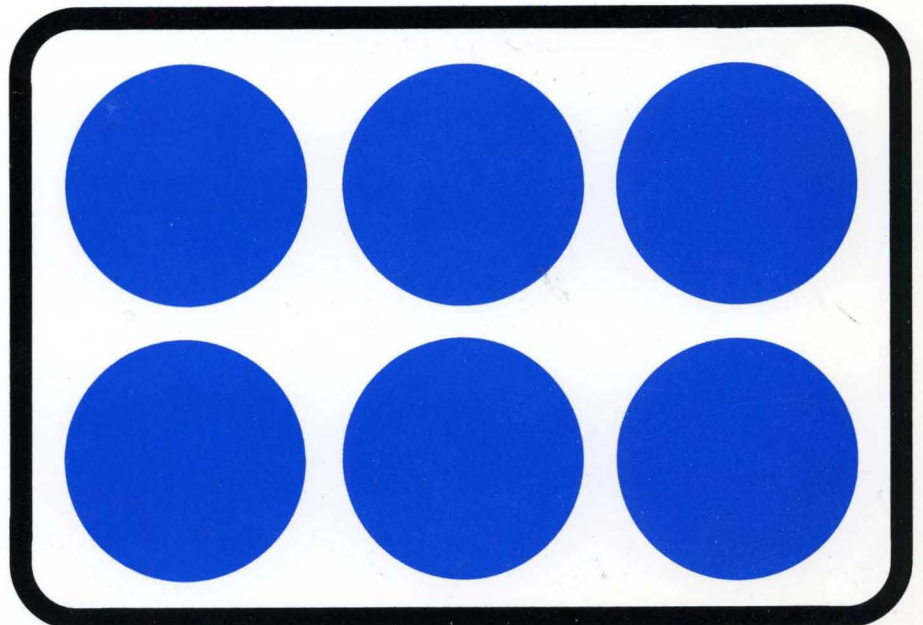


## 1990 DISK/TREND<sup>®</sup> REPORT

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 DRIVESIndustry 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		1990		1991		1992		1993		
Revenues						Forecast				
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-----		-----Forecast-----		-----1990-----		-----1991-----		-----1992-----		-----1993-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
<b>U.S. Manufacturers</b>														
IBM Captive	9,485.4	41.8%	9,485.4	41.8%	11,435.9	44.5%	11,435.9	44.5%	13,106.2	45.6%	13,195.6	43.7%	14,364.5	45.1%
	+7.1%				+20.6%				+14.6%		+7.1%		+8.9%	
Other U.S. Captive	2,100.7	9.2%	2,100.7	9.2%	1,914.7	7.4%	1,914.7	7.4%	2,054.0	7.1%	2,128.6	7.0%	2,008.6	6.3%
	+22.5%				-8.9%				+7.3%		+3.6%		-5.6%	
PCM/Reseller	2,112.2	9.3%	2,112.2	9.3%	2,203.1	8.5%	2,203.1	8.5%	2,284.0	7.9%	2,272.9	7.5%	2,200.0	6.9%
	+19.7%				+4.3%				+3.7%		-5.5%		-3.2%	
OEM/Integrator	3,461.4	15.2%	3,461.4	15.2%	4,262.8	16.5%	4,262.8	16.5%	4,727.6	16.4%	5,296.4	17.5%	5,278.5	16.5%
	+10.8%				+23.2%				+10.9%		+12.0%		-3.3%	
Total U.S. Manufacturers	17,159.7	75.5%	17,159.7	75.5%	19,816.5	76.9%	19,816.5	76.9%	22,171.8	77.0%	22,893.5	75.7%	23,851.6	74.8%
	+11.0%				+15.5%				+11.9%		+3.3%		+4.2%	
<b>Non-U.S. Manufacturers</b>														
Captive	2,822.2	12.4%	2,822.2	12.4%	3,006.9	11.7%	3,006.9	11.7%	2,998.6	10.4%	3,179.7	10.5%	3,471.0	10.9%
	+15.7%				+6.5%				-3.3%		+6.0%		+9.2%	
PCM/Reseller	711.1	3.1%	711.1	3.1%	791.6	3.0%	791.6	3.0%	1,070.5	3.7%	1,362.4	4.5%	1,705.8	5.3%
	+3.0%				+11.3%				+35.2%		+27.3%		+25.2%	
OEM/Integrator	1,967.3	9.0%	1,967.3	9.0%	2,072.3	8.4%	2,072.3	8.4%	2,454.3	8.9%	2,719.1	9.3%	2,812.5	9.0%
	+7.1%				+5.3%				+18.4%		+10.8%		+3.4%	
Total Non-U.S. Manufacturers	5,500.6	24.5%	5,500.6	24.5%	5,870.8	23.1%	5,870.8	23.1%	6,523.4	23.0%	7,261.2	24.3%	7,989.3	25.2%
	+10.8%				+6.7%				+11.1%		+11.3%		+10.0%	
<b>Worldwide Recap</b>														
Captive	14,408.3	63.6%	14,408.3	63.6%	16,357.5	63.7%	16,357.5	63.7%	18,158.8	63.3%	18,503.9	61.4%	19,844.1	62.3%
	+10.8%				+13.5%				+11.0%		+1.9%		+7.2%	
PCM/Reseller	2,823.3	12.5%	2,823.3	12.5%	2,994.7	11.7%	2,994.7	11.7%	3,354.5	11.7%	3,635.3	12.1%	3,905.8	12.3%
	+15.0%				+6.1%				+12.0%		+8.4%		+7.4%	
OEM/Integrator	5,428.7	23.9%	5,428.7	23.9%	6,335.1	24.6%	6,335.1	24.6%	7,181.9	25.0%	8,015.5	26.5%	8,091.0	25.4%
	+9.4%				+16.7%				+13.4%		+11.6%		+9.9%	
Total All Manufacturers	22,660.3	100.0%	22,660.3	100.0%	25,687.3	100.0%	25,687.3	100.0%	28,695.2	100.0%	30,154.7	100.0%	31,840.9	100.0%
	+10.9%				+13.4%				+11.7%		+5.1%		+5.6%	

