drive in late 1994, later changing the specification to 9.1 gigabytes in late 1995. Comparable drives have been introduced by five additional manufacturers, with production programs at varying stages of readiness.

Market status

1995 shipments in the 5-10 gigabyte capacity range consisted of 328,800 drives, mostly 5.25" models. The 1996 total is projected at 1.4 million drives, with growth in 5.25" drive shipments still under way, but supplemented by over a million 3.5" drives. Sales revenues are expected to jump from 1995's $626 million to $2.4 billion in 1996.

Specific actions by only a few companies will be instrumental in the assumptions underlying the shipment forecasts for 1996 in this product group. It is expected that IBM will start to utilize 3.5" drives in this group to double the capacity currently offered with the RAMAC mainframe disk drive arrays (see Table 74 in the product group for drives with more than 10 gigabytes capacity). It is expected that the 5.25" Seagate Elite 9 shipments to independent vendors of mainframe storage subsystems will increase only modestly and will peak in 1996, following the introduction of the Elite 23. It is assumed that IBM and the other manufacturers who have announced 3.5" drives in this capacity range will actually be able to deliver more than a million drives this year. Significant deviations from these assumptions will affect the outlook for the product group.

The mix of applications for this product group will be completely changed by the end of the current forecast period, as personal computers become a major market for the low cost drives expected by 1999. 49.6% of the product group's 1995 shipments were used with mainframe computers, but the share for mainframes will drop to 0.5% in 1999, despite an increase in the quantities utilized for this application. A similar phenomenon is expected with network/midrange systems, with 1995's 47.5% share of unit shipments dropping to 1.5% in 1999. Personal computers are expected to rise from zero share in 1995 to 96.0% in 1999.

Seagate Technology maintained a strong lead in noncaptive unit shipments in 1995, with 86.1% of the worldwide total, all 5.25" drives, followed by second place Micropolis, with 12.3%.

Marketing trends

Although all disk drives currently produced for sale in this capacity range are high performance models, currently the disk drive industry's leading edge

products, it is expected that by 1999 low cost drives designed for personal computer applications will dominate the group's product mix. Unit shipments are expected to increase at an annual average rate of 325% during the 1997-99 period, with 1999 unit shipments projected at 65 million drives. Sales revenues are forecasted at $28.3 billion in 1999, 45.5% of the disk drive industry's revenue total for that year.

As with all DISK/TREND product groups, the product mix is expected to undergo striking changes. 5.25" drives are projected to decline to an insignificant shipment level. 3.5" drives will become 96.5% of the product group's shipments. The group's first 2.5" disk drive shipments are predicted for 1998, rising the next year to over 2 million drives.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
10.8"	3.5	--	--	--	--
	1.1%	--	--	--	--
5.25"	325.0	390.0	220.0	80.0	15.0
	98.9%	27.5%	5.4%	.2%	--
3.5"	.3	1,029.0	3,880.0	31,810.0	62,645.0
	--	72.5%	94.6%	98.9%	96.5%
2.5"	--	--	--	320.0	2,330.0
	--	--	--	.9%	3.5%
Total	328.8	1,419.0	4,100.0	32,210.0	64,990.0

The fact that separate high performance and low cost 3.5" disk drive types will coexist in this product group during the 1997-99 period means that the price per megabyte calculations which apply to noncaptive drive shipments during those years will be composite figures. The OEM/Integrator average price per megabyte for 3.5" drives in 1995 was 18 cents, dropping to an estimated 10 cents in 1996.

DISK/TREND calculates price per megabyte by totaling all applicable sales revenues and dividing by the total capacity of all drives shipped of the type being measured. Therefore, the 1995 and 1996 figures represent only high performance 3.5" drives, the type actually available during those years. However, the combination of high performance and low cost 3.5" drives which will be shipped

in subsequent years will represent just that: A combination. The resulting average prices per megabyte will therefore also be a combination figure.

Technical trends

During the last few years, the most challenging product development problems for the disk drive industry were presented by the capacities in this product group. As the industry moves up in recording density and drive performance objectives, it is always necessary to solve new problems in numerous technical areas, including the head/disk interface, track density/head positioning, semiconductor data rates, new encoding methods, magnetic/electrical interference, new interface requirements, and a myriad of other electronic and mechanical engineering considerations. In addition, there is the challenge of developing and securing reliable supplies of many new components, never previously in quantity production.

Many of these challenges will continue to affect product development efforts for this capacity range, especially during the next year or two. But the industry's leading edge is already moving up to high capacities, with 3.5" drives above 10 gigabytes expected within the next year. In future years, many of the new products for the 5-10 gigabyte range will be depopulated models derived from development programs initiated for higher capacity targets. The completely different development activities targeted at low cost 3.5" and 2.5" drives will also have a major impact on this product group in future years. The basic objectives for such programs will be efficient manufacturing of drives designed at about half of the leading edge areal density achieved in production drives each year.

Forecasting assumptions

1. IBM will double the capacity of the RAMAC mainframe array in 1996, using 3.5" disk drives in this group, and will also utilize its 3.5" drives in network servers and midrange systems.
2. 5.25" drive shipments will peak in 1996, then decline in shipments through 1999, as sales momentum moves to higher capacity 5.25" and 3.5" drives.
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 5-10 gigabyte capacities will exceed one million units in 1996 and will continue to grow through 1999, dominated by shipments of low cost models for personal computer applications starting in 1998.

5. The first 2.5" drives in this product group will be shipped in 1998, with shipments growing to at least two million drives in 1999.

TABLE 63

FIXED DISK DRIVES, 5 - 10 GIGABYTES·

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast 1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	39.1	59.5	591.1	851.0	2,006.5	2,959.0	1,963.0	2,926.0	3,009.8	4,562.6
Other U.S. Captive	--	--	175.0	185.5	210.0	238.0	276.0	312.0	388.5	441.0
TOTAL U.S. CAPTIVE	39.1	59.5	766.1	1,036.5	2,216.5	3,197.0	2,239.0	3,238.0	3,398.3	5,003.6
PCM/Distributor	191.1	215.9	193.1	263.4	250.3	342.4	1,456.9	2,085.4	2,256.5	3,316.5
OEM/Integrator	309.3	328.1	801.0	911.3	918.8	1,125.9	6,005.6	7,510.8	9,238.5	12,301.5
TOTAL U.S. NONCAPTIVE	500.4	544.0	994.1	1,174.7	1,169.1	1,468.3	7,462.5	9,596.2	11,495.0	15,618.0
TOTAL U.S. REVENUES	539.5	603.5	1,760.2	2,211.2	3,385.6	4,665.3	9,701.5	12,834.2	14,893.3	20,621.6
Non-U.S. Manufacturers										
Captive	--	--	--	--	155.0	248.0	247.9	451.6	448.7	887.2
PCM/Distributor	22.5	22.5	22.6	30.8	58.0	80.0	449.5	692.2	797.5	1,452.5
OEM/Integrator	--	--	82.6	126.1	162.4	251.1	1,625.9	2,503.4	3,420.9	5,316.1
TOTAL NON-U.S. REVENUES	22.5	22.5	105.2	156.9	375.4	579.1	2,323.3	3,647.2	4,667.1	7,655.8
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	562.0	626.0	1,865.4	2,368.1	3,761.0	5,244.4	12,024.8	16,481.4	19,560.4	28,277.4
OEM Average Price ($000)		1.646		1.035		.533		.407		.356

TABLE 64

FIXED DISK DRIVES, 5 - 10 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995 Shipments		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	2.3	3.5	113.0	160.0	480.0	705.0	795.0	1,180.0	1,780.0	2,700.0
Other U.S. Captive	--	--	50.0	53.0	75.0	85.0	115.0	130.0	185.0	210.0
TOTAL U.S. CAPTIVE	2.3	3.5	163.0	213.0	555.0	790.0	910.0	1,310.0	1,965.0	2,910.0
PCM/Distributor	106.5	121.0	130.0	175.0	370.0	520.0	3,215.0	4,600.0	5,780.0	8,500.0
OEM/Integrator	187.8	199.3	755.0	860.0	1,685.0	2,085.0	14,755.0	18,455.0	26,038.0	34,670.0
TOTAL U.S. NONCAPTIVE	294.3	320.3	885.0	1,035.0	2,055.0	2,605.0	17,970.0	23,055.0	31,818.0	43,170.0
TOTAL U.S. SHIPMENTS	296.6	323.8	1,048.0	1,248.0	2,610.0	3,395.0	18,880.0	24,365.0	33,783.0	46,080.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	50.0	80.0	95.0	180.0	230.0	500.0
PCM/Distributor	5.0	5.0	21.0	29.0	95.0	130.0	995.0	1,535.0	1,995.0	3,635.0
OEM/Integrator	--	--	92.0	142.0	320.0	495.0	3,980.0	6,130.0	9,505.0	14,775.0
TOTAL NON-U.S. SHIPMENTS	5.0	5.0	113.0	171.0	465.0	705.0	5,070.0	7,845.0	11,730.0	18,910.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	301.6	328.8	1,161.0	1,419.0	3,075.0	4,100.0	23,950.0	32,210.0	45,513.0	64,990.0
Total Capacity (Terabytes)	2,730.8	2,973.9	10,247.1	12,468.8	26,862.1	35,711.8	190,906.3	256,613.2	318,540.1	454,793.3
Cumulative Shipments (Units in millions)										
IBM	.1	.2	.2	.3	.7	1.0	1.5	2.2	3.3	4.9
Non-IBM	.3	.4	1.4	1.7	4.0	5.0	27.1	36.1	70.9	98.4
WORLDWIDE TOTAL	.5	.6	1.6	2.0	4.7	6.1	28.6	38.3	74.2	103.3

TABLE 65

FIXED DISK DRIVES, 5 - 10 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues			Forecast									
				1996		1997		1998			1999		
	>=10"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS													
IBM Captive	59.5	--	--	--	851.0	--	2,959.0	--	2,755.0	171.0	--	3,850.0	712.6
Other U.S. Captive	--	--	--	--	185.5	--	238.0	--	312.0	--	--	441.0	--
PCM/Distributor	--	215.9	--	117.0	146.4	64.0	278.4	22.5	2,061.0	1.9	7.0	3,295.5	14.0
OEM/Integrator	--	327.6	.5	366.0	545.3	170.5	955.4	57.8	7,415.6	37.4	10.0	12,000.8	290.7
TOTAL U.S. REVENUES	59.5	543.5	.5	483.0	1,728.2	234.5	4,430.8	80.3	12,543.6	210.3	17.0	19,587.3	1,017.3
NON-U.S. MANUFACTURERS													
Captive	--	--	--	--	--	--	248.0	--	432.0	19.6	--	736.0	151.2
PCM/Distributor	--	22.5	--	5.5	25.3	8.0	72.0	4.0	686.3	1.9	--	1,448.0	4.5
OEM/Integrator	--	--	--	8.2	117.9	12.0	239.1	4.0	2,490.9	8.5	--	5,216.4	99.7
TOTAL NON-U.S. REVENUES	--	22.5	--	13.7	143.2	20.0	559.1	8.0	3,609.2	30.0	--	7,400.4	255.4
WORLDWIDE RECAP													
Captive	59.5	--	--	--	1,036.5	--	3,445.0	--	3,499.0	190.6	--	5,027.0	863.8
	-92.4%	--	--	--	--	--	+232.4%	--	+1.6%	--	--	+43.7%	+353.2%
PCM/Distributor	--	238.4	--	122.5	171.7	72.0	350.4	26.5	2,747.3	3.8	7.0	4,743.5	18.5
	--	-49.2%	--	-48.6%	--	-41.2%	+104.1%	-63.2%	+684.0%	--	-73.6%	+72.7%	+386.8%
OEM/Integrator	--	327.6	.5	374.2	663.2	182.5	1,194.5	61.8	9,906.5	45.9	10.0	17,217.2	390.4
	--	+209.9%	--	+14.2%	--	-51.2%	+80.1%	-66.1%	+729.3%	--	-83.8%	+73.8%	+750.5%
Total Revenues	59.5	566.0	.5	496.7	1,871.4	254.5	4,989.9	88.3	16,152.8	240.3	17.0	26,987.7	1,272.7
	-93.4%	-1.6%	--	-12.2%	--	-48.8%	+166.6%	-65.3%	+223.7%	--	-80.7%	+67.1%	+429.6%
ANNUAL SHARE, BY DIAMETER	9.5%	90.5%	--	21.0%	79.0%	4.9%	95.1%	.5%	98.1%	1.4%	.1%	95.5%	4.4%

Note: ">=" indicates "greater than or equal to".

TABLE 66

FIXED DISK DRIVES, 5 - 10 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments			Forecast									
				1996		1997		1998			1999		
	>=10"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
U.S. MANUFACTURERS													
IBM Captive	3.5	--	--	--	160.0	--	705.0	--	1,000.0	180.0	--	1,750.0	950.0
Other U.S. Captive	--	--	--	--	53.0	--	85.0	--	130.0	--	--	210.0	--
PCM/Distributor	--	121.0	--	65.0	110.0	40.0	480.0	15.0	4,580.0	5.0	5.0	8,450.0	45.0
OEM/Integrator	--	199.0	.3	305.0	555.0	155.0	1,930.0	55.0	18,310.0	90.0	10.0	33,805.0	855.0
TOTAL U.S. SHIPMENTS	3.5	320.0	.3	370.0	878.0	195.0	3,200.0	70.0	24,020.0	275.0	15.0	44,215.0	1,850.0
NON-U.S. MANUFACTURERS													
Captive	--	--	--	--	--	--	80.0	--	160.0	20.0	--	320.0	180.0
PCM/Distributor	--	5.0	--	8.0	21.0	10.0	120.0	5.0	1,525.0	5.0	--	3,620.0	15.0
OEM/Integrator	--	--	--	12.0	130.0	15.0	480.0	5.0	6,105.0	20.0	--	14,490.0	285.0
TOTAL NON-U.S. SHIPMENTS	--	5.0	--	20.0	151.0	25.0	680.0	10.0	7,790.0	45.0	--	18,430.0	480.0
WORLDWIDE RECAP													
Captive	3.5	--	--	--	213.0	--	870.0	--	1,290.0	200.0	--	2,280.0	1,130.0
	-89.7%	--	--	--	--	--	+308.5%	--	+48.3%	--	--	+76.7%	+465.0%
PCM/Distributor	--	126.0	--	73.0	131.0	50.0	600.0	20.0	6,105.0	10.0	5.0	12,070.0	60.0
	--	+410.1%	--	-42.1%	--	-31.5%	+358.0%	-60.0%	+917.5%	--	-75.0%	+97.7%	+500.0%
OEM/Integrator	--	199.0	.3	317.0	685.0	170.0	2,410.0	60.0	24,415.0	110.0	10.0	48,295.0	1,140.0
	--	+372.7%	--	+59.3%	--	-46.4%	+251.8%	-64.7%	+913.1%	--	-83.3%	+97.8%	+936.4%
Total Shipments	3.5	325.0	.3	390.0	1,029.0	220.0	3,880.0	80.0	31,810.0	320.0	15.0	62,645.0	2,330.0
	-91.4%	+386.5%	--	+20.0%	--	-43.6%	+277.1%	-63.6%	+719.8%	--	-81.2%	+96.9%	+628.1%
ANNUAL SHARE, BY DIAMETER	1.1%	98.9%	--	27.6%	72.4%	5.4%	94.6%	.2%	98.9%	.9%	--	96.5%	3.5%
TOTAL CAPACITY (Terabytes)	19.9	2,951.4	2.6	3,545.1	8,923.7	1,999.8	33,712.0	727.2	253,806.0	2,080.0	136.3	439,512.0	15,145.0

Note: ">=" indicates "greater than or equal to".

TABLE 67

FIXED DISK DRIVES, 5 - 10 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	162.9	49.6	325.0	.5
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	156.3	47.5	974.9	1.5
PERSONAL COMPUTERS				
Business and professional, single user	--	--	62,390.3	96.0
WORKSTATIONS				
Engineering and office, single user	9.6	2.9	649.9	1.0
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	649.9	1.0
OTHER APPLICATIONS	--	--	--	--
Total	328.8	100.0	64,990.0	100.0

TABLE 68

FIXED DISK DRIVES, 5 - 10 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
>=10"	2.99	--	--	--	--
5.25"	--	--	--	--	--
3.5"	--	.63	.52	.36	.29
2.5"	--	--	--	.14	.11
Captive Average	2.99	.63	.52	.33	.24
PCM/Distributor					
>=10"	--	--	--	--	--
5.25"	.20	.18	.15	.14	.15
3.5"	--	.14	.06	.05	.05
2.5"	--	--	--	.05	.04
PCM/Distributor Average	.20	.16	.07	.05	.05
OEM/Integrator					
>=10"	--	--	--	--	--
5.25"	.18	.13	.11	.11	.11
3.5"	.18	.10	.05	.05	.05
2.5"	--	--	--	.06	.05
OEM/Integrator Average	.18	.11	.05	.05	.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.

">=" indicates "greater than or equal to".

TABLE 69

FIXED DISK DRIVES, 5 - 10 GIGABYTES

MARKET SHARE SUMMARY
Worldwide Shipments of Noncaptive Disk Drives

	1995 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
Drive Manufacturers	5.25"	3.5"	Total		5.25"	3.5"	Total	
Seagate Technology	265.0	--	265.0	88.5	280.0	--	280.0	86.1
Micropolis	29.0	--	29.0	9.7	40.0	--	40.0	12.3
Other U.S.	--	.3	.3	.1	--	.3	.3	.1
Other Non-U.S.	5.0	--	5.0	1.7	5.0	--	5.0	1.5
TOTAL	299.0	.3	299.3	100.0	325.0	.3	325.3	100.0

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

1996 DISK/TREND REPORT

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

Coverage

Examples of disk drives in this group include:

5.25" disk diameter

Seagate Technology	ST423451N/W/FC

At the time this edition of the DISK/TREND Report is released there are no disk drives with more than 10 gigabytes capacity in production -- but the product group has both a past and a future. In 1993, IBM introduced the 3390-9, a final attempt to extend the life of the 3390 10.8" disk drive family, for a number of years IBM's primary disk drive series for mainframe applications. The 3390-9 was the first member of the family to use magnetoresistive heads, and capacity was increased threefold to 17 gigabytes. Unfortunately, the drive's improved capacity and price per megabyte came at the expense of a drastic reduction in performance, a strategy which found limited acceptance in the mainframe world, and 1995 saw the end of the 3390-9.

Currently, Seagate Technology's 5.25" Elite 23, a 23 gigabyte descendant of the company's successful Elite 9, has been announced for availability in mid-1996. The Elite 23 will offer the industry's best price per megabyte to date, and is expected to be widely used in established mainframe, network server and mid-range applications, plus new video server and imaging markets. Long term, however, the main event in this product group will be the 3.5" drives expected to be introduced during the coming year, which will rapidly become the major participants in the more than 10 gigabyte market.

Market status

In 1995, the only activity in this product group was IBM's close out of the 3390-9, generating shipments of an estimated 1,500 units. It is currently assumed that Seagate's Elite 23 will be the only disk drive with more than 10 gigabytes capacity which will actually be shipped during 1996, with deliveries scheduled to start during the third quarter of the year. If shipments start on time, the established sales momentum of the Elite family is expected to generate

shipments of 40,000 drives during the remainder of 1996, with sales revenues of $76 million.