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

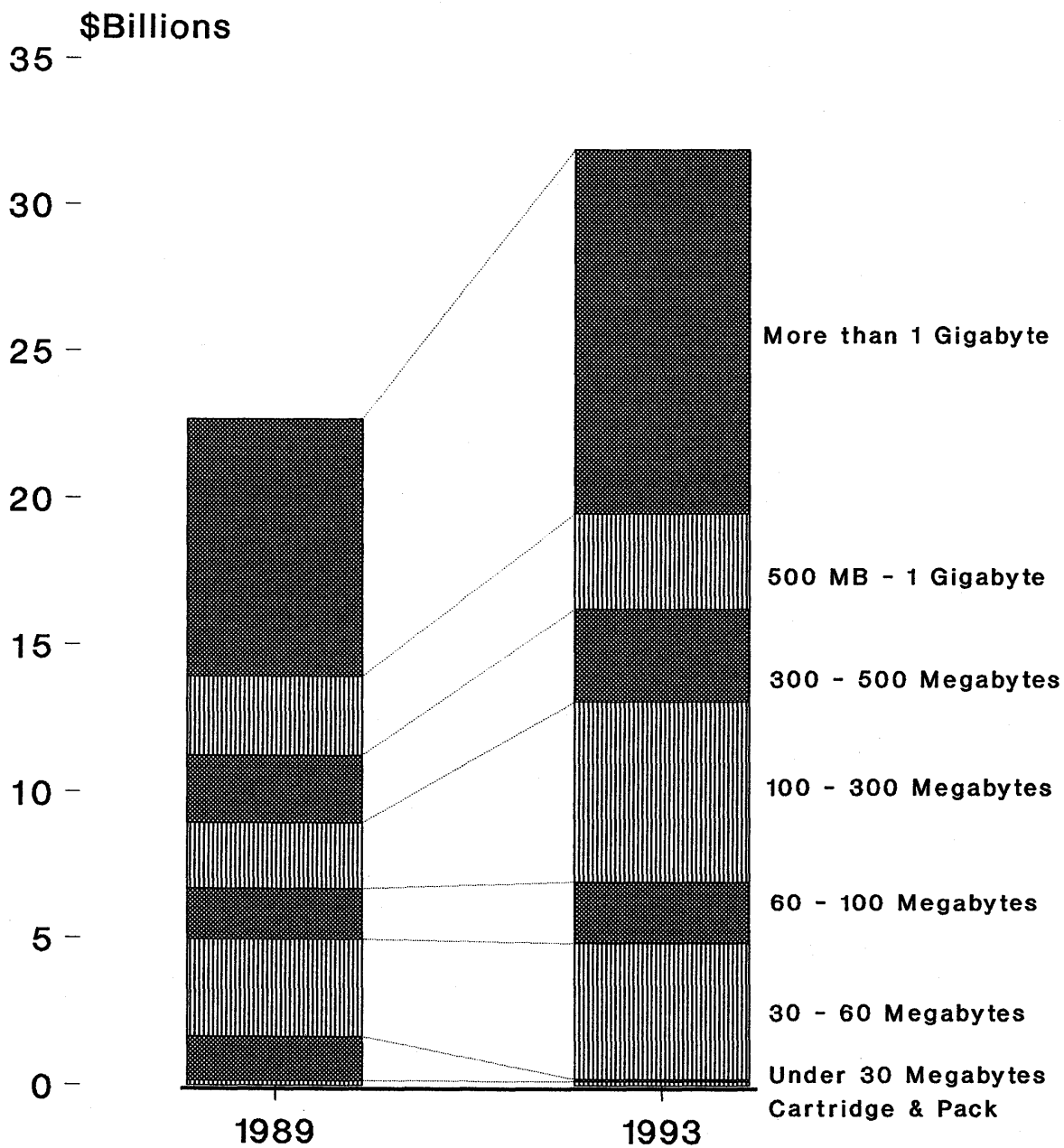


TABLE 3  
CONSOLIDATED WORLDWIDE REVENUES  
RIGID DISK DRIVES  
PRODUCT CATEGORY REVIEW  
REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	-----1989-----		-----1990-----		-----1991-----		-----Forecast-----		-----1992-----		-----1993-----	
	Revenues		Revenues		Revenues		Revenues		Revenues		Revenues	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
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