Marketing trends

The shipment activity level for this product group is expected to pick up rapidly starting in 1997, with shipments climbing to a forecasted 650,000 drives. By 1999, it is projected that the nature of the group's product mix and customer base will have changed drastically, with disk drives designed for competitive desktop personal computer markets a strong majority of total shipments. 1999 shipments are projected at 30.8 million drives, with sales revenues of $18.1 billion.

Worldwide total unit shipments (000)	1995	1996	1997	1998	1999
10.8"	1.5	--	--	--	--
	100.0%	--	--	--	--
5.25"	--	40.0	90.0	110.0	60.0
	--	100.0%	13.8%	2.5%	.2%
3.5"	--	--	560.0	4,230.0	30,735.0
	--	--	86.2%	97.5%	99.8%
Total	1.5	40.0	650.0	4,430.0	30,795.0

Disk drives designed for high-end applications will continue to have a major role in this product group even after their shipment quantities are dwarfed by low-end drives for personal computer applications. All of the forecasted 5.25" drive shipments in this product group are expected to be used in high-end applications. The 15-18 gigabyte high-end 3.5" drives expected to be in production within the next year will probably be utilized in mainframe disk drive array subsystems by 1998 (see Table 74, drives with 8,514 megabytes available capacity) by IBM and others, and will also find extensive usage in network file servers and midrange systems.

Nevertheless, the low-end 3.5" drives will provide a major portion of the product group's 1999 projected shipments. An estimated 95% of 1999's total unit shipments will be used with personal computers, driving down average unit

prices to new lows for disk drives in this class. When Initial OEM/Integrator shipments of 3.5" drives start in 1997, the average price per megabyte is estimated at 6 cents, falling to 2 cents per megabyte in 1999.

Technical trends

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 1999 with areal densities of about 6.2 gigabits per square inch. At that recording density each 3.5" disk will have a capacity of about 7 to 8 gigabytes, depending on the encoding method and zoning technique, without compression. Advances in areal density have also made it possible to extend the life of high-end 5.25" drives, with currently announced drives at 23 gigabytes, using 14 disks. Clearly, both 5.25" and 3.5" drives could be produced with capacities in the 70 to 100 gigabyte range by 1999 -- if the market wants that much capacity in a single drive. The industry has been confronted with questions, doubts and concerns for at least 30 years about the maximum capacity per drive that makes sense. In the next few years, the customers will probably set the capacity limit per drive, not the technology.

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. High-end 3.5" drives in the more than 10 gigabyte range will be produced by several manufacturers in 1997, followed by low-end drives for personal computer applications in 1998, with shipments exceeding 30 million drives in 1999.
3. Shipments of 5.25" drives will start in mid-1996 and will increase at a moderate rate through 1998, then decline, in the face of intense competition from 3.5" drives.

TABLE 70

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

REVENUE SUMMARY

	DISK DRIVE REVENUES, BY SHIPMENT DESTINATION ($M)									
	1995 Revenues		Forecast							
			1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	36.0	54.0	--	--	72.0	96.0	1,155.0	1,645.0	1,592.5	2,340.0
Other U.S. Captive	--	--	--	--	32.4	40.5	81.0	108.0	120.0	165.0
TOTAL U.S. CAPTIVE	36.0	54.0	--	--	104.4	136.5	1,236.0	1,753.0	1,712.5	2,505.0
PCM/Distributor	--	--	19.0	19.0	61.4	72.1	187.8	236.3	1,118.4	1,397.3
OEM/Integrator	--	--	47.5	57.0	439.3	493.8	1,548.0	1,815.0	7,495.0	9,358.8
TOTAL U.S. NONCAPTIVE	--	--	66.5	76.0	500.7	565.9	1,735.8	2,051.3	8,613.4	10,756.1
TOTAL U.S. REVENUES	36.0	54.0	66.5	76.0	605.1	702.4	2,971.8	3,804.3	10,325.9	13,261.1
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	30.0	--	140.0	--	221.0
PCM/Distributor	--	--	--	--	14.3	33.4	32.4	71.4	230.9	506.8
OEM/Integrator	--	--	--	--	18.2	36.4	253.2	424.0	2,488.8	4,151.4
TOTAL NON-U.S. REVENUES	--	--	--	--	32.5	99.8	285.6	635.4	2,719.7	4,879.2
Worldwide Recap										
TOTAL WORLDWIDE REVENUES	36.0	54.0	66.5	76.0	637.6	802.2	3,257.4	4,439.7	13,045.6	18,140.3
OEM Average Price ($000)		--		1.900		1.019		.628		.505

TABLE 71

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1995		Forecast							
	Shipments		1996		1997		1998		1999	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers										
IBM Captive	1.0	1.5	--	--	15.0	20.0	165.0	235.0	245.0	360.0
Other U.S. Captive	--	--	--	--	12.0	15.0	45.0	60.0	80.0	110.0
TOTAL U.S. CAPTIVE	1.0	1.5	--	--	27.0	35.0	210.0	295.0	325.0	470.0
PCM/Distributor	--	--	10.0	10.0	52.0	60.0	260.0	325.0	2,033.0	2,540.0
OEM/Integrator	--	--	25.0	30.0	430.0	480.0	2,440.0	2,865.0	14,890.0	18,605.0
TOTAL U.S. NONCAPTIVE	--	--	35.0	40.0	482.0	540.0	2,700.0	3,190.0	16,923.0	21,145.0
TOTAL U.S. SHIPMENTS	1.0	1.5	35.0	40.0	509.0	575.0	2,910.0	3,485.0	17,248.0	21,615.0
Non-U.S. Manufacturers										
Captive	--	--	--	--	--	10.0	--	70.0	--	130.0
PCM/Distributor	--	--	--	--	10.0	25.0	40.0	90.0	413.0	910.0
OEM/Integrator	--	--	--	--	20.0	40.0	415.0	695.0	4,880.0	8,140.0
TOTAL NON-U.S. SHIPMENTS	--	--	--	--	30.0	75.0	455.0	855.0	5,293.0	9,180.0
Worldwide Recap										
TOTAL WORLDWIDE SHIPMENTS	1.0	1.5	35.0	40.0	539.0	650.0	3,365.0	4,340.0	22,541.0	30,795.0
Total Capacity (Terabytes)	17.0	25.5	805.0	920.0	8,623.5	10,420.0	60,112.5	77,377.5	471,380.5	643,755.0
Cumulative Shipments (Units in millions)										
IBM	--	--	--	--	--	--	.2	.2	.4	.6
Non-IBM	--	--	--	--	.5	.6	3.7	4.7	26.0	35.2
WORLDWIDE TOTAL	--	--	--	--	.5	.7	3.9	5.0	26.5	35.8

TABLE 72

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

WORLDWIDE REVENUES ($M)

BREAKDOWN BY DISK DIAMETER

	1995 Revenues >=10"	Forecast 1996 5.25"	1997 5.25"	1997 3.5"	1998 5.25"	1998 3.5"	1999 5.25"	1999 3.5"
U.S. MANUFACTURERS								
IBM Captive	54.0	--	--	96.0	--	1,645.0	--	2,340.0
Other U.S. Captive	--	--	--	40.5	--	108.0	--	165.0
PCM/Distributor	--	19.0	29.3	42.8	38.0	198.3	18.5	1,378.8
OEM/Integrator	--	57.0	120.3	373.5	144.0	1,671.0	78.8	9,280.0
TOTAL U.S. REVENUES	54.0	76.0	149.6	552.8	182.0	3,622.3	97.3	13,163.8
NON-U.S. MANUFACTURERS								
Captive	--	--	--	30.0	--	140.0	--	221.0
PCM/Distributor	--	--	19.0	14.4	18.6	52.8	9.0	497.8
OEM/Integrator	--	--	--	36.4	--	424.0	--	4,151.4
TOTAL NON-U.S. REVENUES	--	--	19.0	80.8	18.6	616.8	9.0	4,870.2
WORLDWIDE RECAP								
Captive	54.0	--	--	166.5	--	1,893.0	--	2,726.0
	-87.7%	--	--	--	--	--	--	+44.0%
PCM/Distributor	--	19.0	48.3	57.2	56.6	251.1	27.5	1,876.6
	--	--	+154.2%	--	+17.2%	+339.0%	-51.4%	+647.4%
OEM/Integrator	--	57.0	120.3	409.9	144.0	2,095.0	78.8	13,431.4
	--	--	+111.1%	--	+19.7%	+411.1%	-45.3%	+541.1%
Total Revenues	54.0	76.0	168.6	633.6	200.6	4,239.1	106.3	18,034.0
	-87.7%	--	+121.8%	--	+19.0%	+569.0%	-47.0%	+325.4%
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	21.0%	79.0%	4.5%	95.5%	.6%	99.4%

Note: ">=" indicates "greater than or equal to".

TABLE 73

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

WORLDWIDE SHIPMENTS (000)

BREAKDOWN BY DISK DIAMETER

	1995 Shipments >=10"	Forecast 1996 5.25"	1997 5.25"	1997 3.5"	1998 5.25"	1998 3.5"	1999 5.25"	1999 3.5"
U.S. MANUFACTURERS								
IBM Captive	1.5	--	--	20.0	--	235.0	--	360.0
Other U.S. Captive	--	--	--	15.0	--	60.0	--	110.0
PCM/Distributor	--	10.0	15.0	45.0	20.0	305.0	10.0	2,530.0
OEM/Integrator	--	30.0	65.0	415.0	80.0	2,785.0	45.0	18,560.0
TOTAL U.S. SHIPMENTS	1.5	40.0	80.0	495.0	100.0	3,385.0	55.0	21,560.0
NON-U.S. MANUFACTURERS								
Captive	--	--	--	10.0	--	70.0	--	130.0
PCM/Distributor	--	--	10.0	15.0	10.0	80.0	5.0	905.0
OEM/Integrator	--	--	--	40.0	--	695.0	--	8,140.0
TOTAL NON-U.S. SHIPMENTS	--	--	10.0	65.0	10.0	845.0	5.0	9,175.0
WORLDWIDE RECAP								
Captive	1.5	--	--	45.0	--	365.0	--	600.0
	-85.0%	--	--	--	--	+711.1%	--	+64.4%
PCM/Distributor	--	10.0	25.0	60.0	30.0	385.0	15.0	3,435.0
	--	--	+150.0%	--	+20.0%	+541.7%	-50.0%	+792.2%
OEM/Integrator	--	30.0	65.0	455.0	80.0	3,480.0	45.0	26,700.0
	--	--	+116.7%	--	+23.1%	+664.8%	-43.7%	+667.2%
Total Shipments	1.5	40.0	90.0	560.0	110.0	4,230.0	60.0	30,735.0
	-85.0%	--	+125.0%	--	+22.2%	+655.4%	-45.5%	+626.6%
ANNUAL SHARE, BY DIAMETER	100.0%	100.0%	13.8%	86.2%	2.5%	97.5%	.2%	99.8%
TOTAL CAPACITY (Terabytes)	25.5	920.0	2,070.0	8,350.0	2,530.0	74,847.5	1,380.0	642,375.0

Note: ">=" indicates "greater than or equal to".

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)									
	1995		FORECAST							
	Shipments		1996		1997		1998		1999	
	US	WW	US	WW	US	WW	US	WW	US	WW
3390-3 type (5676 MB)										
IBM	2.2	3.5	--	--	--	--	--	--	--	--
PCM	10.0	16.0	1.5	2.5	--	--	--	--	--	--
3390-9 type (17028 MB)										
IBM	1.0	1.5	--	--	--	--	--	--	--	--
PCM	3.8	6.0	.7	1.0	--	--	--	--	--	--
Disk subsystems with array capability (Average available capacity per drive)										
IBM (1419 MB)	165.0	255.0	--	--	--	--	--	--	--	--
IBM (2838 MB)	98.0	150.0	140.0	220.0	13.0	20.0	--	--	--	--
PCM (2838 MB)	53.0	82.0	91.0	140.0	23.0	35.0	--	--	--	--
IBM (5676 MB)	--	--	52.0	80.0	166.0	255.0	52.0	80.0	--	--
PCM (5676 MB)	--	--	78.0	120.0	130.0	200.0	63.0	115.0	13.0	20.0
IBM (8514 MB)	--	--	--	--	--	--	96.0	145.0	156.0	240.0
PCM (8514 MB)	54.0	82.0	29.0	45.0	26.0	40.0	85.0	130.0	133.0	205.0
PCM (17028 MB)	--	--	7.0	10.0	20.0	30.0	36.0	55.0	48.0	75.0
TOTAL SPINDLES	387.0	596.0	399.2	618.5	378.0	580.0	332.0	525.0	350.0	540.0
TOTAL FORMATTED CAPACITY (Terabytes)		1,956.8		2,741.5		3,590.1		4,384.7		5,179.4
		+73.9%		+40.1%		+31.0%		+22.1%		+18.1%

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 10 GIGABYTES

APPLICATIONS SUMMARY
Percentage of Worldwide Shipments

APPLICATION	1995 Estimate Units (000)	1995 Estimate %	1999 Projection Units (000)	1999 Projection %
VERY HIGH PERFORMANCE				
Supercomputers and high end imaging	--	--	--	--
MAINFRAME SYSTEMS				
General purpose	1.5	100.0	338.7	1.1
NETWORKS/MIDRANGE SYSTEMS				
Midrange systems and network servers	--	--	1,108.6	3.6
PERSONAL COMPUTERS				
Business and professional, single user	--	--	29,255.3	95.0
WORKSTATIONS				
Engineering and office, single user	--	--	92.4	.3
CONSUMER, GAME AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	1.5	100.0	30,795.0	100.0

TABLE 76

FIXED DISK DRIVES, MORE THAN 10 GIGABYTES

WORLDWIDE PRICE PER MEGABYTE ($/MB)

DISK DIAMETER		Forecast			
	1995	1996	1997	1998	1999
Captive					
>=10"	2.11	--	--	--	--
5.25"	--	--	--	--	--
3.5"	--	--	.26	.35	.28
2.5"	--	--	--	--	--
Captive Average	2.11	--	.26	.35	.28
PCM/Distributor					
>=10"	--	--	--	--	--
5.25"	--	.08	.08	.08	.08
3.5"	--	--	.06	.03	.02
2.5"	--	--	--	--	--
PCM/Distributor Average	--	.08	.07	.04	.02
OEM/Integrator					
>=10"	--	--	--	--	--
5.25"	--	.08	.08	.07	.07
3.5"	--	--	.06	.03	.02
2.5"	--	--	--	--	--
OEM/Integrator Average	--	.08	.06	.03	.02

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.

">=" indicates "greater than or equal to".

1996 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 are now 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/Distributor 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 newer 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.

1996 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 300 megabytes
3. Fixed disk drives, 300 - 500 megabytes
4. Fixed disk drives, 500 MB - 1 gigabyte
5. Fixed disk drives, 1 - 2 gigabytes
6. Fixed disk drives, 2 - 3 gigabytes
7. Fixed disk drives, 3 - 5 gigabytes
8. Fixed disk drives, 5 - 10 gigabytes
9. Fixed disk drives, more than 10 gigabytes

MANUFACTURER	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY	AREAL TECHNOLOGY
DRIVE	A130	A260	A340	A345L	A520F
DISK/TREND GROUP	2	2	3	3	4
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	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 131.48	F: 262.96	F: 350.20	F: 350.20	F: 526.42
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	4	4	4	6
Tracks per surface	1438	1438	2120	2120	2120
Track density (TPI)	2763	2763	3920	3920	3920
Maximum linear density (BPI) (FCI)	80000 60000	80000 60000	74240 55667	74240 55667	74240 55667
Areal density (Mb/square inch)	221.0	221.0	291.0	291.0	291.0
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	2981	2981	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15	15	13	13	13
Average rotational delay (msec)	10.1	10.1	8.3	8.3	8.3
Average access time (msec)	25.1	25.1	21.3	21.3	21.3
Data transfer rate (MBytes/sec) Internal, min/max External	 2.0/3.5 2.280	 2.0/3.9 2.280	 2.3/3.9 2.485	 2.3/3.9 2.485	 2.3/3.9 2.485
SIZE: (mm) H x W x D	12.5 x 69.9 x 87.6	15.2 x 69.9 x 87.6	15 x 69.9 x 88.9	12.7 x 69.9 x 88.9	19 x 69.9 x 88.9
FIRST CUSTOMER SHIPMENT	6/93	9/93	8/94	9/94	10/94
COMMENTS	*Glass disk.	*Glass disk.	*Glass disk.	*Glass disk.	*Glass disk.

MANUFACTURER	AVATAR SYSTEMS	AVATAR SYSTEMS	AVATAR SYSTEMS	AVATAR SYSTEMS	CALLUNA TECHNOLOGY
DRIVE	AR-2170NI Remington	AR-2170NS Remington	AR-3170FI Magnum	AR-3170FS Magnum	CT-130MC CT-130FD callunacard
DISK/TREND GROUP	1	1	1	1	2
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	65 mm	65 mm	65 mm	65 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	IDE	SCSI-2	IDE	SCSI-2	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 170	F: 170	F: 170	F: 170	F: 130
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	2	2	2	2
Tracks per surface	2404	2404	2404	2404	1958
Track density (TPI)	4300	4300	4300	4300	4400
Maximum linear density (BPI) (FCI)	81000 60750	81000 60750	81000 60750	81000 60750	82391 61793
Areal density (Mb/square inch)	348.3	348.3	348.3	348.3	362.5
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3805	3805	3805	3805	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)	12	12	12	12	16
Average rotational delay (msec)	8	8	8	8	6.25
Average access time (msec)	20	20	20	20	22.25
Data transfer rate (MBytes/sec) Internal, min/max External	1.5/2.8 13.3 DMA Mode 1	1.5/2.8 10.0 synch.	1.5/2.8 13.3 Mode 1	1.5/2.8 10.0 synch.	2.3/4.5 11.1
SIZE: (mm) H x W x D	17.5 x 72.4 x 107.9	17.5 x 72.46 x 107.9	25.4 x 101.6 x 146	25.4 x 101.6 x 146	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	6/95	6/95	6/95	6/95	5/94
COMMENTS	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk.	Removable data cartridge. *Glass disk. Includes 3.5" 1.44 MB floppy drive.	Removable data cartridge. *Glass disk. Includes 3.5" 1.44 MB floppy drive.	PCMCIA Type III *Carbon disk. CT-130FD is 50 pin IDE version