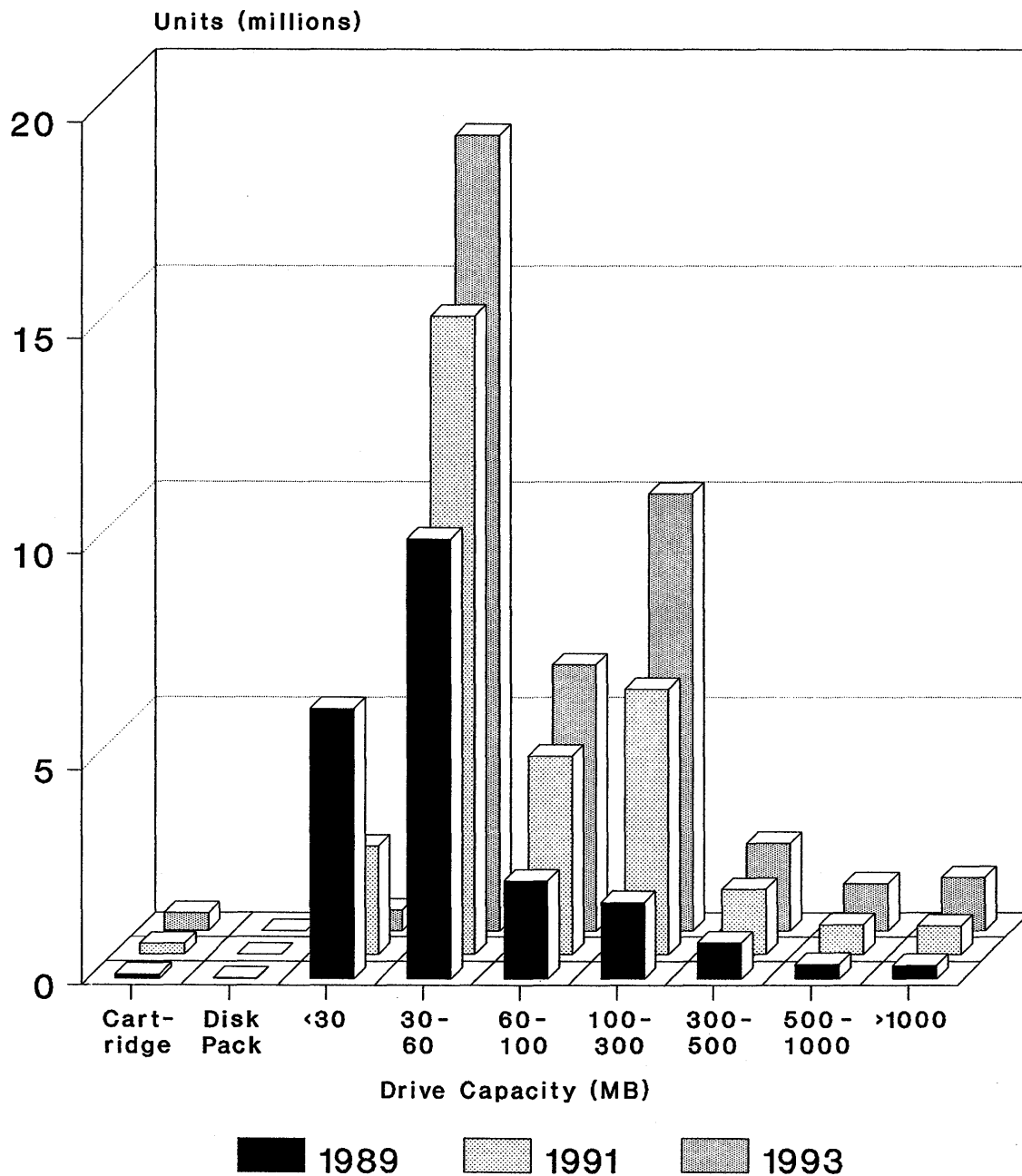


TABLE 4  
 CONSOLIDATED WORLDWIDE SHIPMENTS  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	-----1989-----		-----Forecast-----							
	---Shipments---		-----1990-----		-----1991-----		-----1992-----		-----1993-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
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

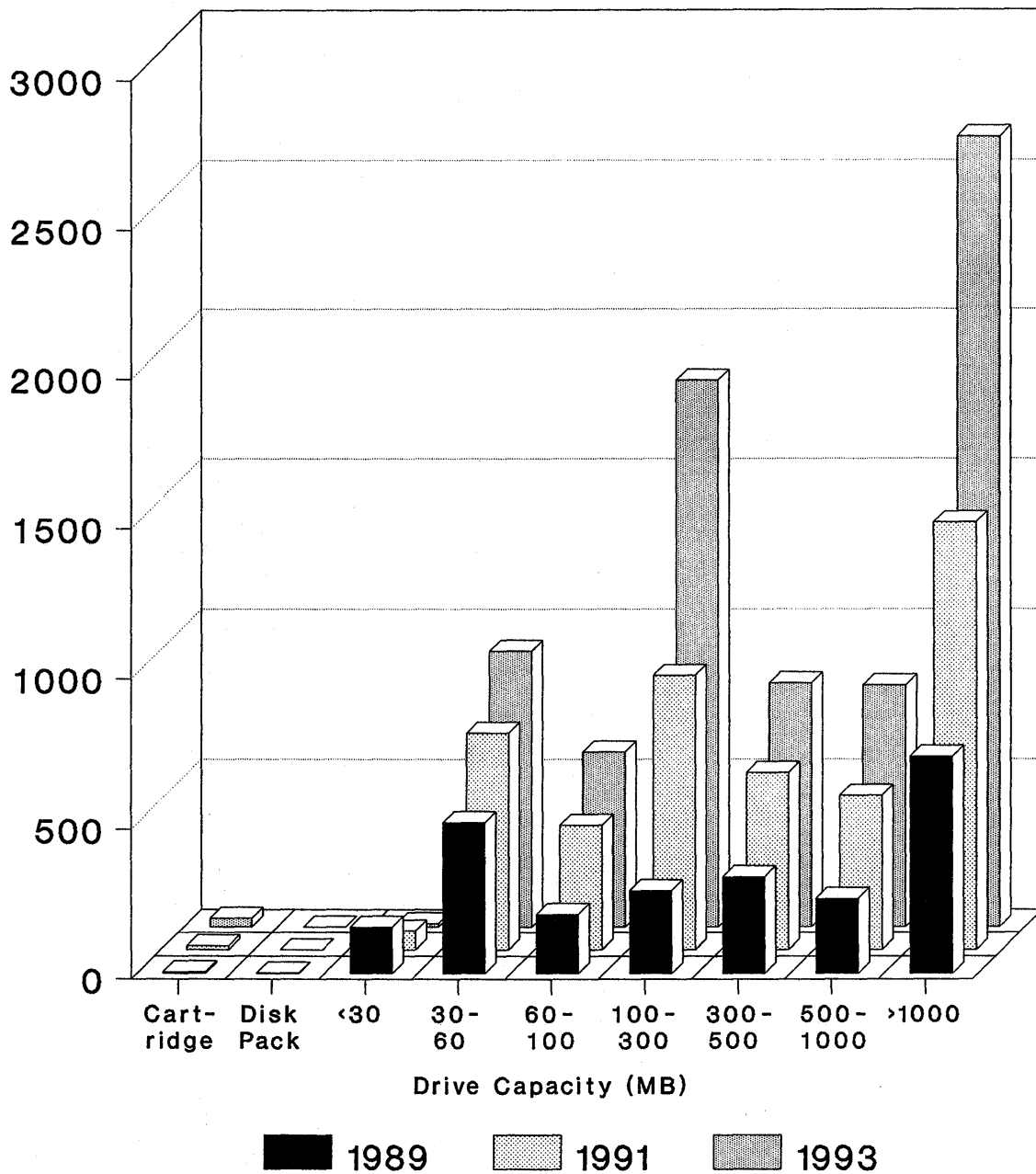


TABLE 5  
CONSOLIDATED WORLDWIDE SHIPMENTS  
RIGID DISK DRIVES  
PRODUCT CATEGORY REVIEW  
CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	-----1989-----		-----1990-----		-----1991-----		-----Forecast-----		-----1992-----		-----1993-----	
	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%
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-----		-----1990-----		-----1991-----		-----Forecast-----		-----1993-----	
	Revenues		Revenues		Revenues		1992		Revenues	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
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-----		-----1990-----		-----1991-----		-----Forecast-----		-----1993-----	
	Shipments		Shipments		Shipments		Shipments		Shipments	
	Units	%	Units	%	Units	%	Units	%	Units	%
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.

## 1990 DISK/TREND REPORT

TABLE 8  
 NON-CAPTIVE WORLDWIDE SHIPMENTS  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPPED IN TERABYTES	-----1989-----		-----1990-----		-----1991-----		-----Forecast-----		-----1993-----	
	Units	Capacity %	Units	%	Units	%	Units	%	Units	%
DISK CARTRIDGE DRIVES	4.8 +143.2%	.3%	8.7 +79.2%	.4%	12.5 +43.4%	.4%	20.1 +60.6%	.5%	28.6 +42.0%	.6%
DISK PACK DRIVES	1.8 -42.9%	.1%	.5 -72.1%	--	-- -88.8%	--	-- --	--	-- --	--
FIXED DISK DRIVES less than 30 Megabytes	142.6 -13.9%	9.2%	104.4 -26.8%	4.5%	62.6 -40.0%	2.1%	29.2 -53.3%	.7%	11.6 -60.2%	.2%
FIXED DISK DRIVES 30 - 60 Megabytes	459.3 +78.0%	29.5%	542.3 +18.1%	23.2%	635.7 +17.2%	21.4%	727.0 +14.4%	18.1%	770.2 +5.9%	15.4%
FIXED DISK DRIVES 60 - 100 Megabytes	133.3 +37.0%	8.6%	250.1 +87.6%	10.7%	340.4 +36.1%	11.3%	409.6 +20.3%	10.1%	437.6 +6.8%	8.6%
FIXED DISK DRIVES 100 - 300 Megabytes	199.2 +41.5%	12.7%	503.0 +152.5%	21.5%	636.6 +26.5%	21.3%	1,024.0 +60.8%	25.3%	1,355.2 +32.3%	26.9%
FIXED DISK DRIVES 300 - 500 Megabytes	245.4 +61.1%	15.8%	281.8 +14.8%	12.0%	407.1 +44.5%	13.6%	530.9 +30.4%	13.1%	626.0 +17.9%	12.4%
FIXED DISK DRIVES 500 Megabytes to 1 GB	158.2 +65.6%	10.1%	306.8 +94.0%	13.1%	384.6 +25.3%	12.9%	459.6 +19.5%	11.4%	481.2 +4.7%	9.5%
FIXED DISK DRIVES more than 1 Gigabyte	215.4 +34.7%	13.7%	344.3 +59.8%	14.6%	513.3 +49.1%	17.0%	846.8 +65.0%	20.8%	1,337.9 +58.0%	26.4%
Total Capacity (Terabytes)	1,560.3 +45.2%	100.0%	2,342.1 +50.1%	100.0%	2,993.1 +27.8%	100.0%	4,047.4 +35.2%	100.0%	5,048.6 +24.7%	100.0%
% 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	%
<b>U.S. MANUFACTURERS</b>								
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
<b>NON-U.S. MANUFACTURERS</b>								
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
		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
U.S. Manufacturers	Type									
Alpha Data	0								14	
Areal Technology	0				2					
Atasi Technology	0						5	5		
Brand Technologies	0						3			
Cardiff Peripherals	0						3	3		
Cerplex Technologies	P,0	8						8	8	
Conner Peripherals	0			2,3	3	3	3			
Digital Equipment	C						5	5	5,14	8
DMA Technologies	0	5								
Hewlett-Packard	C,0			3		5	3,5	3,5	5,8	5
Ibis	0									14
IBM	C,0			3	2,3,5	2,3,5	3,5,8,14	3,5,8,14	5,8,14	5,10,14
Kalok	0			3	3	3				
Maxtor	0				3	3,5	3,5	3,5	3,5	5
MFM Technology	0	5								
Micropolis	0					5	5	5	5	5
Microscience International	0				3,5	5	3,5		5	5
Miltope	0			5	5		5	5		
Northern Telecom	0						8	8	8	8
Orca Technology	0							3	5	
Plus Development	P,0			3	3	3	3			
PrairieTek	0			2	2					
Quantum	0				2,3	2,3	3	3	3	
Seagate Technology	0		8	3,5	3,5	3,5	3,5	3,5,8	5,8	5,8
Sequel	0					8	8	8		
Storage Technology	P,0									14
SyQuest Technology	P,0	5								
Western Digital	P,0			3	2,3	2	3	3		
Asian Manufacturers										
Alps Electric	0			3	3		3			
Esperit	0				3	3				
Fuji Electric	0			3	3		3			
Fujitsu	C,P,0			3,5	3,5	5	3,5,8	5,8,10	5,8,10	5,8,10
Goldstar Telecommunication	0			3	3					
Hitachi	C,P,0			3,5	3,5,8	5,8	3,5,8	5,8	5,8,14	5,8,14
Hyosung Computer	0					5	5			
JVC (Victor Company)	0			2,3	3					
Kyocera	0			3	3		3			
Magtron	P,0						5			
Mitsubishi Electric	C,0				3,5	3	3,8	8	8	
Mitsumi Electric	0				3	3	3			
NEC	C,0			3,5	3,5		3,5	5	5,8	5,8
Ricoh	0	5								
Samsung Electronics	C,0				3					
Sony	0				3					
Teac	0				3	3				
Tokico	0				3	3	3			
Toshiba	C,0				3	5	3,5,8	5,8	5,8	
Y-E Data	0				3	3	3			
Zentek	P,0				3	3	3			
European Manufacturers										
DZU	0				5		14	14	14	
Kovo	0		14							
Rodime	P,0					3	3	3	3	
Sagem	0				5		5			
South American Manufacturers										
Digirede	0				5	5	5	5	5	
Edisa Informatica	C,0						5	5	5	
Elebra	0			3	5	5			8	
Flexdisk	0			3						
Microlab	0			5	5	5				
Prologica	C,0					3				

## 1990 DISK/TREND REPORT



## 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 Magnetix 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.

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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



## DISK CARTRIDGE DRIVES

### Coverage

Examples of disk drives in this group include:

#### 8" disk diameter

Cerplex (Century Data)	7110, 7130
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#### 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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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

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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.

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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
<b>U.S. Manufacturers</b>										
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
<b>Non-U.S. Manufacturers</b>										
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
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE REVENUES	36.8	65.9	57.4	68.1	75.3	91.5	90.7	118.5	102.3	139.5
<b>OEM Average Price (\$000)</b>										
	.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		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				1990			Forecast 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				Forecast						
	14"	8"	5.25"	<5.25"	8"	5.25"	<5.25"	8"	5.25"	1992	1993
	Shipments										
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 -----		1993 Projection -----	
	Units (000) -----	% -----	Units (000) -----	% -----
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

Drive Manufacturers	1989 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
	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



## 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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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.

**1990 DISK/TREND REPORT**

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		1990		1991		1992		1993	
	Revenues		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		1990		1991		1992		1993	
	Shipments									
	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		Forecast				
	Revenues		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		Forecast				
	14"	9"	14"	9"	9"	All Dia.	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 -54.5%	2.3 -61.0%	1.6 -75.4%	1.4 -39.1%	.7 -50.0%	--	--
Total Shipments	8.0 -57.7%	2.3 -61.0%	1.6 -80.0%	1.4 -39.1%	.7 -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 -----		No units in this product category are forecasted to be shipped in 1993
	Units (000) -----	% -----	
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	

FIXED DISK DRIVES, LESS THAN 30 MEGABYTES



FIXED DISK DRIVES, LESS THAN 30 MEGABYTESCoverage

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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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

## **1990 DISK/TREND REPORT**

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

## **1990 DISK/TREND REPORT**

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 .8%	53.7 1.2%	10.2 .4%	-- --	-- --
5.25" half high	1,848.1 29.6%	1,004.5 23.0%	358.8 14.1%	104.0 8.7%	21.0 4.4%
3.5"	4,356.1 69.4%	2,599.8 59.2%	1,176.0 46.3%	484.0 40.8%	198.0 41.9%
2.5"	24.0 .2%	730.0 16.6%	1,003.0 39.2%	601.0 50.5%	255.0 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