MANUFACTURER	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	CALLUNA TECHNOLOGY	FUJITSU
DRIVE	CT-170MC CT-170FD callunacard	CT-260MC CT-260FD callunacard	CT-390MC CT-390FD callunacard	CT-520MC CR-520FD callunacard	M2614ES/ESA/ESB M2614S/SA/SB
DISK/TREND GROUP	2	2	3	4	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	48 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	Ferrite
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	F: 182.36
REMOVABLE	F: 170	F: 260	F: 390	F: 520	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 17,408
Data surfaces per spindle	4	4	3	4	8
Tracks per surface	1768	1958	2576	2576	1334
Track density (TPI)	4400	4400	6000	6000	1681
Maximum linear density (BPI) (FCI)	58082 43561	82391 61793	118285 88714	118285 88714	29571 22178
Areal density (Mb/square inch)	255.6	362.5	709.7	709.7	49.7
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4800	4800	4800	4800	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)	16	16	12	12	20/25*
Average rotational delay (msec)	6.25	6.25	6.25	6.25	8.6
Average access time (msec)	22.25	22.25	18.25	18.25	28.6/33.6*
Data transfer rate (MBytes/sec) Internal, min/max External	 1.8/3.1 11.1	 2.3/4.5 11.1	 3.4/6.4 20.0	 3.4/6.4 20.0	 2.5 synch. 1.5 asynch.
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	9/94	3/95	3Q96	3Q96	4Q88
COMMENTS	PCMCIA Type III *Carbon disk. CT-170FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-260FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-390FD is 50 pin IDE version	PCMCIA Type III *Carbon disk. CT-520FD is 50 pin IDE version	*ESA/S/SA/SB.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2614ET/T	M2636S	M2636T	M2637S	M2637T
DISK/TREND GROUP	2	2	2	2	2
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	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-2	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 180.31	F: 200	F: 200	F: 240	F: 240
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	5	5	6	6
Tracks per surface	1334	1572	1572	1572	1572
Track density (TPI)	1681	2660	2660	2660	2660
Maximum linear density (BPI) (FCI)	29571 22178	57000 42750	57000 42750	57000 42750	57000 42750
Areal density (Mb/square inch)	49.7	151.6	151.6	151.6	151.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3490	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	20/25	14.5	14.5	14.5	14.5
Average rotational delay (msec)	8.6	6.7	6.7	6.7	6.7
Average access time (msec)	28.6/33.6	21.2	21.2	21.2	21.2
Data transfer rate (MBytes/sec) Internal, min/max External	 7.4 max.	 2.1/2.6 10.0 synch. 4.0 asynch.	 2.1/2.6 8.0	 2.1/2.6 10.0 synch. 4.0 asynch.	 2.1/2.6 8.0
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100	17 x 69.9 x 100
FIRST CUSTOMER SHIPMENT	3Q89	1Q93	1Q93	2Q93	1Q93
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2681S	M2681T	M2703S	M2622F/FA/FB M2622H/HA/HB	M2622S/SA/SB
DISK/TREND GROUP	2	2	2	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
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	MIG	MIG	MR Thin Film	MIG	MIG
Interface	SCSI-2	IDE	SCSI-2	SCSI-1/2	SCSI-1/2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 264	F: 264	F: 218	F: 330.17	F: 330.17
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	3	3	3	7	7
Tracks per surface	2379	2379	2306	1435	1435
Track density (TPI)	2713	2713	4017	1751	1751
Maximum linear density (BPI) (FCI)	58000 43500	58000 43500	84800	46383 34787	46383 34787
Areal density (Mb/square inch)	157.4	157.4	340.6	81.2	81.2
Recording code	1,7 RLL	1,7 RLL	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4500	5400	4400	4400
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)	13.8	13.8	12	12	12
Average rotational delay (msec)	6.7	6.7	5.6	6.8	6.8
Average access time (msec)	20.5	20.5	17.6	18.8	18.8
Data transfer rate (MBytes/sec) Internal, min/max External	2.8/4.7 10.0 synch. 5.0 asynch.	2.8/4.7 11.1 PIO Mode 3	3.7/5.9 10.0 synch. 5.0 asynch.	10.0 synch. 4.0 asynch.	2.4/3.0 5.0 synch. 3.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	17 x 69.9 x 100	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q94	1Q94	4Q94	4Q91	1Q91
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2622T	M2623F/FA/FB M2623H/HA/HB	M2623S/SA/SB	M2623T	M2682S
DISK/TREND GROUP	3	3	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	MIG	MIG	MIG	MIG	MIG
Interface	IDE	SCSI-1/2	SCSI-1/2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 326.7	F: 425.1	F: 425.1	F: 420.1	F: 353
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	9	9	9	4
Tracks per surface	1435	1435	1435	1435	2379
Track density (TPI)	1751	1751	1751	1751	2713
Maximum linear density (BPI) (FCI)	46383 34787	46383 34787	46383 34787	46383 34787	58000 43500
Areal density (Mb/square inch)	81.2	81.2	81.2	81.2	157.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4400	4400	4400	4400	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.	Dedicated Surf.	Embedded
Average positioning time (msec)	12	12	12	12	13.8
Average rotational delay (msec)	6.8	6.8	6.8	6.8	6.7
Average access time (msec)	18.8	18.8	18.8	18.8	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	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.	2.4/3.0 7.4 max.	2.8/4.7 10.0 synch. 5.0 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	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q91	4Q91	1Q91	3Q91	1Q94
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2682T	M1603SAU Picobird-7'E	M1603TAU Picobird-7'E	M1612TAU Picobird-8'	M2684S
DISK/TREND GROUP	3	4	4	4	4
MARKET	OEM	OEM, PCM	OEM, PCM	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	MIG	Thin Film	Thin Film	MIG	MIG
Interface	IDE	SCSI-2	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 352	F: 540	F: 540	F: 545	F: 532
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	3	3	2	6
Tracks per surface	2379	3457	3457	4133	2379
Track density (TPI)	2713	3676	3676	4394	2700
Maximum linear density (BPI) (FCI)	58000 43500	72700 54525	72700 54525	90853	58000 43500
Areal density (Mb/square inch)	157.4	267.2	267.2	399.2	156.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	8,9 PRML	1,7 RLL
Rotational speed (RPM)	4500	5400	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)	13.8	10	10	12	13.8
Average rotational delay (msec)	6.7	5.6	5.6	6.67	6.7
Average access time (msec)	20.5	15.6	15.6	18.67	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	2.8/4.7 11.1 PIO Mode 3	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	2.8/4.7 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	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q94	3/95	2/95	9/95	1Q94
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2684T	M2712TAM Hornet-6'	M2713TAM Hornet-6'	F6429G	F6429H
DISK/TREND GROUP	4	4	4	5	5
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Disk diameter	95 mm	65 mm	65 mm	130 mm	130 mm
Recording medium	Thin Film	Thin Film*	Thin Film*	Thin Film	Thin Film
DRIVE: Heads	MIG	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	Fujitsu	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 528	F: 544	F: 816	F: 1,260	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 47,476	F: 47,476
Data surfaces per spindle	6	2	3	15	15
Tracks per surface	2379	3916	3916	1770	2655
Track density (TPI)	2700	6606	6606	3310	3310
Maximum linear density (BPI) (FCI)	58000 43500	133000	133000	45423 34067	53084 39813
Areal density (Mb/square inch)	156.6	878.6	878.6	150.4	175.7
Recording code	1,7 RLL	PR4ML	PR4ML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	3634	3634	4340	4340
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)	13.8	12	12	10.5	12
Average rotational delay (msec)	6.7	8.26	8.26	6.9	6.9
Average access time (msec)	20.5	20.26	20.26	17.4	18.9
Data transfer rate (MBytes/sec) Internal, min/max External	2.8/4.7 11.1 PIO Mode 3	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	4.5
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	12.5 x 70 x 100	12.5 x 70 x 100		
FIRST CUSTOMER SHIPMENT	1Q94	10/95	10/95	6/94	6/94
COMMENTS		*Glass disk.	*Glass disk.	Drive has maximum of 32 spindles.	Drive has maximum of 32 spindles.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M1606SAU Picobird-7'E	M1606TAU Picobird-7'E	M1614TAU Picobird-8'	M1623TAU	M1636TAU
DISK/TREND GROUP	5	5	5	5	5
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	MIG	MR Thin Film	MR Thin Film
Interface	SCSI-2	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,080	F: 1,090	F: 1,700	F: 1,280
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	2	2
Tracks per surface	3457	3457	4133	6237	6237
Track density (TPI)	3676	3676	4394	6600	6600
Maximum linear density (BPI) (FCI)	72700 54525	72700 54525	90853	120000	136300
Areal density (Mb/square inch)	267.2	267.2	399.2	792.0	899.6
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	8,9 RLL	8,9 RLL
Rotational speed (RPM)	5400	5400	4500	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10	10	12	10 RD/12 WR	10 RD/12 WR
Average rotational delay (msec)	5.6	5.6	6.67	5.6	5.6
Average access time (msec)	15.6	15.6	18.67	15.6 RD/17.6 WR	15.6 RD/17.6 WR
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	7.6/12.5 16.6 PIO Mode 4 16.6 DMA Mode 2	7.6/13.8 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	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	3/95	2/95	9/95	5/96	5/96
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M1637TAU	M2694EH/EHA/EHB M2694ES/ESA/ESB	M2694H/HA/HB M2694S/SA/SB	M2714TAM Hornet-6'	F6429K
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM, PCM	OEM	OEM	OEM	Captive
MEDIA: Disk diameter	95 mm	95 mm	95 mm	65 mm	130 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	IDE	SCSI-2	SCSI-2	IDE	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,926	F: 1,083.9	F: 1,083.9	F: 1,088	F: 2,835
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 47,476
Data surfaces per spindle	3	15	15	4	20
Tracks per surface	6237	1819	1819	3916	2988
Track density (TPI)	6600	2208	2208	6606	3310
Maximum linear density (BPI) (FCI)	136000	48724 36543	48724 36543	133000	56681 42510
Areal density (Mb/square inch)	897.6	107.6	107.6	878.6	187.6
Recording code	8,9 RLL	1,7 RLL	1,7 RLL	PR4ML	1,7 RLL
Rotational speed (RPM)	5400	5400	4400	3634	4340
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)	10 RD/12 WR	10	10	12	12
Average rotational delay (msec)	5.6	5.6	6.8	8.26	6.9
Average access time (msec)	15.6 RD/17.6 WR	15.6	16.8	20.26	18.9
Data transfer rate (MBytes/sec) Internal, min/max External	7.6/13.7 16.6 PIO Mode 4 16.6 DMA Mode 2	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	4.5
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	12.5 x 70 x 100	
FIRST CUSTOMER SHIPMENT	5/96	11/92	5/92	10/95	6/94
COMMENTS				*Glass disk.	Drive has maximum of 32 spindles.

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M1624TAU	M1638TAU	M2932S/H/Q/R Allegro-2	M2952S/Q/R/E Allegro-3'	M2934S/H/Q/R Allegro-2
DISK/TREND GROUP	6	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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,160	F: 2,560	F: 2,170	F: 2,420	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	4	4	9	5	18
Tracks per surface	6237	6237	3422	5565	3422
Track density (TPI)	6600	6600	3871	6500	3871
Maximum linear density (BPI) (FCI)	120000	136300	100946	118000	100946
Areal density (Mb/square inch)	792.0	899.6	390.8	767.0	390.8
Recording code	8,9 RLL	8,9 RLL	8,9 RLL	8,9 RLL	8,9 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	Embedded	Embedded	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	10 RD/12 WR	10 RD/12 WR	10 RD/11.2 WR	8	10 RD/11.2 WR
Average rotational delay (msec)	5.6	5.6	4.17	4.17	4.17
Average access time (msec)	15.6 RD/17.6 WR	15.6 RD/17.6 WR	14.17/16.17	12.17	14.17/16.17
Data transfer rate (MBytes/sec)					
Internal, min/max	7.6/12.5	7.6/13.8	8.6/11.3	9.5/14.0	8.6/11.3
External	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	20.0 synch. 12.0 asynch.	40.0 synch. 20.0 asynch.	20.0 synch. 12.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	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
FIRST CUSTOMER SHIPMENT	5/96	5/96	3/95	10/95	3/95
COMMENTS					

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	GIGASTORAGE INTERNATIONAL	GIGASTORAGE INTERNATIONAL
DRIVE	M2954S/Q/R/E Allegro-3'	M2948S Allegro-3	M2949S/Q/R/E	B5108A	B5128A
DISK/TREND GROUP	7	8	8	5	5
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	MR Thin Film	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,350	F: 8,800	F: 9,100	F: 1,080	F: 1,286
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	18	2	2
Tracks per surface	5565	5751	5770		
Track density (TPI)	6500	6500	6500	4250	5100
Maximum linear density (BPI) (FCI)	118000	118000	118574	95000 71250	92000 70500
Areal density (Mb/square inch)	767.0	767.0	770.7	403.8	469.2
Recording code	8,9 RLL	8,9 RLL	PR4ML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	7200	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	Embedded	Embedded
Average positioning time (msec)	8	10	10 RD/11.5 WR	10.5	10.5
Average rotational delay (msec)	4.17	4.17	4.17	8.3	8.3
Average access time (msec)	12.17	14.17	14.17/15.67	18.8	18.8
Data transfer rate (MBytes/sec) Internal, min/max External	9.5/14.0 40.0 synch. 20.0 asynch.	9.5/14.0 40.0 synch. 20.0 asynch.	--/14.0 20.0 synch. 12.0 asynch.	5.0/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.0/10.0 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 146	41.3 x 101.6 x 146	41.3 x 101.6 x 146	25.4 x 146 x 210	25.4 x 146 x 210
FIRST CUSTOMER SHIPMENT	10/95	10/95		4/96	6/96
COMMENTS					

MANUFACTURER	GIGASTORAGE INTERNATIONAL	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	B5256A	C3324A	C3724S,SC C3724TC,D SureStore 1000+	C3724W,WC SureStore 1000+	C5270A 1080A SureStore
DISK/TREND GROUP	6	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	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	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,577	F: 1,200	F: 1,200	F: 1,200	F: 1,084
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	5	5	5	4
Tracks per surface		3610	3610	3610	3721
Track density (TPI)	5100	4000	4000	4000	4232
Maximum linear density (BPI) (FCI)	92000 70500	92000	92000	92000	92130 69098
Areal density (Mb/square inch)	469.2	368.0	368.0	368.0	389.9
Recording code	1,7 RLL	PRML	PRML	PRML	1,7 RLL
Rotational speed (RPM)	3600	5400	5400	5400	4480
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.	Embedded
Average positioning time (msec)	12	9.5 RD/10.5 WR	9.5	9.5	12
Average rotational delay (msec)	8.3	5.6	5.6	5.6	6.7
Average access time (msec)	20.3	15.1 RD/16.1 WR	15.1	15.1	18.7
Data transfer rate (MBytes/sec) Internal, min/max	5.0/10.0	5.7/8.0	5.7/8.0	5.7/8.0	--/6.2
External	16.6 PIO Mode 4 16.6 DMA Mode 2	20.0 synch. 5.0 asynch.	10.0 synch. 5.0 asynch.	20.0 synch. 10.0 asynch.	16.6 PIO Mode 4 16.6 DMA Mode 2
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	7/96	4/95	4/95	4/95	11/95
COMMENTS					Mfg. by Maxtor.

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	C5271A 1600A SureStore	C5272AK 1300A SureStore	C3325A	C3725S,SC C3725TC,D SureStre 2000LP	C3725W,WC SureStre 2000LP
DISK/TREND GROUP	5	5	6	6	6
MARKET	PCM	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	IDE	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,626	F: 1,336	F: 2,170	F: 2,170	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	6	4	9	9	9
Tracks per surface	3721	4702	3610	3610	3610
Track density (TPI)	4232	4880	4000	4000	4000
Maximum linear density (BPI) (FCI)	92130 69098	98000 73500	92000	92000	92000
Areal density (Mb/square inch)	389.9	478.2	368.0	368.0	368.0
Recording code	1,7 RLL	1,7 RLL	PRML	PRML	PRML
Rotational speed (RPM)	4480	4480	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	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	12	9.5 RD/10.5 WR	9.5	9.5
Average rotational delay (msec)	6.7	6.7	5.6	5.6	5.6
Average access time (msec)	18.7	18.7	15.1 RD/16.1 WR	15.1	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	--/6.2 16.6 PIO Mode 4 16.6 DMA Mode 2	4.6/8.1 16.6 PIO Mode 4 16.6 DMA Mode 2	5.7/8.0 20.0 synch. 10.0 asynch.	5.7/8.0 10.0 synch. 5.0 asynch.	5.7/8.0 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	11/95	3/96	4Q94	4/95	4/95
COMMENTS	Mfg. by Maxtor.	Mfg. by Maxtor.			

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI	HITACHI
DRIVE	C5273AK 2000A SureStore	C3653A Cougar 1	DK312C-20	DK312C-25	DK211A-51
DISK/TREND GROUP	6	8	2	2	4
MARKET	PCM	OEM, PCM	OEM	OEM	OEM
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	MR Thin Film	MIG	MIG	MIG
Interface	IDE	SCSI-2	SCSI	SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,004	F: 8,700	F: 209	F: 251	F: 510
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	F: 19,456	F: 19,456	Varies by zone
Data surfaces per spindle	6	20	10	12	6
Tracks per surface	4702	5294	1076	1076	1967
Track density (TPI)	4880	5730	1660	1660	3500
Maximum linear density (BPI) (FCI)	98000 73500	139022	38800 25866	38800 25866	83000 62250
Areal density (Mb/square inch)	478.2	796.6	64.4	64.4	290.5
Recording code	1,7 RLL	8,9 PRML	2,7 RLL	2,7 RLL	1,7 RLL
Rotational speed (RPM)	4480	7200	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	8.7 RD/9.5 WR	16.8*	16.8*	12 RD/15 WR
Average rotational delay (msec)	6.7	4.17	8.3	8.3	6.7
Average access time (msec)	18.7	12.87/13.67	25.1	25.1	18.7 RD/21.7 WR
Data transfer rate (MBytes/sec) Internal, min/max External	 4.6/8.1 16.6 PIO Mode 4 16.6 DMA Mode 2	 11.0/15.6 20.0 synch. 5.0 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	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	19 x 69.9 x 101.6
FIRST CUSTOMER SHIPMENT	3/96	4Q95	3Q89	3Q89	5/94
COMMENTS	Mfg. by Maxtor.		*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	DK211A-68	DK212A-81	DK222A-54	DK223A-81	DK325C-57
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	MIG			MIG	Thin Film
Interface	IDE	IDE	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 680	F: 810	F: 540	F: 810	F: 573
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	6	4	6	6
Tracks per surface	1969	2602	2602	2605	2458
Track density (TPI)	3500	4500	4500	4400	2800
Maximum linear density (BPI) (FCI)	83000 62250	99000 74250	99000 74250	99000	52200 39150
Areal density (Mb/square inch)	290.5	445.5	445.5	435.6	146.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	8,9 GCR	1,7 RLL
Rotational speed (RPM)	4464	4464	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	Dedicated Surf.
Average positioning time (msec)	12 RD/15 WR	12	12	12	12.4
Average rotational delay (msec)	6.7	6.7	6.7	6.7	6.7
Average access time (msec)	18.7 RD/21.7 WR	18.7	18.7	18.7	19.1
Data transfer rate (MBytes/sec) Internal, min/max External	 3.0/4.8 8.0	 3.0/5.1 11.1 PIO Mode 3	 3.6/6.1 11.1 PIO Mode 3	 3.7/6.1 16.6 PIO Mode 4 16.6 DMA Mode 2	 5.0 synch. 2.5 asynch.
SIZE: (mm) H x W x D	19 x 69.9 x 101.6	19.05 x 69.9 x 101.9	12.5 x 69.9 x 101.9	12.7 x 70 x 100	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	7/94	1Q95	1Q95	2Q96	3Q92
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK326C-6	DK326C-6WD	DK212A-10	DK213A-13	DK315C-11
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
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		MIG	Thin Film
Interface	SCSI-2	SCSI-2	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 601	F: 601	F: 1,080	F: 1,350	F: 1,100
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 30,200
Data surfaces per spindle	4	4	8	10	15
Tracks per surface	3202	3202	2602	2605	2488
Track density (TPI)	3600	3600	4500	4400	2800
Maximum linear density (BPI) (FCI)	63500 47625	63500 47625	99000 74250	99000	54000 40500
Areal density (Mb/square inch)	228.6	228.6	445.5	435.6	151.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	8,9 GCR	1,7 RLL
Rotational speed (RPM)	6300	6300	4464	4464	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	Dedicated Surf.
Average positioning time (msec)	9.8	9.8	12	12	10.4
Average rotational delay (msec)	4.76	4.76	6.7	6.7	6.7
Average access time (msec)	14.56	14.56	18.7	18.7	17.1
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.	3.6/6.1 11.1 PIO Mode 3	3.7/6.1 16.6 PIO Mode 4 16.6 DMA Mode 2	10.0 synch. 2.5 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	19.05 x 69.9 x 101.9	19 x 70 x 100	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1/94	3/94	1Q95	2Q96	2Q92
COMMENTS					

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK315C-14	DK326C-10	DK326C-10WD	DK328C-21 DK328C-21WD DK328C-21WS	DKU-881-310 DKU-F881-304
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	95 mm	6.5"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MR Thin Film	Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	Hitachi, IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,400	F: 1,052	F: 1,052	F: 2,100	F: 2,838
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	F: 56,664
Data surfaces per spindle	15	7	7	5	15
Tracks per surface	2464	3202	3202	5840	3339
Track density (TPI)	2800	3600	3600	5800	2520
Maximum linear density (BPI) (FCI)	52300 39225	63500 47625	63500 47625	120000 90000	47300 35475
Areal density (Mb/square inch)	146.4	228.6	228.6	696.0	119.2
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	6300	6300	5400	4260
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.	Embedded	Dedicated Surf.
Average positioning time (msec)	11.8	9.8	9.8	9.8	13.5
Average rotational delay (msec)	6.7	4.76	4.76	5.6	7.1
Average access time (msec)	18.5	14.56	14.56	15.4	20.6
Data transfer rate (MBytes/sec) Internal, min/max External	2.7/4.5 10.0 synch. 2.5 asynch.	4.5/7.0 10.0 synch. 2.5 asynch.	4.5/7.0 20.0 synch. 5.0 asynch.	6.7/11.0 20.0 synch. 10.0 asynch.	4.2
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146	--
FIRST CUSTOMER SHIPMENT	3Q92	1/94	3/94	4Q95	5/93
COMMENTS					Available with 4 to 32 HDAs.