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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>U.S. Manufacturers</u>										
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
<u>Non-U.S. Manufacturers</u>										
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
<u>Worldwide Recap</u>										
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		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			Forecast											
	Revenues			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			Forecast											
	Shipments			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 -53.3%	531.4 -57.9%	--	9.0 -63.1%	177.0 -66.7%	--	2.0 -77.8%	42.0 -76.3%	--	-- -100.0%	19.0 -54.8%	--	--	8.0 -57.9%	--
PCM/Reseller	1,450.9 -21.6%	1,261.0 +64.9%	5.0 --	838.8 -42.2%	903.6 -28.3%	10.0 +100.0%	302.0 -64.0%	549.0 -39.2%	18.0 +80.0%	84.0 -72.2%	280.0 -49.0%	6.0 -66.7%	21.0 -75.0%	145.0 -48.2%	-- -100.0%
OEM/Integrator	424.5 -56.6%	2,563.7 -15.6%	19.0 --	210.4 -50.4%	1,519.2 -40.7%	720.0 --	65.0 -69.1%	585.0 -61.5%	985.0 +36.8%	20.0 -69.2%	185.0 -68.4%	595.0 -39.6%	-- -100.0%	45.0 -75.7%	255.0 -57.1%
Total Shipments	1,899.8 -34.1%	4,356.1 -14.0%	24.0 --	1,058.2 -44.3%	2,599.8 -40.3%	730.0 --	369.0 -65.1%	1,176.0 -54.8%	1,003.0 +37.4%	104.0 -71.8%	484.0 -58.8%	601.0 -40.1%	21.0 -79.8%	198.0 -59.1%	255.0 -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 -----		1993 Projection -----	
	Units (000) -----	% -----	Units (000) -----	% -----
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

Drive Manufacturers	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	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



FIXED DISK DRIVES, 30-60 MEGABYTESCoverage

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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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.

## **1990 DISK/TREND REPORT**

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.

## **1990 DISK/TREND REPORT**

### 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 1.8%	53.1 .3%	112.2 .8%	110.1 .7%	70.0 .4%
5.25" half high	3,424.1 33.6%	2,367.9 19.1%	1,438.8 9.7%	737.9 4.3%	250.0 1.3%
3.5"	6,604.4 64.6%	10,028.4 80.3%	12,250.0 82.8%	13,100.0 77.6%	13,230.0 71.9%
2.5"	.5 --	55.0 .3%	1,010.0 6.7%	2,960.0 17.4%	4,880.0 26.4%
	10,209.3	12,504.4	14,811.0	16,908.0	18,430.0

## **1990 DISK/TREND REPORT**

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		Forecast							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
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
<b>Non-U.S. Manufacturers</b>										
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
<b>Worldwide Recap</b>										
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		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			Forecast											
	Revenues			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			Forecast											
	Shipments			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 -60.0%	948.2 +92.4%	--	26.7 -63.9%	1,619.4 +70.8%	12.0 --	6.0 -77.5%	1,890.0 +16.7%	200.0 --	3.0 -50.0%	1,735.0 -8.2%	630.0 +215.0%	-- -100.0%	1,555.0 -10.4%	1,470.0 +133.3%
PCM/Reseller	2,521.7 +28.8%	1,246.8 +241.8%	--	2,020.5 -19.9%	2,174.5 +74.4%	6.0 --	1,275.0 -36.9%	2,780.0 +27.8%	30.0 +400.0%	660.0 -48.2%	3,255.0 +17.1%	70.0 +133.3%	225.0 -65.9%	3,550.0 +9.1%	130.0 +85.7%
OEM/Integrator	1,008.7 -20.5%	4,409.4 +180.8%	.5 --	373.8 -62.9%	6,234.5 +41.4%	37.0 --	270.0 -27.8%	7,580.0 +21.6%	780.0 --	185.0 -31.5%	8,110.0 +7.0%	2,260.0 +189.7%	95.0 -48.6%	8,125.0 +2%	3,280.0 +45.1%
Total Shipments	3,604.4 +5.6%	6,604.4 +172.0%	.5 --	2,421.0 -32.8%	10,028.4 +51.8%	55.0 --	1,551.0 -35.9%	12,250.0 +22.2%	1,010.0 --	848.0 -45.3%	13,100.0 +6.9%	2,960.0 +193.1%	320.0 -62.3%	13,230.0 +1.0%	4,880.0 +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		1993 Projection	
	Units (000)	%	Units (000)	%
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

Drive Manufacturers	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	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



FIXED DISK DRIVES, 60-100 MEGABYTESCoverage

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*
Esprt	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	R03085A*, R03071S**
Seagate Technology	ST1096N*, ST3096A**
Teac	SD-380**
Tokico	TD3081C*
Y-E Data	YD-3082*
Zentek	H3060A*



2.5" disk diameter

IBM  
Quantum  
Western Digital

WDA-260\*\*  
80S/AT Go.Drive\*\*  
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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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.

## 1990 DISK/TREND REPORT

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.

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

## **1990 DISK/TREND REPORT**

### 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
<b>U.S. Manufacturers</b>										
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
<b>Non-U.S. Manufacturers</b>										
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
<b>Worldwide Recap</b>										
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			1990				1991				1992			1993		
	Revenues																
	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	-- -100.0%	292.1 -5.0%	770.0 +51.0%	-- -71.5%	83.3 -4.4%	736.0 -4.4%	2.8 --	-- -82.0%	15.0 +4.5%	768.8 +900.0%	28.0 +900.0%	6.0 -60.0%	794.5 +3.3%	77.6 +177.1%	-- -100.0%	773.1 -2.7%	162.0 +108.8%
PCM/Reseller	-- -20.0%	205.5 -20.0%	44.3 +735.8%	-- -13.7%	177.3 +458.2%	247.3 +458.2%	-- --	-- -32.0%	120.6 +33.0%	329.0 +33.0%	-- --	72.7 -39.7%	344.1 +4.6%	5.9 --	32.6 -55.2%	303.6 -11.8%	17.0 +188.1%
OEM/Integrator	6.6 -35.9%	200.4 -40.1%	214.9 +838.4%	2.1 -68.2%	107.3 -46.5%	422.1 +96.4%	-- --	1.3 -38.1%	67.1 -37.5%	590.3 +39.8%	55.2 --	30.0 -55.3%	618.9 +4.8%	150.1 +171.9%	11.3 -62.3%	554.5 -10.4%	241.0 +60.6%
Total Revenues	6.6 -95.7%	698.0 -22.4%	1,029.2 +91.2%	2.1 -68.2%	367.9 -47.3%	1,405.4 +36.6%	2.8 --	1.3 -38.1%	202.7 -44.9%	1,688.1 +20.1%	83.2 --	108.7 -46.4%	1,757.5 +4.1%	233.6 +180.8%	43.9 -59.6%	1,631.2 -7.2%	420.0 +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			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		1993 Projection	
	Units (000)	%	Units (000)	%
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

Drive Manufacturers	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	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



FIXED DISK DRIVES, 100-300 MEGABYTESCoverage

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	R03259AP*
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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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

## 1990 DISK/TREND REPORT



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.

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

## **1990 DISK/TREND REPORT**

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.

## **1990 DISK/TREND REPORT**

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		-----Forecast-----							
	Revenues		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
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
<b>Non-U.S. Manufacturers</b>										
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
<b>Worldwide Recap</b>										
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		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				Forecast												
	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 -83.3%	75.4 -70.4%	642.8 +42.4%	601.2 +111.9%	63.1 -16.3%	451.2 -29.8%	1,026.5 +70.7%	13.2 -79.1%	285.1 -36.8%	1,966.9 +91.6%	52.0 --	217.0 -23.9%	2,385.0 +21.3%	123.0 +136.5%	113.3 -47.8%	2,755.5 +15.5%	228.0 +85.4%
PCM/Reseller	-- --	-- --	80.7 -27.1%	30.7 +230.1%	-- --	120.4 +49.2%	183.0 +496.1%	-- --	110.5 -8.2%	464.5 +153.8%	-- --	85.2 -22.9%	777.2 +67.3%	-- --	60.0 -29.6%	980.2 +26.1%	1.9 --
OEM/Integrator	8.1 -59.9%	16.9 -53.4%	398.3 -30.1%	340.1 +300.6%	4.5 -73.4%	258.7 -35.0%	1,118.7 +228.9%	1.9 -57.8%	171.9 -33.6%	1,453.2 +29.9%	-- --	93.9 -45.4%	1,857.7 +27.8%	15.8 --	38.4 -59.1%	1,879.6 +1.2%	74.4 +370.9%
Total Revenues	43.2 -81.2%	92.3 -68.3%	1,121.8 .9%	972.0 +157.2%	67.6 -26.8%	830.3 -26.0%	2,328.2 +139.5%	15.1 -77.7%	567.5 -31.7%	3,884.6 +66.8%	52.0 --	396.1 -30.2%	5,019.9 +29.2%	138.8 +166.9%	211.7 -46.6%	5,615.3 +11.9%	304.3 +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				Forecast												
	Shipments				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 -83.3%	6.8 -73.5%	192.2 +50.5%	332.4 +114.6%	6.4 -5.9%	136.0 -29.2%	659.5 +98.4%	1.2 -81.3%	72.0 -47.1%	1,419.0 +115.2%	40.0 --	55.0 -23.6%	1,840.0 +29.7%	100.0 +150.0%	29.0 -47.3%	2,295.0 +24.7%	195.0 +95.0%
PCM/Reseller	-- --	-- --	88.8 -22.2%	43.3 +230.5%	-- --	167.0 +88.1%	347.0 +701.4%	-- --	168.0 +.6%	980.0 +182.4%	-- --	138.0 -17.9%	1,740.0 +77.6%	-- --	100.0 -27.5%	2,395.0 +37.6%	5.0 --
OEM/Integrator	2.6 -58.7%	7.3 -53.5%	484.8 -20.4%	623.2 +540.5%	1.9 -74.0%	354.8 -26.8%	2,315.0 +271.5%	.8 -57.9%	251.0 -29.3%	3,229.0 +39.5%	-- --	146.0 -41.8%	4,435.0 +37.3%	40.0 --	66.0 -54.8%	4,855.0 +9.5%	200.0 +400.0%
Total Shipments	4.6 -74.9%	14.1 -65.9%	765.8 -10.0%	998.9 +276.5%	8.3 -41.1%	657.8 -14.1%	3,321.5 +232.5%	2.0 -75.9%	491.0 -25.4%	5,628.0 +69.4%	40.0 --	339.0 -31.0%	8,015.0 +42.4%	140.0 +250.0%	195.0 -42.5%	9,545.0 +19.1%	400.0 +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		1993 Projection	
	Units (000)	%	Units (000)	%
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

Drive Manufacturers	1989 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
	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



FIXED DISK DRIVES, 300-500 MEGABYTESCoverage

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
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9" disk diameter

Seagate Technology	ST6344J
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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	R03414T*
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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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

**1990 DISK/TREND REPORT**

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

## **1990 DISK/TREND REPORT**



"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.

## 1990 DISK/TREND REPORT

### 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		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	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		1990		1991		Forecast		1992	
	Shipments									
	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

## 1990 DISK/TREND REPORT

	1989				Forecast															
	Revenues				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"	14"	8"	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 -81.2%	420.7 -44.4%	911.6 +116.1%	--	33.6 -52.2%	188.2 -55.3%	771.9 -15.3%	1,168.5 --	4.2 -87.5%	52.5 -72.1%	481.1 -37.7%	1,585.2 +35.7%	2.0 -52.4%	28.0 -46.7%	294.3 -38.8%	1,707.3 +7.7%	108.2 -63.2%	--	1,779.2 +4.2%	--
PCM/Reseller	-- --	2.5 --	140.7 +161.5%	9.6 --	-- --	-- -100.0%	70.7 -49.8%	30.9 +221.9%	-- --	-- --	71.8 +1.6%	95.2 +208.1%	-- --	-- --	21.4 -70.2%	214.6 +125.4%	-- -100.0%	--	333.6 +55.5%	--
OEM/Integrator	47.6 -72.7%	116.2 -55.9%	577.6 +60.2%	--	28.0 -41.2%	53.0 -54.4%	678.3 +17.4%	6.2 --	24.0 -14.3%	24.3 -54.2%	625.9 -7.7%	205.8 --	9.5 -60.4%	5.2 -78.6%	534.6 -14.6%	404.9 +96.7%	372.1 -30.4%	--	553.9 +36.8%	--
Total Revenues	117.9 -78.5%	539.4 -47.1%	1,629.9 +94.9%	9.6 --	61.6 -47.8%	241.2 -55.3%	1,520.9 -6.7%	1,205.6 --	28.2 -54.2%	76.8 -68.2%	1,178.8 -22.5%	1,886.2 +56.5%	11.5 -59.2%	33.2 -56.8%	850.3 -27.9%	2,326.8 +23.4%	480.3 -43.5%	--	2,666.7 +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											
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	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
Other U.S. Captive	1.5	.3	43.1	--	.4	--	61.0	--	--	--	49.0	26.0	--	--	32.0	54.0
PCM/Reseller	--	.5	116.2	8.0	--	--	62.7	25.6	--	--	50.0	95.0	--	--	12.0	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	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
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	42.0
PCM/Reseller	--	--	.7	--	--	--	.1	--	--	--	4.0	15.0	--	--	2.0	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	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	260.0
WORLDWIDE RECAP																
Captive	3.8 -82.6%	28.8 -45.2%	166.4 +115.5%	--	1.7 -55.3%	13.8 -52.1%	144.3 -13.3%	285.0 --	.2 -88.2%	3.5 -74.6%	90.0 -37.6%	394.0 +38.2%	.1 -50.0%	2.0 -42.9%	57.0 -36.7%	435.0 +10.4%
PCM/Reseller	-- --	.5 --	116.9 +212.6%	8.0 --	-- --	-- -100.0%	62.8 -46.3%	25.6 +220.0%	-- --	-- --	54.0 -14.0%	110.0 +329.7%	-- --	-- --	14.0 -74.1%	263.0 +139.1%
OEM/Integrator	6.2 -69.3%	39.0 -56.5%	473.1 +88.3%	--	4.0 -35.5%	18.9 -51.5%	620.9 +31.2%	5.4 --	4.0 --	9.0 -52.4%	620.0 --	240.0 --	1.9 -52.5%	2.0 -77.8%	554.0 -10.6%	501.0 +108.8%
Total Shipments	10.0 -76.2%	68.3 -52.0%	756.4 +106.7%	8.0 --	5.7 -43.0%	32.7 -52.1%	828.0 +9.5%	316.0 --	4.2 -26.3%	12.5 -61.8%	764.0 -7.7%	744.0 +135.4%	2.0 -52.4%	4.0 -68.0%	625.0 -18.2%	1,199.0 +61.2%
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%
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	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