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	H-6587-314 H-6587-324	H-6588-314	DK306-45	DK328C-43 DK328C-43WD DK328C-43WS	DKU-881-10 DKU-F881-904 H-6588-9
DISK/TREND GROUP	6	6	7	7	8
MARKET	Captive	Captive	Captive	OEM	Captive,OEM,PCM
MEDIA: Disk diameter	9.5"	6.5"	95 mm	95 mm	6.5"
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	MR Thin Film	MR Thin Film
Interface	Hitachi, IBM	Hitachi, IBM	SCSI	SCSI-2	Hitachi, IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,920	F: 2,920	F: 4,360	F: 4,300	F: 8,514
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 56,664	F: 56,664	Varies by zone	Varies by zone	F: 113,328
Data surfaces per spindle	15	15	29	10	19
Tracks per surface	3436	3436		5840	3955
Track density (TPI)	1930	2520		5800	3500
Maximum linear density (BPI) (FCI)	29100 21825	47300 35475		120000 90000	81964 61473
Areal density (Mb/square inch)	56.2	119.2		696.0	286.9
Recording code	1,7 RLL	1,7 RLL		1,7 RLL	1,7 RLL
Rotational speed (RPM)	4260	4260	6300	5400	1980
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.
Average positioning time (msec)	12	13.5	11.5	9.8	16.5
Average rotational delay (msec)	7.1	7.1	4.8	5.6	15.2
Average access time (msec)	19.1	20.6	16.3	15.4	31.7
Data transfer rate (MBytes/sec) Internal, min/max External	4.2	4.2	4.7-6.9	6.7/11.0 20.0 synch. 10.0 asynch.	3.9
SIZE: (mm) H x W x D	--	--		25.4 x 101.6 x 146	--
FIRST CUSTOMER SHIPMENT	9/90	6/93	3Q95	4Q95	6/94
COMMENTS	-314: max. 8 HDAs. -324: max. 12 HDAs. Also compatible mode to H-6586K 2 heads/surface	Available with 4 to 32 HDAs.	HDD for H-6595 (RAID for mainframe.)		Available with 4 to 32 HDAs.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DB0A-2540 Travelstar LP (Bolero)	DB0A-2720 Travelstar LP (Bolero)	DPRA-20810 Travelstar XP (Presto)	DPRS-20810 Travelstar XP (Presto)	DS0A-20540 Travelstar 2LP (Sonata)
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	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	IDE	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 540	F: 720	F: 810	F: 810	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	4	4	4	2
Tracks per surface	3478	3478	3478	3478	4131
Track density (TPI)	6350	6350	6350	6350	7257
Maximum linear density (BPI) (FCI)	101400 76050	101400 76050	110300 82725	110300 82725	127200 95400
Areal density (Mb/square inch)	643.9	643.9	700.4	700.4	923.1
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4000	4000	4900	4900	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)	13	13	12	12	13 RD
Average rotational delay (msec)	7.5	7.5	6.1	6.1	7.5
Average access time (msec)	20.5	20.5	18.1	18.1	20.5 RD
Data transfer rate (MBytes/sec) Internal, min/max External	3.3/4.9 11.1 PIO Mode 3	3.3/4.9 11.1 PIO Mode 3	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
SIZE: (mm) H x W x D	12.5 x 70 x 100	12.5 x 70 x 100	17 x 70 x 100	17 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	10/94	10/94	6/95	7/95	10/95
COMMENTS	*Glass disk.	*Glass disk.			*Glass disk.

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DSOA-20810 Travelstar 2LP (Sonata)	DJAA-31270 Deskstar (Jafar)	DJAA-31700 Deskstar (Jafar)	DMCA-21080 Travelstar 3LP (Marcato)	DMCA-21440 Travelstar 3LP (Marcato)
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM	OEM, PCM	OEM, PCM	OEM	OEM
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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 810	F: 1,270	F: 1,700	F: 1,080	F: 1,440
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	4	3	4
Tracks per surface	4131	6119	6119	4975	4975
Track density (TPI)	7257	6684	6684	8600	8600
Maximum linear density (BPI) (FCI)	127200 95400	99100 77325	99100 77325	152500	152500
Areal density (Mb/square inch)	923.1	662.4	662.4	1312	1312
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	PRML	PRML
Rotational speed (RPM)	4000	4500	4500	4000	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13 RD	12 RD	12 RD	13	13
Average rotational delay (msec)	7.5	6.67	6.67	7.5	7.5
Average access time (msec)	20.5 RD	18.67 RD	18.67 RD	20.5	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	4.2/6.7 16.6 PIO Mode 4 16.6 DMA Mode 2	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	4.9/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2	4.9/7.7 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	12.5 x 70 x 100	25.4 x 101.6 x 146	25.4 x 101.6 x 146	12.5 x 70 x 100	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	10/95	4Q95	4Q95	6/96	6/96
COMMENTS	*Glass disk.				

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DPRA-21215 Travelstar XP (Presto)	DPRS-21215 Travelstar XP (Presto)	DSOA-21080 Travelstar 2LP (Sonata)	DAQA-32160 Deskstar 3 (Aquarius)	DCRA-22160 Travelstar 2XP (Crescendo)
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM, PCM	OEM
MEDIA: Disk diameter	65 mm	65 mm	65 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	IDE	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,215	F: 1,215	F: 1,080	F: 2,160	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	6	6	4	4	6
Tracks per surface	3478	3478	4131	6911	4928
Track density (TPI)	6350	6350	7257	7257	8600
Maximum linear density (BPI) (FCI)	110300 82725	110300 82725	127200 95400	120900	153000
Areal density (Mb/square inch)	700.4	700.4	923.1	877.4	1316
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	4900	4900	4000	5400	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)	12	12	13 RD	9.5 RD	12
Average rotational delay (msec)	6.1	6.1	7.5	5.6	6.1
Average access time (msec)	18.1	18.1	20.5 RD	15.1	18.1
Data transfer rate (MBytes/sec) Internal, min/max External	4.5/7.1 11.1 PIO Mode 3	4.5/7.1 10.0 synch.	4.2/6.7 16.6 PIO Mode 4 16.6 DMA Mode 2	7.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	6.1/9.3 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	17 x 70 x 100	17 x 70 x 100	12.5 x 70 x 100	25.4 x 101.6 x 146	17 x 70 x 100
FIRST CUSTOMER SHIPMENT	6/95	7/95	10/95	6/96	6/96
COMMENTS			*Glass disk.		

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DFHC-32160 Ultrastar XP (Starfire HP)	DFHS-32160 Ultrastar XP (Starfire HP)	DORS-32160 Ultrastar ES (Orion)	DAQA-33240 Deskstar 3 (Aquarius)	DCHC-34550 Ultrastar 2XP (Scorpion HP)
DISK/TREND GROUP	6	6	6	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-2/3	IDE	SSA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,255	F: 2,255	F: 2,160	F: 3,240	F: 4,550
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	5	6	9
Tracks per surface	4416	4416	6717	6911	6077
Track density (TPI)	4352	4352	7056	7257	6160
Maximum linear density (BPI) (FCI)	125000	125000	103600 77700	120900	134500
Areal density (Mb/square inch)	544.0	544.0	731.0	877.4	828.5
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	7200	7200	5400	5400	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	7.5 RD/9.0 WR	7.5 RD/9.0 WR	8.5 RD	9.5 RD	7.5
Average rotational delay (msec)	4.17	4.17	5.6	5.6	4.17
Average access time (msec)	11.67/13.17	11.67/13.17	14.1 RD	15.1	11.67
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.	5.9/9.0 40.0 synch. 20.0 asynch.	7.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	10.2/15.4 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	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	1/96	6/96	4Q95
COMMENTS					

1996 DISK/TREND REPORT

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	DCHS-34550 Ultrastar 2XP (Scorpion HP)	DFHS-34320 Ultrastar XP (Starfire HP)	DFHC-34320 Ultrastar XP (Starfire HP)	DCHC-39100 Ultrastar 2XP (Scorpion HP)	DCHS-39100 Ultrastar 2XP (Scorpion HP)
DISK/TREND GROUP	7	7	7	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	SCSI-2/3	SCSI-2	SSA	SSA	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 4,512	F: 4,512	F: 9,100	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	9	16	16	18	18
Tracks per surface	6077	4416	4416	6077	6077
Track density (TPI)	6160	4352	4352	5966	5966
Maximum linear density (BPI) (FCI)	134500	125000	125000	134500	134500
Areal density (Mb/square inch)	828.5	544.0	544.0	802.4	802.4
Recording code	PRML	PRML	PRML	PRML	PRML
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)	7.5	8.0 RD/9.5 WR	8.0 RD/9.5 WR	8.5 RD	8.5 RD
Average rotational delay (msec)	4.17	4.17	4.17	4.17	4.17
Average access time (msec)	11.67	12.17/13.67	12.17/13.67	12.67 RD	12.67 RD
Data transfer rate (MBytes/sec)					
Internal, min/max	10.2/15.4	9.6/12.6	9.6/12.6	10.2/15.4	10.2/15.4
External	40.0 synch. 20.0 asynch.	20.0 synch. 10.0 asynch.	20.0	40.0	40.0 synch. 20.0 asynch.
SIZE: (mm) H x W x D	25.4 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	41.3 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	4Q95	2Q94	2Q94	4Q95	4Q95
COMMENTS					

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

MANUFACTURER	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS	INTEGRAL PERIPHERALS
DRIVE	PocketFile 260	8340PA Viper 340	8510PA Viper 510	21080 Platinum/1080	21200 Platinum/1200
DISK/TREND GROUP	2	3	4	5	5
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	48 mm	48 mm	48 mm	65 mm	65 mm
Recording medium	Thin Film*	Thin Film*	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MR	Thin Film	Thin Film
Interface	PCMCIA-ATA	PCMCIA-ATA	PCMCIA-ATA	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	F: 1,083.8	F: 1,216.9
REMOVABLE	F: 260.4	F: 340.6	F: 514	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	6	6
Tracks per surface	1650	2000	2600	3270	3505
Track density (TPI)	4200	5100	6640	5100	6000
Maximum linear density (BPI) (FCI)	105000 78750	123600 92700	120000 90000	131000 98250	118350 88760
Areal density (Mb/square inch)	441.0	630.4	796.8	668.1	710.1
Recording code	1,7 PRML	1,7 PRML	1,7 PRML	1,7 RLL	1,7 PRML
Rotational speed (RPM)	4500	4500	4500	4200	4300
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	13	13
Average rotational delay (msec)	6.7	6.7	5.77	7.14	6.98
Average access time (msec)	18.7	18.7	18.77	20.14	19.98
Data transfer rate (MBytes/sec) Internal, min/max External	--/5.7 16.0	--/6.0 16.0	--/6.4 10.0	--/8.0 16.0	--/9.0 16.0
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	10.5 x 54 x 85.6	10.5 x 54 x 85.6	12.7 x 70.1 x 101.9	12.7 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	3Q94	4Q94		3Q95	
COMMENTS	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III Ramp loaded heads. *Untextured disks.	PCMCIA Type III	Ramp loaded heads.	

MANUFACTURER	IOMEGA	IOMEGA	JTS	JTS	JTS
DRIVE	Jaz 1GB IDE	Jaz 1GB SCSI	N0640-2AR Nordic	N0810-2AF/AR Nordic	N1080-2AR Nordic
DISK/TREND GROUP	1	1	4	4	5
MARKET	OEM, PCM	OEM, PCM	OEM	OEM	OEM
MEDIA: Disk diameter	95 mm	95 mm	84 mm	84 mm	84 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	MIG	MIG	MIG
Interface	IDE	SCSI-2	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 540/1,070	F: 540/1,070	F: 641.7	F: 810	F: 1,080
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	4204	4204	3303	3832	4032
Track density (TPI)	4301	4301	4280	4970	5000
Maximum linear density (BPI) (FCI)	89200 66900	89200 66900	74246 55685	84556 63417	93313 69985
Areal density (Mb/square inch)	383.6	383.6	317.8	420.2	466.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	4103	4103	4103
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	10 RD/12 WR	10 RD/12 WR	15 RD/16 WR	14	14
Average rotational delay (msec)	5.6	5.6	7.3	7.3	7.3
Average access time (msec)	15.6 RD/17.6 WR	15.6 RD/17.6 WR	22.3 RD/23.3 WR	21.3	21.3
Data transfer rate (MBytes/sec) Internal, min/max External	3.5/6.7 13.3 PIO Mode 4	3.5/6.7 10.0 synch. 5.0 asynch.	--/5.3 16.6 PIO Mode 4 16.6 DMA Mode 2	3.7/5.4 16.6 PIO Mode 4 16.6 DMA Mode 2	4.0/7.3 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 101.6 x 149.9	25.4 x 101.6 x 149.9	10.5 x 90 x 120	10.5 x 90 x 120	10.5 x 90 x 120
FIRST CUSTOMER SHIPMENT	1Q96	4Q95	11/95	5/96	8/96
COMMENTS					

MANUFACTURER	JTS	JTS	JTS	JTS	MAXTOR
DRIVE	N1620-3AR Nordic	P1000-2AF Palladium	P1600-3AF Palladium	P2000-3AF Palladium	250837 Laramie
DISK/TREND GROUP	5	5	5	6	4
MARKET	OEM	OEM, PCM	OEM, PCM	OEM, PCM	OEM
MEDIA: Disk diameter	84 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	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	F: 837
REMOVABLE	F: 1,620	F: 1,000	F: 1,600	F: 2,000	--
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	6	5
Tracks per surface	4032	4629	4832	5047	3196
Track density (TPI)	5000	4640	4844	5058	5080
Maximum linear density (BPI) (FCI)	93313 69985	84572 63429	86026 64520	97270 72952	92200 69150
Areal density (Mb/square inch)	466.6	392.4	416.7	492.0	468.4
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4103	4103	4103	4500	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)	14	14	14	14	14
Average rotational delay (msec)	7.3	7.3	7.3	6.7	6.7
Average access time (msec)	21.3	21.3	21.3	20.7	20.7
Data transfer rate (MBytes/sec) Internal, min/max External	4.0/7.3 16.6 PIO Mode 4 16.6 DMA Mode 2	--/5.3 16.6 PIO Mode 4 16.6 DMA Mode 2	--/5.3 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/.7 11.1 PIO Mode 3
SIZE: (mm) H x W x D	12.7 x 90 x 120	12.7 x 101.6 x 146	16.5 x 101.6 x 146	16.5 x 101.6 x 146	12.5 x 70 x 100
FIRST CUSTOMER SHIPMENT	8/96	12/95	4/96	5/96	4Q95
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	7541AP/A Durango	7850AV	251005 Laramie	251340 Laramie	71084AP/A Durango
DISK/TREND GROUP	4	4	5	5	5
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	Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 541	F: 854	F: 1,005	F: 1,340	F: 1,084
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	6	8	4
Tracks per surface		3721	3196	3196	3721
Track density (TPI)	4232	3900	5080	5080	4232
Maximum linear density (BPI) (FCI)	92000 69000	73870 55400	92200 69150	92200 69150	92000 69000
Areal density (Mb/square inch)	389.3	288.1	468.4	468.4	389.3
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	6.7
Average access time (msec)	18.7	20.45	20.7	20.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	4.6/8.1 16.6 PIO Mode 4 16.6 DMA Mode 2	2.8/5.3 11.1 PIO Mode 3	--/.7 11.1 PIO Mode 3	--/.7 11.1 PIO Mode 3	4.6/8.1 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	12.5 x 70 x 100	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	6/95	4Q94	4Q95	4Q95	6/95
COMMENTS					

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE	71260A Excalibur	71336AP/A Genstone	71626AP/A Durango	71670AP/A Genstone	72004AP/A Genstone
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	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: 1,260	F: 1,336	F: 1,626	F: 1,670	F: 2,004
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	5	6
Tracks per surface	3854	4702	3721	4702	4702
Track density (TPI)	4030	4974	4232	4974	4974
Maximum linear density (BPI) (FCI)	78400 58800	98000 73500	92000 69000	98000 73500	98000 73500
Areal density (Mb/square inch)	316.0	487.5	389.3	487.5	487.5
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	4500	4480	4500	4480	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	12	12
Average rotational delay (msec)	6.67	6.7	6.7	6.7	6.7
Average access time (msec)	18.67	18.7	18.7	18.7	18.7
Data transfer rate (MBytes/sec) Internal, min/max External	3.9/6.1 11.1 PIO Mode 3 13.3 DMA Mode 1	4.7/8.1 16.6 PIO Mode 4 16.6 DMA Mode 2	4.6/8.1 16.6 PIO Mode 4 16.6 DMA Mode 2	4.7/8.1 16.6 PIO Mode 4 16.6 DMA Mode 2	4.7/8.1 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	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		6/95		1/96
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	4221 Taurus 2	4221AV 4221WAV Taurus 2	4421	3243 Capricorn 4	3243AV 3243WAV Capricorn 4
DISK/TREND GROUP	6	6	6	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	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,050	F: 2,050	F: 2,147	F: 4,294	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	9	9	7	19	19
Tracks per surface		4050	4050	3956	3956
Track density (TPI)			4300	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	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	7200	5400	7200	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	8.9	8.9	8.9	8.9	8.9
Average rotational delay (msec)	4.17	4.17	5.6	4.17	4.17
Average access time (msec)	13.07	13.07	14.5	13.07	13.07
Data transfer rate (MBytes/sec) Internal, min/max External	6.1/10.1 20.0 synch. 5.0 asynch.	6.1/10.1 20.0 synch.* 5.0 asynch.	5.6/11.7 10.0 synch.	5.8/10.0 20.0 synch. 5.0 asynch.	5.8/10.0 20.0 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	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q94	12/94	1Q96	2Q94	11/94
COMMENTS		*Max. sustained transfer rate is 7.3 MB/sec. Optimized for video applications.			*Max. sustained transfer rate is 7.2 MB/sec. Optimized for video applications.

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MOMENTUM PERIPHERALS
DRIVE	3343 Taurus 4	1991 Scorpio 9	1991AV 1991WAV Scorpio 9	3391 Capricorn 9	MOMENTUM 130
DISK/TREND GROUP	7	8	8	8	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	95 mm	130 mm	130 mm	95 mm	48 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	Thin Film
Interface	Ultra SCSI	SCSI-2	SCSI-2	Ultra SCSI	PCMCIA-ATA
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 9,091	F: 9,091	F: 9,100	--
REMOVABLE	--	--	--	--	F: 130
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	10	27	27	23	4
Tracks per surface	4755	4449	4477		1076
Track density (TPI)					3200
Maximum linear density (BPI) (FCI)					76500 51000
Areal density (Mb/square inch)					244.8
Recording code	PRML	1,7 RLL	1,7 RLL	PRML	1,7 RLL
Rotational speed (RPM)	7200	5400	5400	7200	4464
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	Embedded
Average positioning time (msec)	8.5	12	12	8.5	15
Average rotational delay (msec)	4.17	5.6	5.6	4.17	6.7
Average access time (msec)	12.67	17.6	17.6	12.67	21.7
Data transfer rate (MBytes/sec) Internal, min/max External	9.9/15.6 40.0 synch.	5.9/9.6 20.0 synch. 5.0 asynch.	5.9/9.6 20.0 synch.* 5.0 asynch.	9.5/15.6 40.0 synch.	1.9/3.2 5000
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 203.2	41.3 x 101.6 x 146.1	10.5 x 54 x 85.6
FIRST CUSTOMER SHIPMENT	2Q96	2Q94	11/94	2Q96	5/96
COMMENTS	Preliminary specification.		*Max. sustained transfer rate is 6.9 MB/sec. Optimized for video applications.		PCMCIA Type III

MANUFACTURER	MOMENTUM PERIPHERALS	MOUNTAIN OPTECH	NEC	NEC	NEC
DRIVE	MOMENTUM 170	SE-9000 ST-9000	D3743	DSE850A	DSE850S
DISK/TREND GROUP	2	8	4	4	4
MARKET	OEM, PCM	PCM	OEM	OEM	OEM
MEDIA: Disk diameter	48 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	PCMCIA-ATA	SCSI-2	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 10,800 F: 9,090	F: 540	F: 850	F: 850
REMOVABLE	F: 170	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	27	2	2	2
Tracks per surface	1407	4925	3678	5045	5045
Track density (TPI)	3200		4000	5350	5350
Maximum linear density (BPI) (FCI)	76500 51000		100000 112500	111000	111000
Areal density (Mb/square inch)	244.8		400.0	593.8	593.8
Recording code	1,7 RLL	1,7 RLL	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	4464	5400	4500	5200	5200
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)	15	13.5	11	11	11
Average rotational delay (msec)	6.7	5.6	6.67	5.77	5.77
Average access time (msec)	21.7	19.1	17.67	16.77	16.77
Data transfer rate (MBytes/sec) Internal, min/max External	1.9/3.2 5000	10.0	16.6 PIO Mode 4 16.6 DMA Mode 2	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	193.5 x 190.5 x 314.5	25.4 x 101.6 x 146	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	5/96	3/96	7/95	6/96	6/96
COMMENTS	PCMCIA Type III	Ruggedized Seagate Elite 9 Modified microcode.			

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3745	D3747	D3845	D3847	DSE1340A
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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,620	F: 1,080	F: 1,620	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	4	6	4	6	4
Tracks per surface	3678	3678	3678	3678	4323
Track density (TPI)	4000	4000	4000	4000	4700
Maximum linear density (BPI) (FCI)	100000 112500	100000 112500	100000 112500	100000 112500	107000 120375
Areal density (Mb/square inch)	400.0	400.0	400.0	400.0	502.9
Recording code	8,9 PRML	8,9 PRML	1,7 RLL	1,7 RLL	8,9 PRML
Rotational speed (RPM)	4500	4500	4500	4500	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11	11	11	11	11
Average rotational delay (msec)	6.67	6.67	6.67	6.67	6.67
Average access time (msec)	17.67	17.67	17.67	17.67	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	10.0 synch.	10.0 synch.	5.0/10.0 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	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	10/95	10/95			9/95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	DSE1340S	DSE1700A	DSE1700S	D3896	DSE2010A
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	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	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI-2	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,340	F: 1,700	F: 1,700	F: 2,160	F: 2,010
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	4	9	6
Tracks per surface	4323	5045	5045	3928	4323
Track density (TPI)	4700	5350	5350	4070	4700
Maximum linear density (BPI) (FCI)	107000 120375	111000	111000	78000 58500	107000 120375
Areal density (Mb/square inch)	502.9	593.8	593.8	317.5	502.9
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	1,7 RLL	8,9 PRML
Rotational speed (RPM)	4500	5200	5200	7200	4500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Dedicated Surf.	Embedded
Average positioning time (msec)	11	11	11	9	11
Average rotational delay (msec)	6.67	5.77	5.77	4.17	6.67
Average access time (msec)	17.67	16.77	16.77	13.17	17.67
Data transfer rate (MBytes/sec) Internal, min/max External	5.0/10.0 10.0 synch. 5.0 asynch.	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	6.23/10.19 20.0 synch.	5.0/10.0 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	25.4 x 101.6 x 146	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	9/95	6/96	6/96	6/95	9/95
COMMENTS					

MANUFACTURER	NEC	NEC	NEC	NEC	NOMAI
DRIVE	DSE2010S	DSE2550A	DSE2550S	DVF4400S	MCD-I
DISK/TREND GROUP	6	6	6	7	1
MARKET	OEM	OEM	OEM	Captive, OEM	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	Thin Film
Interface	SCSI-2	IDE	SCSI-2	SCSI, FC	SCSI-2, IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,010	F: 2,550	F: 2,550	F: 4,400	--
REMOVABLE	--	--	--	--	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	6	6	6	10	2
Tracks per surface	4323	5045	5045	5707	
Track density (TPI)	4700	5350	5350	6100	4250
Maximum linear density (BPI) (FCI)	107000 120375	111000	111000	117000 131625	100000
Areal density (Mb/square inch)	502.9	593.8	593.8	713.7	425.0
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML
Rotational speed (RPM)	4500	5200	5200	7200	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	8.7/9.0	10
Average rotational delay (msec)	6.67	5.77	5.77	4.17	6.6
Average access time (msec)	17.67	16.77	16.77	12.87/13.17	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	5.0/10.0 10.0 synch. 5.0 asynch.	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	12.6 16.6 PIO Mode 4 16.6 DMA Mode 2	11.64/14.99 10.0 synch.	4.1/8.8 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 101.6 x 146.05	25.4 x 102 x 150
FIRST CUSTOMER SHIPMENT	9/95	6/96	6/96	1Q96	4Q95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	127A Daytona	127S Daytona	170A Daytona	170S Daytona	256A Daytona
DISK/TREND GROUP	2	2	2	2	2
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	2	2	2	3	3
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	3	3	3	3	4
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 10.0 synch. 6.0 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	4	4	4	4	4
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	4	4	4	4	4
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 10.0 synch. 6.0 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	4	4	4	4	4
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	10.0 synch. 6.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	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	1.0 AT Fireball TM	1.0 S Fireball TM	1.2 Bigfoot	1080A Fireball
DISK/TREND GROUP	4	5	5	5	5
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM	OEM, PCM
MEDIA: Disk diameter	95 mm	95 mm	95 mm	130 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	Thin Film	Thin Film
Interface	SCSI-2	IDE	Ultra SCSI	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 684 F: 535	F: 1,082.7	F: 1,082.7	F: 1,286	F: 1,089
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	2	4
Tracks per surface	3117	6825	6825	5738	3835
Track density (TPI)	3256	6775	6775	4298	4700
Maximum linear density (BPI) (FCI)	61509 46132	109000 122625	109000 122625	107221 113922	92982 98783
Areal density (Mb/square inch)	200.3	738.5	738.5	460.8	437.0
Recording code	1,7 RLL	16,17 PRML	16,17 PRML	16,17 PRML	PRML
Rotational speed (RPM)	5400	4500	4500	3600	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	9.5	12	12	15.5	12
Average rotational delay (msec)	5.6	6.7	6.7	8.3	5.6
Average access time (msec)	15.1	18.7	18.7	23.8	17.6
Data transfer rate (MBytes/sec) Internal, min/max External	3.4/6.9 20.0 synch. 10.0 asynch.	5.1/11.3 16.6 PIO Mode 4 16.6 DMA Mode 2	5.1/11.3 20.0 synch. 6.0 asynch.	6.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	--/10.5 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 146.05	25.4 x 101.6 x 146.05	19.05 x 146.05 x 203.2	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/94	6/96	6/96	3/96	5/95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	1080AT Europa	1080S Empire	1080S Fireball	1280A Fireball	1280S Fireball
DISK/TREND GROUP	5	5	5	5	5
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	MR Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	IDE	SCSI-3	SCSI	IDE	SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	U: 1,232 F: 1,080	F: 1,092.7	F: 1,282	F: 1,282
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	4	4	4
Tracks per surface	2925	2874	3835	4142	4142
Track density (TPI)	5300	3014	4700	4270	4270
Maximum linear density (BPI) (FCI)	96373 108420	63600 47700	92982 98783	108964 115774	108964 115774
Areal density (Mb/square inch)	510.8	191.7	437.0	465.3	465.3
Recording code	PRML	1,7 RLL	PRML	16,17 PRML	16,17 PRML
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	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	14	9.5 RD/11 WR	12	11	11
Average rotational delay (msec)	7.9	5.6	5.6	5.6	5.6
Average access time (msec)	21.9	15.1 RD/16.6 WR	17.6	16.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	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 10.0 synch. 6.0 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	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	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3Q95	4Q93	5/95	10/95	10/95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	1400S Empire	1770A Sirocco	1770S Sirocco	DSP3107L	DSP3133L
DISK/TREND GROUP	5	5	5	5	5
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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-3	IDE	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,604 F: 1,400	F: 1,700	F: 1,700	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	8	4	4	8	10
Tracks per surface	3115	5900	5900	3117	3117
Track density (TPI)	3200	5850	5850	3256	3256
Maximum linear density (BPI) (FCI)	80000 90000	108234 114999	108234 114999	61509 46132	61509 46132
Areal density (Mb/square inch)	256.0	633.2	633.2	200.3	200.3
Recording code	PRML	16,17 PRML	16,17 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	4500	4500	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 RD/11 WR	11 RD	11 RD	9.5	9.5
Average rotational delay (msec)	5.6	6.7	6.7	5.6	5.6
Average access time (msec)	15.1 RD/16.6 WR	17.7 RD	17.7 RD	15.1	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	4.6/8.3 20.0 synch. 5.0 asynch.	5.0/9.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.0/9.0 10.0 synch. 6.0 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	1Q94	3/96	3/96	10/94	10/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	VP31110S Capella	XP31070S Atlas	2.1 AT Fireball TM	2.1 S Fireball TM	2.1 S Viking
DISK/TREND GROUP	5	5	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	MR Thin Film	Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	IDE	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,412 F: 1,108	U: 1,344 F: 1,075	F: 2,168.8	F: 2,168.8	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	4	4	4
Tracks per surface	4165	3832	6825	6825	6720
Track density (TPI)	4350	3858	6775	6775	6750
Maximum linear density (BPI) (FCI)	98600 73950	81765 61324	109000 122625	109000 122625	123000 131000
Areal density (Mb/square inch)	428.9	315.4	738.5	738.5	830.3
Recording code	1,7 RLL	1,7 RLL	16,17 PRML	16,17 PRML	16,17 PRML
Rotational speed (RPM)	5400	7200	4500	4500	7200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	8.5 RD/9.5 WR	8.5	10.5	10.5	8.5 RD
Average rotational delay (msec)	5.6	4.17	6.7	6.7	4.17
Average access time (msec)	14.1 RD/15.1 WR	12.67	16.9	16.9	12.67 RD
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.	5.1/11.3 16.6 PIO Mode 4 16.6 DMA Mode 2	5.1/11.3 20.0 synch. 6.0 asynch.	9.3/15.0 40.0 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 146.05	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.05
FIRST CUSTOMER SHIPMENT	1Q95	4Q94	6/96	6/96	4Q96
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	2.4 Bigfoot	2100S Empire	2550A Sirocco	2550S Sirocco	DSP3210
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	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	MR Thin Film	MR Thin Film	MR Thin Film
Interface	IDE	SCSI-3	IDE	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,577	U: 2,406 F: 2,100	F: 2,550	F: 2,550	U: 2,688 F: 2,148
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	12	6	6	16
Tracks per surface	5738	3115	5900	5900	3045
Track density (TPI)	4298	3200	5850	5850	3256
Maximum linear density (BPI) (FCI)	107221 113922	80000 90000	108234 114999	108234 114999	64000 48000
Areal density (Mb/square inch)	460.8	256.0	633.2	633.2	208.4
Recording code	16,17 PRML	PRML	16,17 PRML	16,17 PRML	1,7 RLL
Rotational speed (RPM)	3600	5400	4500	4500	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	15.5	9.5 RD/11 WR	11 RD	11 RD	9.5
Average rotational delay (msec)	8.3	5.6	6.7	6.7	5.6
Average access time (msec)	23.8	15.1 RD/16.6 WR	17.7 RD	17.7 RD	15.1
Data transfer rate (MBytes/sec) Internal, min/max External	6.0/11.1 16.6 PIO Mode 4 16.6 DMA Mode 2	4.6/8.3 20.0 synch. 5.0 asynch.	5.0/9.0 16.6 PIO Mode 4 16.6 DMA Mode 2	5.0/9.0 10.0 synch. 6.0 asynch.	3.4/6.9 20.0 synch. 10.0 asynch.
SIZE: (mm) H x W x D	19.05 x 146.05 x 203.2	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	3/96	1Q94	3/96	3/96	10/94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	VP32210S Capella	XP32140 Grand Prix	XP32150S Atlas	XP32151S Grand Prix	XP32181S Atlas II
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	MR Thin Film	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-3	SCSI-2	SCSI-3	Ultra SCSI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,824 F: 2,216	F: 2,140	U: 2,689 F: 2,150	U: 2,619 F: 2,150	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	8	10	10	10	5
Tracks per surface	4165		3832	4066	5964
Track density (TPI)	4350	4000	3858	4000	6000
Maximum linear density (BPI) (FCI)	98600 73950		81765 61324	79600	106000 79500
Areal density (Mb/square inch)	428.9		315.4	318.4	636.0
Recording code	1,7 RLL	PRML	1,7 RLL	PRML	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)	8.5 RD/9.5 WR	8.6 RD/10.6 WR	8.5	8.6 RD/10.6 WR	7.9
Average rotational delay (msec)	5.6	4.17	4.17	4.17	4.17
Average access time (msec)	14.1 RD/15.1 WR	12.77/14.77	12.67	12.77/14.77	12.07
Data transfer rate (MBytes/sec) Internal, min/max External	5.8/8.7 20.0 synch. 10.0 asynch.	5.8/9.7 20.0 synch.	6.1/10.2 20.0 synch. 10.0 asynch.	5.8/9.7 20.0 synch.	8.8/13.3 40.0
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146.1	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146
FIRST CUSTOMER SHIPMENT	1Q95		4Q94	4Q94	4Q95
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	3.2 AT Fireball TM	3.2 S Fireball TM	4.3 S Viking	XP34280 Grand Prix	XP34300S Atlas
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	Thin Film	Thin Film
Interface	IDE	Ultra SCSI	Ultra SCSI	SCSI-3	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,254.9	F: 3,254.9	F: 4,360	F: 4,280	U: 5,378 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	6	6	8	20	20
Tracks per surface	6825	6825	6720		3832
Track density (TPI)	6775	6775	6750	4000	3858
Maximum linear density (BPI) (FCI)	109000 122625	109000 122625	123000 131000		81765 61324
Areal density (Mb/square inch)	738.5	738.5	830.3		315.4
Recording code	16,17 PRML	16,17 PRML	16,17 PRML	PRML	1,7 RLL
Rotational speed (RPM)	4500	4500	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)	10.5	10.5	8.5 RD	8.6 RD/10.6 WR	8.5
Average rotational delay (msec)	6.7	6.7	4.17	4.17	4.17
Average access time (msec)	16.9	16.9	12.67 RD	12.77/14.77	12.67
Data transfer rate (MBytes/sec) Internal, min/max External	5.1/11.3 16.6 PIO Mode 4 16.6 DMA Mode 2	5.1/11.3 20.0 synch. 6.0 asynch.	9.3/15.0 40.0 synch.	5.8/9.7 20.0 synch.	6.1/10.2 20.0 synch. 10.0 asynch.
SIZE: (mm) H x W x D	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.05	25.4 x 101.6 x 146.05	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	6/96	6/96	4Q96		4Q94
COMMENTS					

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	RAYMOND ENGINEERING	RAYMOND ENGINEERING
DRIVE	XP34301S Grand Prix	XP34361S Atlas II	XP39100S Atlas II	8440	84300
DISK/TREND GROUP	7	7	8	2	3
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	MR Thin Film	MR Thin Film	Ferrite	Thin Film
Interface	SCSI-3	Ultra SCSI-3	Ultra SCSI-3	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 5,238 F: 4,300	F: 4,360	F: 9,100	--	--
REMOVABLE	--	--	--	F: 40.55	F: 306
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	F: 11,264	F: 27,648
Data surfaces per spindle	20	10	20	8	9
Tracks per surface	4066	5964	5964	450	1231
Track density (TPI)	4000	6000	6000	850	2075
Maximum linear density (BPI) (FCI)	79600	106000 79500	111000 83250	17000 17000	46227 30818
Areal density (Mb/square inch)	318.4	636.0	666.0	14.4	95.9
Recording code	PRML	1,7 RLL	1,7 RLL	MFM	2,7 RLL
Rotational speed (RPM)	7200	7200	7200	3637	3688
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)	8.6 RD/10.6 WR	7.9	7.9	115	25
Average rotational delay (msec)	4.17	4.17	4.17	8.3	8.1
Average access time (msec)	12.77/14.77	12.07	12.07	123.3	33.1
Data transfer rate (MBytes/sec) Internal, min/max External	 5.8/9.7 20.0 synch.	 8.8/13.3 40.0	 8.8/13.9 40.0	 0.4	 1.2
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	25.4 x 101.6 x 146	41.3 x 101.6 x 146	58.4 x 106.7 x 188	58.4 x 106.7 x 188
FIRST CUSTOMER SHIPMENT	4Q94	4Q95	4Q95	1987	1991
COMMENTS			FC AL interface available 1996.	Mil-Spec ruggedized drive and electronics assembly. *Removable disk drive cartridge	Mil-Spec ruggedized drive and electronics assembly. *Removable disk drive cartridge

MANUFACTURER	SAGEM	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	MSA 252-200	ACB-21011A	ACB-21202A	PLS-31084A	STG-31271A
DISK/TREND GROUP	2	5	5	5	5
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	65 mm	65 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	F: 1,011	F: 1,200	F: 1,080.3	F: 1,281.6
REMOVABLE	F: 200	--	--	--	--
Capacity per track (Bytes)	F: 23,040	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	16	6	6	4	4
Tracks per surface	720			3950	4482
Track density (TPI)	950	5100		4405	5000
Maximum linear density (BPI) (FCI)	19680 14760	123000 92250		91656 103113	99914 112404
Areal density (Mb/square inch)	18.7	627.3		403.7	499.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	8,9 RLL	PRML
Rotational speed (RPM)	3600	4200	4200	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	13	12	11	12
Average rotational delay (msec)	8.3	7.1	7.1	6.7	6.67
Average access time (msec)	25.3	20.1	19.1	17.7	18.67
Data transfer rate (MBytes/sec) Internal, min/max External	1.5	--/8.0 16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	--/8.8 11.1 PIO Mode 3 13.3 DMA Mode 1	--/9.4 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	220 x 440 x 500	12.5 x 69.9 x 101.6	12.5 x 69.9 x 101.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/90	1996		6/95	2/96
COMMENTS	Militarized subsystem. Removable Head/Disk module.				