APPLICATION	1989 Estimate		1993 Projection	
	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

Drive Manufacturers	1989 Net Shipments											
	To United States Destinations						Worldwide					
	Units (000)					%	Units (000)					%
	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



FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTECoverage

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
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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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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

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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

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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
<b>U.S. Manufacturers</b>										
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
<b>Non-U.S. Manufacturers</b>										
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
<b>Worldwide Recap</b>										
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		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			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 -74.8%	1,605.4 +91.6%	5.4 --	272.0 -48.6%	1,061.6 -33.9%	443.2 --	171.5 -36.9%	531.0 -50.0%	662.0 +49.4%	450.0 --	108.0 -37.0%	90.0 -83.1%	776.0 +17.2%	1,051.0 +133.6%	36.0 -66.7%	820.0 +5.7%	1,654.0 +57.4%
PCM/Reseller	-- --	3.0 -69.4%	40.2 +408.9%	-- --	.8 -73.3%	56.6 +40.8%	-- --	.4 -50.0%	78.6 +38.9%	9.1 --	-- --	-- -100.0%	105.7 +34.5%	26.9 +195.6%	-- --	86.9 -17.8%	56.2 +108.9%
OEM/Integrator	32.6 -65.4%	269.1 -41.0%	211.3 +523.3%	22.6 -30.7%	155.6 -42.2%	469.2 +122.1%	10.0 -55.8%	79.2 -49.1%	543.5 +15.8%	18.0 --	9.0 -10.0%	27.8 -64.9%	551.8 +1.5%	64.8 +260.0%	-- -100.0%	418.9 -24.1%	178.6 +175.6%
Total Revenues	561.6 -74.4%	1,877.5 +44.0%	256.9 +514.6%	294.6 -47.5%	1,218.0 -35.1%	969.0 +277.2%	181.5 -38.4%	610.6 -49.9%	1,284.1 +32.5%	477.1 --	117.0 -35.5%	117.8 -80.7%	1,433.5 +11.6%	1,142.7 +139.5%	36.0 -69.2%	1,325.8 -7.5%	1,888.8 +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			Forecast													
	Shipments			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 -71.3%	96.3 +89.9%	.3 --	15.0 -51.0%	68.1 -29.3%	48.0 --	9.5 -36.7%	36.0 -47.1%	72.0 +50.0%	75.0 --	6.0 -36.8%	6.0 -83.3%	89.0 +23.6%	188.0 +150.7%	2.0 -66.7%	104.0 +16.9%	332.0 +76.6%
PCM/Reseller	-- --	.8 -57.9%	18.0 +462.5%	-- --	.2 -75.0%	31.0 +72.2%	-- --	.1 -50.0%	49.0 +58.1%	7.0 --	-- --	-- -100.0%	70.0 +42.9%	22.0 +214.3%	-- --	64.0 -8.6%	50.0 +127.3%
OEM/Integrator	1.6 -89.0%	73.0 -35.0%	124.1 +773.9%	1.3 -18.7%	45.7 -37.4%	333.0 +168.3%	1.0 -23.1%	24.0 -47.5%	419.0 +25.8%	15.0 --	1.0 --	9.0 -62.5%	461.0 +10.0%	58.0 +286.7%	-- -100.0%	367.0 -20.4%	181.0 +212.1%
Total Shipments	32.2 -73.4%	170.1 +3.2%	142.4 +718.4%	16.3 -49.4%	114.0 -33.0%	412.0 +189.3%	10.5 -35.6%	60.1 -47.3%	540.0 +31.1%	97.0 --	7.0 -33.3%	15.0 -75.0%	620.0 +14.8%	268.0 +176.3%	2.0 -71.4%	535.0 -13.7%	563.0 +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		1993 Projection	
	Units (000)	%	Units (000)	%
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

Drive Manufacturers	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	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



FIXED DISK DRIVES, MORE THAN 1 GIGABYTECoverage

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
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10.5" disk diameter

Fujitsu	F6425M4, F6425H
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9.5" disk diameter

Hitachi	DKU-86I, H-6587
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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 "Red-wing" 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.

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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:

<u>Worldwide sales (\$M)</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>	<u>1993</u>
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-

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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.