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS
DRIVE	WNR-31601A	WNR-32101A	WNR-32101S	WNR-32102A	WNR-32401A
DISK/TREND GROUP	5	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	IDE	IDE	SCSI-2	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,610	F: 2,013	F: 2,013	F: 2,100	F: 2,400
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	5	5	4	6
Tracks per surface	5589	5589	5589		
Track density (TPI)	5700	5700	5700	6000	5700
Maximum linear density (BPI) (FCI)	95900 108000	95900 108000	95900 108000	116000 131000	95900 108000
Areal density (Mb/square inch)	546.6	546.6	546.6	696.0	546.6
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML	8,9 PRML
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)	11	11	11	9.9	11
Average rotational delay (msec)	5.6	5.6	5.6	5.7	5.6
Average access time (msec)	16.6	16.6	16.6	15.6	16.6
Data transfer rate (MBytes/sec) Internal, min/max External	5.4/10.6 16.6 PIO Mode 4 16.6 DMA Mode 2	5.4/10.6 16.6 PIO Mode 4 16.6 DMA Mode 2	5.4/10.6 10.0 synch.	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	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	4/96	1996	1996	10/96	6/96
COMMENTS					

MANUFACTURER	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	WNR-32501A	WNR-32502A	WNR-33202A	ST3491A Medalist 425xe	ST9420AG Marathon 420sl
DISK/TREND GROUP	6	6	7	3	3
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	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,416	F: 2,500	F: 3,200	F: 428	F: 420.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	6	5	6	4	4
Tracks per surface	5589				
Track density (TPI)	5700	6000	6000		3807
Maximum linear density (BPI) (FCI)	95900 108000	116000 131000	116000 131000		94000 70500
Areal density (Mb/square inch)	546.6	696.0	696.0		357.9
Recording code	8,9 PRML	8,9 PRML	8,9 PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	5400	3811	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	9.9	9.9	14	16
Average rotational delay (msec)	5.6	5.6	5.6	7.87	6.7
Average access time (msec)	16.6	15.5	15.5	21.87	22.7
Data transfer rate (MBytes/sec) Internal, min/max External	5.4/10.6 16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	11.1 PIO Mode 3 13.3 DMA Mode 1	--/5.5 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 102.1 x 146.6	12.75 x 70.1 x 101.9
FIRST CUSTOMER SHIPMENT	1996			4Q93	1Q95
COMMENTS					*Glass disks.

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3541A	ST3620N ST3620NC ST3620ND Hawk 1LP	ST3630A Medalist 630xe	ST3636A Medalist 636	ST3660A Medalist 545xe
DISK/TREND GROUP	4	4	4	4	4
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	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 541	U: 635 F: 535	F: 631	F: 636	F: 545
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	5	4	2	4
Tracks per surface	3924	2700			
Track density (TPI)	4100	3000		4973	
Maximum linear density (BPI) (FCI)	93000 70000	49000 36750		88500 66375	
Areal density (Mb/square inch)	381.3	147.0		440.1	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	5411	3811	4500	3811
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)	14	9 RD/10.5 WR	14	12.5	14
Average rotational delay (msec)	8.3	5.54	7.87	6.7	7.87
Average access time (msec)	22.3	14.54/16.04	21.87	19.2	21.87
Data transfer rate (MBytes/sec) Internal, min/max External	--/5.1 16.6 PIO Mode 4 16.6 DMA Mode 2	3.2/5.9 10.0 synch.	--/4.9 11.1 PIO Mode 3 13.3 DMA Mode 1	--/6.4 16.6 PIO Mode 4 16.6 DMA Mode 2	--/4.4 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 102.1 x 146.6	25.4 x 101.6 x 146.1	25.4 x 102.1 x 146.6
FIRST CUSTOMER SHIPMENT	6/95	3Q93	9/94	2/96	9/94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST3850A(1) Medalist 850xe	ST3851A	ST3852A Medalist 850	ST9816AG Marathon 810	ST9840A Marathon 840sl
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
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	Thin Film	Thin Film	Thin Film	MR Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 850	F: 850	F: 850	F: 810.7	F: 840
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	8	4
Tracks per surface		3640			
Track density (TPI)		3849		3807	5555
Maximum linear density (BPI) (FCI)		77000 58000		90000 67500	120000
Areal density (Mb/square inch)		296.4		342.6	666.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	3811	3600	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	14	12.5	16	14
Average rotational delay (msec)	7.87	8.3	6.7	6.7	6.7
Average access time (msec)	21.87	22.3	19.2	22.7	20.7
Data transfer rate (MBytes/sec) Internal, min/max External	--/5.3 16.6 PIO Mode 4 16.6 DMA Mode 2	--/4.4 16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	--/5.5 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	25.4 x 102.1 x 146.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	19.15 x 70.1 x 101.9	12.7 x 70.1 x 100.5
FIRST CUSTOMER SHIPMENT		11/94	3Q96	4/95	4/96
COMMENTS				*Glass disks.	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST11200N ST11200ND Hawk 1	ST11950N Barracuda 1	ST31051N Hawk 2XL	ST31051W ST31051WC ST31051WD Hawk 2XL	ST31081A
DISK/TREND GROUP	5	5	5	5	5
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	SCSI-2	SCSI-2	SCSI-2	Ultra SCSI	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,200 F: 1,050	U: 2,031 F: 1,689	F: 1,050	F: 1,080	F: 1,082
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	4	4
Tracks per surface	1877	2706	4117	4117	3924
Track density (TPI)	2150	3047			4100
Maximum linear density (BPI) (FCI)	42000 31500	52187 39140			93000 70000
Areal density (Mb/square inch)	90.3	159.0			381.3
Recording code	1,7 RLL	1,7 RLL	PRML	PRML	1,7 RLL
Rotational speed (RPM)	5411	7200	5411	5411	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)	10.5 RD/12 WR	8 RD/9 WR	9 RD/10.5 WR	9 RD/10.5 WR	14
Average rotational delay (msec)	5.6	4.17	5.54	5.54	8.3
Average access time (msec)	16.1/17.6	12.17/13.17	14.54/16.04	14.54/16.04	22.3
Data transfer rate (MBytes/sec) Internal, min/max External	2.9/5.1 10.0 synch. 4.0 asynch.	4.3/7.0 10.0 synch. 5.0 asynch.	5.5/8.3 20.0 synch.	5.5/8.3 40.0	--/5.1 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	41.3 x 101.6 x 146.1	41.3 x 101.6 x 151.6	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q92	4/93	8/95		6/95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST31200N ST31200NC ST31200ND Hawk 1LP	ST31200W ST31200WC ST31200WD Hawk 1LP	ST31230DC ST31230N ST31230NC ST31230ND Hawk 2LP	ST31230W ST31230WC ST31230WD Hawk 2LP	ST31250N Barracuda 2LP
DISK/TREND GROUP	5	5	5	5	5
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	MR Thin Film	MR Thin Film	
Interface	SCSI-2	SCSI-2	SCSI-2	SCSI-2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,260 F: 1,050	U: 1,260 F: 1,052	U: 1,200 F: 1,050	U: 1,200 F: 1,050	U: 1,205 F: 1,021
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	5	5	5
Tracks per surface	2700	2700	3892	3892	3711
Track density (TPI)	3000	3000	4200	4200	
Maximum linear density (BPI) (FCI)	55000 41250	55000 41250	78000 58500	78000 58500	
Areal density (Mb/square inch)	165.0	165.0	327.6	327.6	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5411	5411	5411	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.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	9 RD/10.5 WR	9 RD/10.5 WR	9 RD/10.5 WR	9 RD/10.5 WR	8 RD/9 WR
Average rotational delay (msec)	5.54	5.54	5.54	5.54	4.17
Average access time (msec)	14.54/16.04	14.54/16.04	14.54/16.04	14.54/16.04	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	3.2/5.9 10.0 synch. 4.0 asynch.	3.2/5.9 20.0 synch.	4.0/7.3 10.0 synch.	4.0/7.3 20.0 synch.	6.2/9.0 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	2Q93		2Q94	2Q94	4Q94
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST31250W ST31250WC ST31250WD Barracuda 2LP	ST31276A Medalist 1276	ST31621A	ST31720A Medalist 1.7	ST51080A Medalist 1080sl
DISK/TREND GROUP	5	5	5	5	5
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	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,205 F: 1,021	F: 1,276	F: 1,623	F: 1,700	F: 1,083
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	6	4	4
Tracks per surface	3711		3924		4834
Track density (TPI)		4973	4100		4923
Maximum linear density (BPI) (FCI)		88500 66375	93000 70000		73444 55083
Areal density (Mb/square inch)		440.1	381.3		361.6
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	7200	4500	3600	4500	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)	8 RD/9 WR	12.5	14	12.5	10.5
Average rotational delay (msec)	4.17	6.7	8.3	6.7	5.6
Average access time (msec)	12.17/13.17	19.2	22.3	19.2	16.1
Data transfer rate (MBytes/sec) Internal, min/max External	6.2/9.0 20.0 synch.	--/6.4 16.6 PIO Mode 4 16.6 DMA Mode 2	--/5.1 16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	4.1/8.5 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 146.1	19 x 102.1 x 127
FIRST CUSTOMER SHIPMENT	4Q94	2/96	6/95	3Q96	10/95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST51080N ST51080NC Medalist 1080sl	ST51270A Medalist 1270sl	ST91350AG Marathon 1350sl	ST91685AG Marathon 1680	ST12400N ST12400NC ST12400ND ST12400WD Hawk 2
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	65 mm	65 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	Thin Film
Interface	SCSI-2	IDE	IDE	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,080	F: 1,282	F: 1,350	F: 1,680	U: 2,537 F: 2,148
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	19
Tracks per surface	4826	5414			2626
Track density (TPI)	4923		5555	5555	3000
Maximum linear density (BPI) (FCI)	73444 55083		120000	120000	50000 37500
Areal density (Mb/square inch)	361.6		666.6	666.6	150.0
Recording code	1,7 RLL	1,7 RLL	PRML	PRML	1,7 RLL
Rotational speed (RPM)	5400	5400	4500	4500	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)	12.5	10.5	14	14	9 RD/10.5 WR
Average rotational delay (msec)	5.6	5.6	6.7	6.7	5.54
Average access time (msec)	18.1	16.1	20.7	20.7	14.54/16.04
Data transfer rate (MBytes/sec) Internal, min/max External	4.1/8.2 10.0 synch. 5.0 asynch.	--/8.9 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	3.4/5.4 10.0 synch. 5.0 asynch.
SIZE: (mm) H x W x D	19 x 102.1 x 127	19 x 102.1 x 127	12.7 x 70.1 x 100.5	17.2 x 70.1 x 100.5	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	10/95	12/95	4/96	4/96	2Q93
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST12450W ST12450WD Barracuda 2,2HP	ST12550N ST12550ND Barracuda 2	ST12550W ST12550WD Barracuda 2	ST32140A Medalist 2140	ST32151N Hawk 2XL
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-2	SCSI-2	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,437 F: 2,134	U: 2,572 F: 2,139	U: 2,572 F: 2,139	F: 2,113	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	18	19	19	8	8
Tracks per surface	2710	2707	2707	4834	4117
Track density (TPI)				4800	
Maximum linear density (BPI) (FCI)				78000 58500	
Areal density (Mb/square inch)				374.4	
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	PRML
Rotational speed (RPM)	7200	7200	7200	5400	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.	Embedded	Embedded
Average positioning time (msec)	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	10.5	9 RD/10.5 WR
Average rotational delay (msec)	4.17	4.17	4.17	5.6	5.54
Average access time (msec)	12.17/13.17	12.17/13.7	12.17/13.17	16.1	14.54/16.04
Data transfer rate (MBytes/sec) Internal, min/max External	 4.3/7.1 20.0 synch.	 4.3/7.0 10.0 synch.	 4.3/7.0 20.0 synch.	 --/8.4 16.6 PIO Mode 4	 5.5/8.3 20.0 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	25.4 x 102.1 x 146.6	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q94	2/93	7/93	3Q95	8/95
COMMENTS	2 head parallel version of Barracuda 2.				

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32151W ST32151WC ST32151WD Hawk 2XL	ST32171DC ST32171W ST32171WC ST32171WD Barracuda 4LP	ST32171FC Barracuda 4LP	ST32171N ST32171ND Barracuda 4LP	ST32271DC ST32271W ST32271WC ST32271WD Barracuda 4LP
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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	Ultra SCSI	Ultra SCSI	FC AL	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,149	F: 2,150	F: 2,150	F: 2,150	F: 2,270
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	5	5	5	5
Tracks per surface	4117	5288	5288	5288	5288
Track density (TPI)		5500	5500	5500	5500
Maximum linear density (BPI) (FCI)		120000	120000	120000	129000
Areal density (Mb/square inch)		660.0	660.0	660.0	709.5
Recording code	PRML	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	5411	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)	9 RD/10.5 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR
Average rotational delay (msec)	5.54	4.17	4.17	4.17	4.17
Average access time (msec)	14.54/16.04	12.17/13.17	12.17/13.17	12.17/13.17	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	 5.5/8.3 40.0	 9.4/15.0 40.0 synch.	 9.4/15.0 100.0 synch.	 9.4/15.0 20.0 synch.	 40.0 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		4Q95	4Q95	4Q95	1Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST32271FC Barracuda 4LP	ST32271N ST32271ND Barracuda 4LP	ST32430N ST32430ND Hawk 2LP	ST32430W ST32430WC ST32430WD Hawk 2LP	ST32550DC ST32550W ST32550WC ST32550WD Barracuda 2LP
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	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: 2,270	F: 2,270	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	5	5	9	9	11
Tracks per surface	5288	5288	3892	3892	3711
Track density (TPI)	5500	5500	4200	4200	
Maximum linear density (BPI) (FCI)	129000	129000	78000 58500	78000 58500	
Areal density (Mb/square inch)	709.5	709.5	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	100.0 synch.	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	1Q96	1Q96	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	6	6	6	6	6
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 25.0	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	ST52160A MedalistPro 2.1	ST52520A MedalistPro 2.5	ST92255AG Marathon 2250	ST15150DC ST15150N ST15150ND Barracuda 4	ST15150FC Barracuda 4
DISK/TREND GROUP	6	6	6	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	MR Thin Film	MR Thin Film	Thin Film	Thin Film
Interface	IDE	IDE	IDE	SCSI-2	Fibre Channel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,113	F: 2,560	F: 2,250	U: 5,062 F: 4,294	U: 5,062 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	4	4	10	21	21
Tracks per surface				3711	3711
Track density (TPI)	6730	6730	5555		
Maximum linear density (BPI) (FCI)	119609	138011	120000		
Areal density (Mb/square inch)	805.0	928.8	666.6		
Recording code	PRML	PRML	PRML	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	4500	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	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	11	11	14	8 RD/9 WR	8 RD/9 WR
Average rotational delay (msec)	5.6	5.6	6.7	4.17	4.17
Average access time (msec)	16.6	16.6	20.7	12.17/13.17	12.17/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	--/12.1 16.6 PIO Mode 4 16.6 DMA Mode 2	--/14.5 16.6 PIO Mode 4 16.6 DMA Mode 2	--/7.6 16.6 PIO Mode 4 16.6 DMA Mode 2	6.0/9.0 10.0 synch.	5.9/9.0 100.0
SIZE: (mm) H x W x D	19 x 101.6 x 127	19 x 101.6 x 127	17.2 x 70.1 x 100.5	41.3 x 101.6 x 151.6	41.3 x 101.6 x 151.6
FIRST CUSTOMER SHIPMENT	3Q96	3Q96	4/96	2Q94	2Q95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST15150W ST15150WC ST15150WD Barracuda 4	ST15230N ST15230ND Hawk 4	ST15230W ST15230WC ST15230WD Hawk 4	ST33440A Medalist 3440	ST34217W ST34217WC ST34217WD
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			MR Thin Film	MR Thin Film
Interface	SCSI-2	SCSI-2	SCSI-2	IDE	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 5,062 F: 4,294	U: 5,160 F: 4,294	U: 5,160 F: 4,294	F: 3,400	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	19	19	8	10
Tracks per surface	3711	3892	3892		6028
Track density (TPI)				5555	6100
Maximum linear density (BPI) (FCI)				120000	118000
Areal density (Mb/square inch)				666.6	719.8
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	8,9 PRML	8,9 PRML
Rotational speed (RPM)	7200	5411	5411	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.	Embedded	Embedded
Average positioning time (msec)	8 RD/9 WR	9 RD/10.5 WR	9 RD/10.5 WR	10.5	8.5 RD/9 WR
Average rotational delay (msec)	4.17	5.54	5.54	5.6	4.17
Average access time (msec)	12.17/13.17	14.54/16.04	14.54/16.04	16.1	12.67/13.17
Data transfer rate (MBytes/sec) Internal, min/max External	6.0/9.0 20.0 synch.	4.3/7.9 10.0 synch.	4.3/7.9 20.0 synch.	--/10.9 16.6 PIO Mode 4 16.6 DMA Mode 2	8.8/13.8 40.0 synch.
SIZE: (mm) H x W x D	41.3 x 101.6 x 151.6	41.3 x 101.6 x 146.1	41.3 x 101.6 x 146.1	26.1 x 102.2 x 147	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	2Q94	4/96	12/95
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST34250A Medalist 4250	ST34371DC ST34371W ST34371WC ST34371WD Barracuda 4LP	ST34371FC Barracuda 4LP	ST34371N ST34371ND Barracuda 4LP	ST34571DC ST34571W ST34571WC ST 34571WD Barracuda 4LP
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	IDE	Ultra SCSI	FC AL	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,250	F: 4,350	F: 4,350	F: 4,350	F: 4,550
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	10	10	10	10	10
Tracks per surface		5288	5288	5288	5288
Track density (TPI)	5555	5500	5500	5500	5500
Maximum linear density (BPI) (FCI)	120000	120000	120000	120000	129000
Areal density (Mb/square inch)	666.6	660.0	660.0	660.0	709.5
Recording code	8,9 PRML	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
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)	10.5	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR	8 RD/9 WR
Average rotational delay (msec)	5.6	4.17	4.17	4.17	4.17
Average access time (msec)	16.1	12.17/13.17	12.17/13.17	12.17/13.17	12.17/13.17
Data transfer rate (MBytes/sec)					
Internal, min/max	--/10.9	9.4/15.0	9.4/15.0	9.4/15.0	
External	16.6 PIO Mode 4 16.6 DMA Mode 2	40.0 synch.	100.0 synch.	20.0 synch.	40.0
SIZE: (mm) H x W x D	26.1 x 102.2 x 147	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 146.1
FIRST CUSTOMER SHIPMENT	4/96	4Q95	4Q95	4Q95	1Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST34571FC Barracuda 4LP	ST34571N ST34571ND Barracuda 4LP	ST19171DC ST19171W ST19171WC ST19171WD Barracuda 9	ST19171FC Barracuda 9	ST19171N Barracuda 9
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	MR Thin Film	MR Thin Film	MR Thin Film	MR Thin Film
Interface	FC AL	SCSI-2	Ultra SCSI	FC AL	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 4,550	F: 4,550	U: 11,700 F: 9,100	U: 11,700 F: 9,100	U: 11,700 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	10	10	20	20	20
Tracks per surface	5288	5288	5333	5333	5333
Track density (TPI)	5500	5500	5500	5500	5500
Maximum linear density (BPI) (FCI)	129000	129000	120000	120000	120000
Areal density (Mb/square inch)	709.5	709.5	660.0	660.0	660.0
Recording code	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)	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 WR	8 RD/9 WR	8 RD/9.5 WR	8 RD/9.5 WR	8 RD/9.5 WR
Average rotational delay (msec)	4.17	4.17	4.17	4.17	4.17
Average access time (msec)	12.17/13.17	12.17/13.17	12.17/13.67	12.17/13.67	12.17/13.67
Data transfer rate (MBytes/sec) Internal, min/max			9.4/15.0	9.4/15.0	9.4/15.0
External	100.0	20.0	40.0	100.0	20.0
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	41.3 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q96	1Q96	1Q96	1Q96	1Q96
COMMENTS					

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST410800N ST410800ND Elite 9	ST410800W ST410800WD Elite 9	ST423451FC Elite 23	ST423451N Elite 23	ST423451W ST423451WD Elite 23
DISK/TREND GROUP	8	8	9	9	9
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	130 mm	130 mm
Recording 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	FC AL	Ultra SCSI	Ultra SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 10,800 F: 9,090	U: 10,800 F: 9,090	F: 23,400	F: 23,400	F: 23,400
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	28	28	28
Tracks per surface	4925	4925	6884	6884	6884
Track density (TPI)				5555	
Maximum linear density (BPI) (FCI)				124000	
Areal density (Mb/square inch)				688.8	
Recording code	1,7 RLL	1,7 RLL	PRML (0,4,4)	PRML (0,4,4)	PRML (0,4,4)
Rotational speed (RPM)	5400	5400	5400	5400	5400
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Dedicated Surf.	Dedicated Surf.	Embedded	Embedded	Embedded
Average positioning time (msec)	11 RD/12 WR	11 RD/12 WR	13 RD/14 WR	13 RD/14 WR	13 RD/14 WR
Average rotational delay (msec)	5.6	5.6	5.6	5.6	5.6
Average access time (msec)	16.6 RD/17.6 WR	16.6 RD/17.6 WR	18.6 RD/19.6 WR	18.6 RD/19.6 WR	18.6 RD/19.6 WR
Data transfer rate (MBytes/sec) Internal, min/max	5.5/8.2	5.5/8.2	9.4/15.0	9.4/15.0	9.4/15.0
External	10.0 synch.	20.0 synch.	100.0	20.0 synch.	40.0 synch.
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	82.6 x 146.1 x 203	82.6 x 146.1 x 203
FIRST CUSTOMER SHIPMENT	2Q94	2Q94	3Q96	3Q96	3Q96
COMMENTS					

MANUFACTURER	SEIKO EPSON	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	EHDD170 Hard Disk Card	XT-1085	XT-1140	XT-2190	XT-4170E
DISK/TREND GROUP	2	2	2	2	2
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Disk diameter	48 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	Thin Film
Interface	PCMCIA-ATA	ST412	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 85.32	U: 143.42	U: 191.23	U: 179.45
REMOVABLE	F: 170.8	--	--	--	--
Capacity per track (Bytes)	Varies by zone	U: 10,416	U: 10,416	U: 10,416	U: 20,940
Data surfaces per spindle	4	8	15	15	7
Tracks per surface	1370	1024	918	1224	1224
Track density (TPI)	3800	1070	1070	1070	1070
Maximum linear density (BPI) (FCI)	84000 63000	9934	9280	11155	21064 14043
Areal density (Mb/square inch)	319.2	10.6	9.9	11.9	22.5
Recording code	1,7 RLL	MFM	MFM	MFM	2,7 RLL
Rotational speed (RPM)	4500	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
Average positioning time (msec)	12	27	25.8	28.9	14
Average rotational delay (msec)	6.7	8.3	8.3	8.3	8.3
Average access time (msec)	18.7	35.3	34.1	37.2	22.3
Data transfer rate (MBytes/sec) Internal, min/max External	12.0	0.625	0.625	0.625	1.25
SIZE: (mm) H x W x D	10.5 x 54 x 85.6	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	3/94	2Q83	2Q83	3Q84	2Q87
COMMENTS	PCMCIA Type III Ramp loaded heads. *Untextured disks. Mfg by Integral Peripherals.				

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SEQUEL	SEQUEL
DRIVE	XT-4170S	XT-4380E	XT-4380S	XT-8380EH	XT-8380SH
DISK/TREND GROUP	2	3	3	3	3
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	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 157.93	U: 384.53	F: 338.41	U: 410.0	F: 360.31
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 20,940	F: 18,432	U: 31,410	F: 27,648
Data surfaces per spindle	7	15	15	8	8
Tracks per surface	1224	1224	1224	1632	1632
Track density (TPI)	1070	1070	1070	1376	1376
Maximum linear density (BPI) (FCI)	21064 14043	21064 14043	21064 14043	31596 21064	31596 21064
Areal density (Mb/square inch)	22.5	22.5	22.5	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)	14	16	16	14.5	14.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	24.3	24.3	22.8	22.8
Data transfer rate (MBytes/sec) Internal, min/max External	4.8 synch.	1.25	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	2/86	2Q87	4Q87	1Q87	1Q88
COMMENTS					

MANUFACTURER	SEQUEL	SEQUEL	SEQUEL	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	XT-8760EH	XT-8760SH	5400	SQ3270A	SQ3270S
DISK/TREND GROUP	4	4	7	1	1
MARKET	OEM	OEM	OEM	OEM, PCM	OEM, PCM
MEDIA: Disk diameter	130 mm	130 mm	130 mm	95 mm	95 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Thin Film	MIG	
Interface	ESDI	SCSI	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 768.9	F: 675.58	F: 4,000	--	--
REMOVABLE	--	--	--	F: 270	F: 270
Capacity per track (Bytes)	U: 31,410	F: 27,648	Varies by zone	F:	F:
Data surfaces per spindle	15	15	26	2	2
Tracks per surface	1632	1632	3055	3140	3140
Track density (TPI)	1376	1376	2756	3280	3280
Maximum linear density (BPI) (FCI)	31596 21064	31596 21064	49000 36750	60000 45000	60000 45000
Areal density (Mb/square inch)	43.5	43.5	135.0	196.8	196.8
Recording code	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3600	3600	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.	Dedicated Surf.	Embedded	Embedded
Average positioning time (msec)	16.5	16.5	11.5	13.5	13.5
Average rotational delay (msec)	8.3	8.3	5.6	8.3	8.3
Average access time (msec)	24.8	24.8	17.1	21.8	21.8
Data transfer rate (MBytes/sec) Internal, min/max External	1.875	4.8 synch.	3.6/5.5 20.0 synch. 10.0 asynch.	2.3/4.0 4.0	2.3/4.0 4.0
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 x 208.8	25.4 x 101.6 x 150	25.4 x 101.6 x 150
FIRST CUSTOMER SHIPMENT	1Q87	1Q88	8/93	4Q93	2/94
COMMENTS				Removable data cartridge. Read/write compatible with 105 MB & 270 MB cartridges.	Removable data cartridge. Read/write compatible with 105 MB & 270 MB cartridges.

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY
DRIVE	SQ5200C	EZ135A	EZ135S	EZFlyer A	EZFlyer S
DISK/TREND GROUP	1	1	1	1	1
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	Ferrite	MIG	MIG	Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI/Parallel	SCSI	Parallel Port
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	--	--	--
REMOVABLE	F: 200	F: 135	F: 135	F: 230	F: 230
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	2	1	1	1	1
Tracks per surface	2260	3140	3140	4192	4192
Track density (TPI)	1875	3280	3280	4200	4200
Maximum linear density (BPI) (FCI)	49820 37365	60000 45000	60000 45000	77800 58400	77800 58400
Areal density (Mb/square inch)	93.4	196.8	196.8	326.8	326.8
Recording code	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	3220	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	18	13.5	13.5	13.5	13.5
Average rotational delay (msec)	9.32	8.3	8.3	8.3	8.3
Average access time (msec)	27.32	21.8	21.8	21.8	21.8
Data transfer rate (MBytes/sec) Internal, min/max External	2.6/3.6 5.0 synch. 3.0 asynch.	2.3/4.0 4.0	2.3/4.0 4.0 synch.	10.0 synch. 5.0 asynch.	1.25
SIZE: (mm) H x W x D	41.3 x 146.1 x 203.2	25.4 x 101.6 x 150	25.4 x 101.6 x 150	40.1 x 146.1 x 191.2	38.1 x 135.9 x 184.2
FIRST CUSTOMER SHIPMENT	2Q94	7/95	7/95	2Q96	2Q96
COMMENTS	Removable data cartridge. Read/write compatible with 44 MB, 88 MB & 200 MB cart.	Removable data cartridge. Internal model.	Removable data cartridge. External model.	Removable data cartridge. Internal model.	Removable data cartridge. External model.

MANUFACTURER	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	TAE IL MEDIA	TOSHIBA	TOSHIBA
DRIVE	SyJET S	SyJET A	TM-3G12-3	MK-1722FCV	MK-1724FCV
DISK/TREND GROUP	1	1	5	2	2
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	Captive, OEM	Captive, 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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI-2	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 1,266	F: 131	F: 262
REMOVABLE	F: 1,300	F: 1,300	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	6	2	4
Tracks per surface	4680	4680	4500	1920	1920
Track density (TPI)	4650	4650	4500	3528	3528
Maximum linear density (BPI) (FCI)	101000 114000	101000 114000	72000 54000	68350 51050	68350 51050
Areal density (Mb/square inch)	469.7	469.7	324.0	241.1	241.1
Recording code	PRML	PRML	1,7 RLL	1,7 RLL	1,7 RLL
Rotational speed (RPM)	5400	5400	4500	4000	4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	12	12	12	13	13
Average rotational delay (msec)	5.5	5.5	6.7	7.5	7.5
Average access time (msec)	17.5	17.5	18.7	20.5	20.5
Data transfer rate (MBytes/sec) Internal, min/max External	5.5/11.5 10.0 synch. 5.0 asynch.	5.5/11.5 16.6 PIO Mode 4	3.1/6.0	2.3/3.9 11.1 PIO Mode 3	2.3/3.9 11.1 PIO Mode 3
SIZE: (mm) H x W x D	38.1 x 133 x 200	25.4 x 101.6 x 149.3	25.4 x 101.6 x 146	12.7 x 70 x 100	12.7 x 70 x 100
FIRST CUSTOMER SHIPMENT	3Q96	3Q96	5/96	3/94	1Q94
COMMENTS	Removable data cartridge. External model.	Removable data cartridge. Internal model.			

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-1824FBV	MK-1824FCV	MK-1924FBV	MK-1924FCV	MK-1926FBV
DISK/TREND GROUP	3	3	4	4	4
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		Thin Film	Thin Film
Interface	SCSI-2	IDE	SCSI-2	IDE	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 352	F: 352	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	4	4	4	4	6
Tracks per surface	2050	2050	2920	2920	2920
Track density (TPI)	3810	3810			
Maximum linear density (BPI) (FCI)	87630 65532	87630 65532			
Areal density (Mb/square inch)	333.9	333.9			
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	13	13	13	13
Average rotational delay (msec)	7.14	7.14	7.14	7.14	7.14
Average access time (msec)	20.14	20.14	20.14	20.14	20.14
Data transfer rate (MBytes/sec) Internal, min/max External	 10.0 synch. 6.0 asynch.	 3.1/5.4 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	12.7 x 70 x 100	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	9/94	9/94	3/95	1Q95	
COMMENTS					

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE	MK-1926FCV	MK-2428FB	MK-2428FC	MK-2526FB	MK-2526FC
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	65 mm
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	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	TOSHIBA
DRIVE	MK-2628FB	MK-2628FC	MK-1301MAV	MK-2720FB	MK-2720FC
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	Thin Film	Thin Film	Thin Film		
Interface	SCSI-2	IDE	IDE	SCSI-2	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 811	F: 811	F: 1,350	F: 1,350	F: 1,350
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	8	8	6	10	10
Tracks per surface	2360	2360			2920
Track density (TPI)					
Maximum linear density (BPI) (FCI)					
Areal density (Mb/square inch)					
Recording code			PRML		
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	13	13	13	13
Average rotational delay (msec)	7.14	7.14	7.14	7.14	7.14
Average access time (msec)	20.14	20.14	20.14	20.14	20.14
Data transfer rate (MBytes/sec) Internal, min/max	--/5.3	--/5.3	--/7.0	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	16.6 PIO Mode 4 16.6 DMA Mode 2	10.0 synch. 6.0 asynch.	16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	19 x 70 x 100	19 x 70 x 100	12.7 x 70 x 100	19 x 70 x 100	19 x 70 x 100
FIRST CUSTOMER SHIPMENT	2/95	12/94	1Q96	9/95	6/95
COMMENTS					

MANUFACTURER	TOSHIBA	TOTTORI SANYO	TOTTORI SANYO	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	MK-2101MAN	S3403 TORiSAN	S3404 TORiSAN	AC2850 Caviar	AC21000 Caviar
DISK/TREND GROUP	6	5	5	4	5
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		Thin Film	Thin Film		Thin Film
Interface	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,160	F: 1,006	F: 1,340	F: 853.6	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	10	6	8	4	4
Tracks per surface	3650	2862	2862		
Track density (TPI)		5260	5260		
Maximum linear density (BPI) (FCI)		104000 111000	104000 111000		
Areal density (Mb/square inch)		547.0	547.0		
Recording code	PRML	PRML	PRML	1,7 RLL	
Rotational speed (RPM)	4200	4500	4500	4500	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	13	15	15	10 RD/12 WR	11 RD/13 WR
Average rotational delay (msec)	7.14	6.7	6.7	6.67	5.8
Average access time (msec)	20.14	21.7	21.7	16.67/18.67	16.8/18.8
Data transfer rate (MBytes/sec) Internal, min/max External	--/7.0 16.6 PIO Mode 4 16.6 DMA Mode 2	3.9/6.9 16.6 PIO Mode 4	3.9/6.9 16.6 PIO Mode 4	 11.1 PIO Mode 3 13.3 DMA Mode 1	5.0/9.6 16.6 PIO Mode 4 16.6 DMA Mode 2
SIZE: (mm) H x W x D	19 x 70 x 100	19 x 69.9 x 88.9	19 x 69.9 x 88.9	25.4 x 101.6 x 146.1	25.4 x 101.6 x 146.1
FIRST CUSTOMER SHIPMENT	1Q96	4/96	5/96	11/94	
COMMENTS		*Glass disk.	*Glass disk.		

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	AC21200 Caviar	AC21600 Caviar	AC31600 Caviar	AC32100 Caviar	AC32500 Caviar
DISK/TREND GROUP	5	5	5	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	IDE	IDE	IDE	IDE	IDE
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,281.9	F: 1,624.6	F: 1,624.6	F: 2,111.8	F: 2,559.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	Varies by zone	Varies by zone	Varies by zone	Varies by zone	Varies by zone
Data surfaces per spindle	4	4	6	5	6
Tracks per surface					
Track density (TPI)	4850	5600	4300	5600	5600
Maximum linear density (BPI) (FCI)	85300	111500	90000	111500	111500
Areal density (Mb/square inch)	413.7	624.4	387.0	624.4	624.4
Recording code	PRML	PRML	PRML	PRML	PRML
Rotational speed (RPM)	5200	5200	5200	5200	5200
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Servo type	Embedded	Embedded	Embedded	Embedded	Embedded
Average positioning time (msec)	11 RD/13 WR	12 RD/14 WR	10 RD/12 WR	12 RD/14 WR	12 RD/14 WR
Average rotational delay (msec)	5.77	5.8	5.77	5.8	5.8
Average access time (msec)	16.77/18.77	17.8/19.8	15.77/17.77	17.8/19.8	17.8/19.8
Data transfer rate (MBytes/sec)					
Internal, min/max	--/9.6	--/11.9		--/11.9	--/11.9
External	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	16.6 PIO Mode 4 16.6 DMA Mode 2	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	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	12/95	3/96	4/95	3/96	3/96
COMMENTS					

MANUFACTURER	WESTERN DIGITAL				
DRIVE	AC33100 Caviar				
DISK/TREND GROUP	7				
MARKET	OEM, PCM				
MEDIA: Disk diameter	95 mm				
Recording medium	Thin Film				
DRIVE: Heads	Thin Film				
Interface	IDE				
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 3,166.7				
REMOVABLE	--				
Capacity per track (Bytes)	Varies by zone				
Data surfaces per spindle	6				
Tracks per surface					
Track density (TPI)	6100				
Maximum linear density (BPI) (FCI)	119000				
Areal density (Mb/square inch)	725.9				
Recording code	PRML				
Rotational speed (RPM)	5200				
PERFORMANCE					
Actuator type	Rotary, Voice Coil				
Servo type	Embedded				
Average positioning time (msec)	12				
Average rotational delay (msec)	5.7				
Average access time (msec)	17.7				
Data transfer rate (MBytes/sec)					
Internal, min/max	--/13.0				
External	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				
FIRST CUSTOMER SHIPMENT	6/96				
COMMENTS					

1996 DISK/TREND REPORT

MANUFACTURER PROFILES

All manufacturers now producing moving head rigid magnetic disk drives, or which have indicated specific plans to enter the market, are listed in this section. The heading "1995 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. "1995 total net sales" covers the fiscal year ending December 31, 1995, 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 1995 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	4.99
Germany	Deutschmark	1.43
Japan	Yen	94.0
Singapore	Dollar	1.42
South Korea	Won	773.0
United Kingdom	Pound	0.633

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

U.S. Manufacturers

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. Several of the Areal drive models continue to be manufactured and sold by Tottori Sanyo (see listing in Asian manufacturer section).

AVATAR SYSTEMS CORPORATION
1455 McCarthy Boulevard
Milpitas, CA 95035

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

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

1995 disk sales: $2,219,700,000
1995 total net sales: $2,716,639,000 Net income: $61,683,000

By any measure, the initial growth of Conner Peripherals remains one of the industry's outstanding success stories. The firm was headed by Finis Conner, cofounder 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. 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 discontinued production of new drives at both the Italy and Scotland sites. 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 held a 90% ownership in this investment. While Conner Peripherals had indicated its desire to concentrate upon drive assembly rather than become vertically integrated, the firm made acquisitions of key technologies, including the sputtered disk production facilities of bankrupt Domain Technology, later expanded with several new sputtering lines.

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 end of the industry price war and with the help of the newer products, the company returned to profitability in late 1993, but has never reestablished a high growth rate. In September, 1995, Conner announced an agreement with Seagate Technology, under which Conner would be acquired. The acquisition was completed in early 1996.

GIGASTORAGE INTERNATIONAL/BELFORT MEMORY INTERNATIONAL
170 Knowles Drive
Los Gatos, CA 95030

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 European 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 designed a 1.08 gigabyte 5.25" drive to be sold at low prices for personal computer applications, and manufacturing started at Belfort in early 1996.

It was a difficult start-up, but not due to conventional product design or manufacturing problems. As the production line started, a variety of French bureaucrats and prosecutors descended on the scene, apparently prompted by a tangled web of French politics. Before the episode was finished, a Gigastorage executive and two local officials were held in jail for weeks, training for plant personnel was disrupted, a protest march was held in Belfort over the potential for lost jobs, and both Gigastorage suppliers and customers were concerned over the strange situation. In late Spring, everyone was released from jail, with various charges of fraud, failure to file paperwork and improper money transfers still pending, although the prosecutor didn't seem to have much of a case. In the middle of this chaos, disk drive production actually commenced at Belfort, although at low levels, and the management is now attempting to obtain additional financing and increase production.

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

1995 disk sales: $729,800,000
1995 total net sales: $31,519,000,000 (FY ending 10/31/95) Net income: $2,433,000,000

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 up to 8.7 gigabytes.

H-P 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 Prairie-Tek. The company was the first to design and manufacture 1.8" disk drives. Its initial product was a 20 megabyte drive, first produced in the second half of 1991, and for which the available market was minimal. Integral had somewhat better luck with a 42 megabyte model, in production since early 1992, and a succession of higher capacity models which followed. The existing 1.8" drives use ramp loaded heads, and are designed to high operating shock and vibration specifications, with low power requirements, in anticipation of wide usage in subnotebook computers and other mobile computer applications.

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

INTERNATIONAL BUSINESS MACHINES CORPORATION
Route 22
Armonk, NY 10504

1995 disk sales: $6,859,500,000
1995 total net sales: $71,940,000,000 Net income: $6,300,000,000

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 40 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 3.24 gigabytes on 3 platters and 2.5" drives with up to 2.16 gigabytes on 3 platters. After taking 5.25" drives up to 1.5 gigabytes in capacity, IBM 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, was destined to be a short-lived product. It was 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 in September, 1994, using 2 gigabyte Allicat 3.5" drives, and was upgraded to 4 gigabyte Starfire drives in October, 1995. A further upgrade for IBM's mainframe array subsystems, to 9.1 gigabyte Scorpion drives, will probably occur before the end of 1996 using midlife upgrades to the 3990-6 disk controller, since competitive pressures make it difficult for IBM to wait for the planned "Seascape" disk controller family, expected to be much later than originally planned. IBM has found it difficult to aggressively ramp up production of the Scorpion 3.5" 9.1 gigabyte drive, but large scale shipments are expected to occur during the second half of 1996.

IBM disk drives are manufactured at a combination of its own plants and in contract manufacturers' facilities, in the United States, Europe and Asia. The original San Jose facility has been producing older 3.5" high-end drives, with newer models transferred to a new $100 million factory in Singapore. San Jose's role will be expanded again, however, benefiting from new expansion plans announced in 1996. 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. 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), and is now a contract manufacturing source for IBM.

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 increased the sales activity for 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 was 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

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

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

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

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

JTS CORPORATION (formerly Kalok Corporation)
166 Baypoint Parkway
San Jose, CA 95134

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, and subsequently sold its entire stepping motor drive product line to Xebec, retaining only the design for a .5" high 3.5" drive family.

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.

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. 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 are now centered on a plant at Madras, India, at a facility originally controlled by the Tandon family. In early 1996, plans were announced for JTS to merge with Atari, with JTS to be the successor company, with completion expected in June, 1996.

MAXTOR CORPORATION (See Asian Manufacturers)

MICROPOLIS PTE. LTD. (See Asian Manufacturers)

QUANTUM CORPORATION
500 McCarthy Boulevard
Milpitas, CA 95035

1995 disk sales: $3,845,400,000
1996 total net sales: $4,422,726,000 (FY ending 3/31/96) Net income: ($90,456,000)

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. 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 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 drives manufactured by MKE.

Quantum hoped to give 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. After more than a year of trying, Quantum found the Digital acquisition difficult to integrate with its existing high-end disk drive operation, resulting in a 1995 reorganization of executive management, closing out its high-end disk drive manufacturing operations, and turning over production of high-end drives to MKE.

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, using some disk drives which are internally manufactured, plus repackaged disk and tape drive mechanisms and flash memory based subsystems.

SEAGATE TECHNOLOGY
920 Disc Drive
Scotts Valley, CA 95066

1995 disk sales: $5,140,700,000
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 was 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 9.1 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 4.5 gigabytes. The Elite 5.25" drive series was successfully extended to 9 gigabytes, with an extremely competitive price per megabyte, and a 23 gigabyte model has been announced for shipment in mid-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. During 1994 Seagate began diversifying into additional markets, acquiring several firms specializing in storage related software, and the company has established a major program to become a major factor in the storage management software market. In September, 1995, Seagate announced an agreement to acquire Conner Peripherals. The acquisition was consummated in early 1996, providing Seagate with major expansions in several areas, including internal disk media manufacturing, low end 3.5" drives for desktop personal computer markets, and a tape drive product line derived from the Conner 1992 acquisition of Archive.

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. Sequel's current major expansion program involves contract manufacturing of the Jaz 3.5" disk cartridge drive for Iomega.

SYQUEST TECHNOLOGY
47071 Bayside Parkway
Fremont, CA 94538

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

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 the 1990's, SyQuest increased the capacity of its 5.25" cartridge disk drive series to 88 megabytes, then to 200 megabytes. A 3.5" disk cartridge drive program resulted in first shipments of 105 and 270 megabyte models in 1993. SyQuest also manufactures the disk cartridges for the drives, and cartridges

accounts for about half of the firm's revenue. A unique 1.8" drive was announced in 1995, utilizing a disk cartridge designed to be removable from a PC Card Type III disk drive, but the project was stopped in early 1996.

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

WESTERN DIGITAL CORPORATION
8105 Irvine Center Drive
Irvine, CA 92718

1995 disk sales: $2,291,100,000
1995 total net sales: $2,130,867,000 (FY ending 7/01/95) Net income: $123,302,000

Western Digital, at the time 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 has continued a program of aggressive development for its Caviar 3.5" drive product line for the desktop personal computer market, with capacities now up to 3.1 gigabytes. WD is also expected to reenter the disk drive market for notebook computers in 1996 with 3" drives produced under a license with JTS, hoping to provide a cost-effective product line to compete with the 2.5" drive market leaders.

Although the impact of the 1993 disk drive price wars resulted in losses, the firm has been profitable in recent years. 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.)

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) and spindle motors. 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 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 withdrew 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

1995 disk sales: $1,383,100,000
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, in Thailand and the Philippines. Intellistor, located in Longmont, Colorado, is a Fujitsu subsidiary which has developed small diameter disk drives and drive arrays. Fujitsu also has 44% ownership in Amdahl.

Fujitsu has marketed most of its captive drives in OEM versions also, using industry standard interfaces, and is a serious contender in the market for OEM rigid disk drives. Fujitsu is also a participant in the IBM plug compatible disk drive market through Amdahl. 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 now extends to 9.1 gigabytes. A 240 megabyte 2.5" drive was added in 1993, followed by a series of drives with capacities now up to 1 gigabyte.

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

1995 disk sales: $515,700,000
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 data storage subsystems in the IBM compatible mainframe and midrange market 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. In recent years Hitachi used a 6.5" drive series for IBM plug compatible drive subsystems, including a 3390-9 equivalent subsystem, before transitioning to high capacity 3.5" drives. 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 OEM 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 family of high capacity 2.5" disk drives, and subsequent development by Hitachi extended the 2.5" series to 1.3 gigabytes. 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

1996 total net sales: $5,084,000,000 (FY ending 3/31/96) Net income: $72,000,000

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 became the largest producer of CD-ROM drives, which are sold mostly through other Matsushita group companies, and has undertaken a new manufacturing program for 120 megabyte 3.5" "floptical" drives, 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. In early 1996, Quantum turned over the balance of its disk drive production to MKE, including high end drives previously manufactured in California and in plants acquired with the purchase of the Digital Equipment disk drive product line.

MAXTOR CORPORATION
Subsidiary of Hyundai Electronics America
211 River Oaks Parkway
San Jose, CA 95134

1995 disk sales: $1,241,200,000
1996 total net sales: $954,040,000 (3 quarters ending 12/95) Net income: ($82,948,000)

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 entered the optical disk drive business in 1988 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" 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. 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.

In 1994, Maxtor improved its financial status when Hyundai invested heavily in the company, acquiring approximately 40% of the firm, and in 1995 Maxtor transferred all of its manufacturing facilities to Hyundai, which produces disk drives for Maxtor in Singapore and Korea. In November, 1995, Maxtor's board of directors agreed to a Hyundai offer to acquire the remainder of the outstanding Maxtor shares. Following shareholder approval early in 1996, Maxtor became a wholly owned subsidiary of Hyundai Electronics America, in turn a subsidiary of Hyundai Electronics Industries Company, Ltd.

MICROPOLIS PTE. LTD.
Subsidiary of Singapore Technologies
5, Serangoon North Ave 5
Singapore 554916

1995 disk sales: $183,400,000 (Micropolis Corporation)
1995 total net sales: $211,264,000 Net income: ($84,288,000)

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 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 the firm's disk drive sales growth 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 after production problems created major losses, a change in management occurred.

In January, 1996, the new management reached an agreement to sell the company's disk drive business, consisting of the Micropolis name, the disk drive product line and disk drive manufacturing facilities to Singapore Technologies, a Singapore government controlled manufacturing conglomerate with numerous technology enterprises. Micropolis shareholders voted approval of the deal and it was consummated at the end of March, 1996. The array and subsystem businesses owned by Micropolis Corporation were retained, and the company changed its name to StreamLogic Corporation. The disk drive business owned by Singapore Technologies was named Micropolis Pte. Ltd., with headquarters and manufacturing in Singapore, while product development and marketing remain at the previous company headquarters in Chatsworth, California.

MOMENTUM PERIPHERALS PTE. LTD.
3 Tech Park Crescent
Singapore 638129

Headquartered in Singapore, Momentum's management consists of ex-pat Americans who have formed a new company to acquire the factory originally established in Singapore by MiniStor to manufacture 1.8" disk drives. The factory and its equipment were purchased from local bankruptcy proceedings, but without purchasing the MiniStor product designs. Momentum has announced 130 and 170 megabyte 1.8" PC Card drives, with production planned for mid-1996.

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

1995 disk sales: $596,800,000
1995 total net sales: $46,828,000,000 (FY ending 3/31/96) Net income: $822,000,000

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", 2.5" 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-ku
Seoul, South Korea

1995 disk sales: $208,100,000
1995 total net sales: $20,948,000,000 Net income: $3,242,000,000

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, extending up to 3.2 gigabytes. In a move to speed up market entry, Samsung arranged for development of 2.5" drives by Integral Peripherals, with production start planned for 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.

TAE IL MEDIA CO., LTD.
456-1 Moknae-dong, Ansan
Kyunggi-do
South Korea

Tae Il was established in 1983 and has become a diversified manufacturer of heads and disks for the disk drive industry, plus heads for tape drives, and other electronic components, including printer components, monitors, batteries and a variety of specialized parts. In 1995, the company initiated an expansion program into completed disk drives, starting with flexible disk drives and CD-ROM drives, and in 1996 expects to begin shipments of a 1.2 gigabyte 3.5" rigid disk drive for personal computer applications. Manufacturing for the disk drive programs will be centered at a Tae Il facility at Harbin, China, with initial sales programs concentrating on the emerging China market.

TOTTORI SANYO ELECTRIC CO., LTD.
7-101, Tachikawa-cho
Tottori City, 680

Following a Sanyo Electric investment in Areal Technology, a California disk drive company founded in the late 1980's by U.S. industry veterans, Tottori Sanyo started production of 2.5" drives in 1991, with all sales initially under the Areal name. Despite successful development of follow-on products by Areal and establishment of an active sales program in the U.S. OEM market, the U.S. operations were closed except for service personnel in 1995. Several of the Areal 2.5" drives remain in production at Tottori Sanyo and are sold primarily in Asian markets by Sanyo and a sales company. Tottori Sanyo has designed new 1 and 1.3 gigabyte 2.5" drives, which will go into production in mid-1996.

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

1995 disk sales: $1,114,900,000
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 revenues are 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.

Toshiba has established a very successful 2.5" disk drive series, as a result of an aggressive development program which provided a significant share 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 2.16 gigabytes. Like many other Japanese companies, Toshiba is shifting its rigid drive production offshore, with a factory in the Philippines.

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 announced drives with capacities up to 520 megabytes. Calluna is currently using disks with carbon substrates in all of its drives.

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 drives produced by Hitachi for plug compatible mainframe and midrange systems, plus optical drive, semiconductor and tape drive storage systems made by third parties. 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.

EUROSTOR S.A./D.D.O. S.A.
Velazquez, 17-3D
28001 Madrid
Spain

After establishing a factory at Cadiz and starting to manufacture 240 megabyte 3.5" drives in 1995, Eurostor/D.D.O. later halted the program when it became clear that the market for drives in that capacity range had collapsed. The organization has regrouped with an expanded management organization, new designs by a California firm for 3.5" drives targeted at the personal computer market, additional financing by European public agencies, an additional manufacturing plant at La Caruna, and entry into the European market planned for the second half of 1996.

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

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

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

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. The company had difficulty in keeping up with the industry's short product life cycles, and in early 1989 top management was completely overhauled as Rodime came perilously near bankruptcy. New financing was obtained, but Rodime never returned to profitability. In mid-1991 Rodime announced that it would file for bankruptcy and cease manufacturing of drives.

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. Appeals court rulings in 1995 and 1996 appear to have weakened the Rodime negotiating position, but Rodime continues to argue that other patent claims are still valid in a separate legal action against Seagate Technology.

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, which have been 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 has operated at manufacturing levels of more than two million small disk drives per year.

DISK/TREND ON DISK

1996 DISK/TREND REPORT

DISK/TREND ON DISK

Introduction

DISK/TREND ON DISK is a licensed set of floppy disks available for separate purchase that contain the statistical tables and specification tables from the annual DISK/TREND Reports. The disk files have been prepared in a format usable on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. A system with a hard disk is highly recommended, but a system with two floppy disks can be used if necessary. All DISK/TREND ON DISK files contain data only -- manipulation of data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended.

Two types of diskette files are supplied for each DISK/TREND disk drive report. The first type contains the statistical tables in ASCII format. File names are keyed to the table numbers in the report for easy identification. The second type contains the specification section in a Lotus 1-2-3 data base format. Multiple disks of each type are provided where the files are too numerous or too large to fit on a single floppy disk. The color 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 instructions 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 1996 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1996 DISK/TREND Report volume.

YOU MAY:

1. Install and use the information on a single computer system, provided that you or the organization by which you are employed has purchased at least one copy of the DISK/TREND report volume associated with the information.
2. Make backup copies of the information for your own use. Such backup copies may be used only on the computer on which the information is installed. You must reproduce the copyright notice on any copies.
3. Reproduce the information, but not the associated programs or documentation, contained in the Product for use within internal documents distributed within the organization by which you are employed.

YOU MAY NOT:

1. Install, or allow the use of, the information on more than a single computer system.
2. Transfer the information through or within a computer network.
3. Distribute the information or any portion thereof in any form outside the organization by which you are employed or modify the information for purposes of distribution.
4. Transfer this license to another party.

AUTOIMPORT

Use of AutoImport is subject to 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:

- o FORMLINA.PRN Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of all DISK/TREND reports.
- o FORMLINB.PRN Used with Table 2.
- o FORMLINF.PRN Used with Tables 3 and 4.
- o FORMLIND.PRN Used with Application tables.
- o 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	1996 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	1996 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, <u>including the extension</u>, which will be of the form yy? where yy is the year of the report and ? is the report type as above.

   Examples: RT4.96R OT14.96O AT19.96A VT6.96V

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

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

   Examples: RT4 OT14 AT19 VT6

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

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

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

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

Mask Generation

1. Start AutoImport as above. When the opening screen appears, select "File" using the 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: RT50.96R

   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: RS196 Rigid disk specification table, Groups 1 to 5
RS296 Rigid disk specification table, Groups 6 to 9
RS396 Complete specification table: supplied on 1.44 megabyte 3.5" or 1.2 megabyte 5.25" diskettes if space permits

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

Using the specification data base

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

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

The data base has been set up for data extraction using Lotus 1-2-3 com-

mands. The Input, Output and Criterion ranges have been predefined, but you, the user, will have to decide how you want the extracted data manipulated and place the appropriate Lotus functions, such as @COUNT, in the appropriate cells. Some rows between the bottom of the input range and the top of the output range have been left empty so that you can do this easily. When the data base is first loaded, you will see the top of the input range, showing the first column (manufacturer name) for the first several manufacturers. Use the arrow keys to find other manufacturers or specific product specifications. If you are not using Lotus 1-2-3, use the equivalent procedure for your spreadsheet.

Operating tips

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

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

- o There are other 'pop-up' programs resident in the memory of your computer. These should be removed.

- o You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.

- o If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You 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 RS196 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 RS296 from the specification diskette (or specification diskette 2) using the Lotus command /FCC.

3. Edit the worksheet to remove the header and criteria range areas that were loaded with the second worksheet.

4. Using the data query (/DQ) command, select the new input range so that it covers the entire worksheet area in which there is data. Remember, the column header row must be included in the input range. Quit the DQ menu.

5. Copy the column header row using the /C command to a row 5 to 10 lines below the input range. Using the /DQ command, select the output range. It should include the header row you just established plus as many rows as you would like, and should extend to the last column of data.

6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it to a new file name first so that you can easily reload if you make an unrecoverable alteration.

Saving time

The specification data base is large and takes significant time to recompute or perform other operations. If you are interested in drives that belong to only a few product groups, it will probably save you time in the long run if you extract only those groups into a new worksheet and use that for the analysis. Use spreadsheet FILE EXTRACT and FILE COMBINE commands for this purpose.

Another way to save time is to use the SORT capabilities of your spreadsheet to organize the data the way you find it most useful. The most commonly done sorts are by manufacturer name and by DISK/TREND product group, but it would also be possible to sort by average seek time, price, and so on.

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

If you are interested in a subset of product groups, use the FILE EXTRACT and FILE COMBINE commands to move these records to another file and use the second file for analysis. The smaller file will take less time to process.

Special data

The specification data base contains one category of information not present in the hard copy report. This is the country code field, representing the continental region in which the headquarters of the drive producer is located. A key is located at the top of the adjacent column to the right.

All specification files have been prepared as Lotus 1-2-3 spreadsheets set up for data extraction. Criterion, Input, and Output ranges are predefined.

If you received more than one specification disk, file RS196.WK1 contains DISK/TREND Product Groups 1 through 5. File RS296.WK1 contains Product Groups 6 through 9. File RS396.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 RS396.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.