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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

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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 main-frame 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		1990		1991		1992		1993	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
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
<b>Non-U.S. Manufacturers</b>										
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
<b>Worldwide Recap</b>										
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
<b>OEM Average Price (\$000)</b>										
	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		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			Forecast											
	Revenues			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 +36.5%	1,002.3 +631.6%	--	6,540.2 +4.3%	1,496.3 +49.3%	845.4 --	5,938.0 -9.2%	1,605.0 +7.3%	2,305.0 +172.7%	4,385.0 -26.2%	1,500.0 -6.5%	3,685.9 +59.9%	3,596.0 -18.0%	1,178.0 -21.5%	5,163.0 +40.1%
PCM/Reseller	300.9 -57.4%	476.8 +223.3%	--	218.0 -27.6%	543.4 +14.0%	3.5 --	261.9 +20.1%	643.3 +18.4%	36.1 +931.4%	122.0 -53.4%	549.3 -14.6%	324.3 +798.3%	-- -100.0%	690.0 +25.6%	467.2 +44.1%
OEM/Integrator	332.2 -13.4%	350.5 +100.1%	2.5 --	232.7 -30.0%	418.5 +19.4%	89.6 --	199.1 -14.4%	450.4 +7.6%	216.4 +141.5%	185.9 -6.6%	439.2 -2.5%	454.5 +110.0%	195.1 +4.9%	326.0 -25.8%	761.0 +67.4%
Total Revenues	6,902.9 +21.5%	1,829.6 +298.0%	2.5 --	6,990.9 +1.3%	2,458.2 +34.4%	938.5 --	6,399.0 -8.5%	2,698.7 +9.8%	2,557.5 +172.5%	4,692.9 -26.7%	2,488.5 -7.8%	4,464.7 +74.6%	3,791.1 -19.2%	2,194.0 -11.8%	6,391.2 +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											
	14"	8"	5.25"	1990 14"	8"	5.25"	1991 14"	8"	5.25"	1992 14"	8"	5.25"	1993 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 +57.9%	40.2 +658.5%	--	171.9 +4.9%	64.2 +59.7%	48.1 --	143.0 -16.8%	74.0 +15.3%	162.0 +236.8%	89.0 -37.8%	75.0 +1.4%	266.0 +64.2%	74.0 -16.9%	62.0 -17.3%	389.0 +46.2%
PCM/Reseller	12.5 -60.3%	21.6 +242.9%	--	9.1 -27.2%	25.6 +18.5%	1.4 --	9.9 +8.8%	25.6 --	19.0 --	5.0 -49.5%	22.0 -14.1%	54.0 +184.2%	-- -100.0%	30.0 +36.4%	82.0 +51.9%
OEM/Integrator	12.2 -19.7%	67.1 +137.1%	1.1 --	8.8 -27.9%	94.3 +40.5%	45.8 --	7.3 -17.0%	109.0 +15.6%	124.0 +170.7%	5.5 -24.7%	112.0 +2.8%	280.0 +125.8%	6.0 +9.1%	93.0 -17.0%	500.0 +78.6%
Total Shipments	188.6 +25.3%	128.9 +223.1%	1.1 --	189.8 +.6%	184.1 +42.8%	95.3 --	160.2 -15.6%	208.6 +13.3%	305.0 +220.0%	99.5 -37.9%	209.0 +.2%	600.0 +96.7%	80.0 -19.6%	185.0 -11.5%	971.0 +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 Shipments		-----FORECAST-----							
	US	WW	1990 US	1990 WW	1991 US	1991 WW	1992 US	1992 WW	1993 US	1993 WW
<u>IBM 9335 (856 MB)</u>	28.0	55.0	23.0	45.0	10.0	20.0	--	--	--	--
<u>IBM 9336 (857 MB)</u>	--	--	36.0	48.0	60.0	85.0	75.0	110.0	80.0	125.0
<u>3380J Type (1260 MB)</u>										
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	--	--	--	--
<u>3380E Type (2520 MB)</u>										
IBM	--	--	--	--	--	--	--	--	--	--
PCM*	3.5	6.9	1.1	1.7	--	--	--	--	--	--
TOTAL	3.5	6.9	1.1	1.7	--	--	--	--	--	--
<u>3380K Type (3780 MB)</u>										
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	--	--
<u>3390 type (3780 MB)</u>										
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
<u>Not yet announced</u>										
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 -----		1993 Projection -----	
	Units (000) -----	% -----	Units (000) -----	% -----
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

Drive Manufacturers	1989 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	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 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

# 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC	ALPS ELECTRIC
DRQ040A	DRQ040D	DRR040C	DRR040D	DRR100C
4	4	4	4	6
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film
MIG	MIG	MIG	MIG	MIG
Alps	SCSI	PC AT	SCSI	PC AT
U: 51.2	F: 42.8	F: 42.8	F: 45.34	F: 105.0
--	--	--	--	--
U: 20,832	F: 17,408	F: 17,920	F: 17,920	F: 17,920
4	4	2	2	4
1	1	1	1	1
615	615	1195	1265	1465
880	880	1400	1740	1740
27022 BPI 18015 FCI 2,7 RLL	27022 BPI 18015 FCI 2,7 RLL	33343 BPI 22229 FCI 2,7 RLL	33343 BPI 22229 FCI 2,7 RLL	33343 BPI 22229 FCI 2,7 RLL
2640	2640	3205	3205	3205
Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Open Loop	Open Loop	Embedded	Embedded	Embedded
45 (including settling)	45 (including settling)	19	19	19
11.4	11.4	9.4	9.4	9.4
56.4	56.4	28.4	28.4	28.4
937.5	1667	750	2000	750
1988	1988	4Q89	1990	1Q90
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	10.5" OD	10.5" OD	65 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	4.0" ID Oxide Coated	4.0" ID Oxide Sputtered	20 mm ID Thin Film	40 mm ID 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	21300 BPI	24440 BPI	57000 BPI	10924
Recording code	22229 FCI 2,7 RLL	15975 FCI 1,7 RLL	18330 FCI 1,7 RLL	38000 FCI 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	

## 1990 DISK/TREND REPORT



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	130 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID	40 mm ID	25 mm ID	25 mm ID	25 mm ID
	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	21848 BPI	29700 BPI	29700 BPI	29700 BPI
Recording code	14565 FCI	14565 FCI	19800 FCI	19800 FCI	19800 FCI
	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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	29700 BPI	29700 BPI	41725 BPI	41725 BPI
Recording code	19800 FCI	19800 FCI	19800 FCI	27817 FCI	27817 FCI
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
	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	95 mm OD	95 mm OD	95 mm OD	200 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	63.5 mm ID 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	41725 BPI	41725 BPI	41725 BPI	10986 BPI
Recording code	27817 FCI	27817 FCI	27817 FCI	27817 FCI	7324 FCI
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
	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	

## 1990 DISK/TREND REPORT

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	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID 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	10986 BPI	12783 BPI	19200 BPI	19739 BPI
Recording code	7324 FCI 2,7 RLL	7324 FCI 2,7 RLL	8522 FCI 2,7 RLL	12800 FCI 2,7 RLL	13159 FCI 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

## 1990 DISK/TREND REPORT

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	65 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	20 mm ID Thin Film	20 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	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	34000 BPI	21379 BPI	21379 BPI	23148 BPI
Recording code	22666 FCI 2,7 RLL	22666 FCI 2,7 RLL	14253 FCI 2,7 RLL	14253 FCI 2,7 RLL	15432 FCI 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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Thin Film, 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	30871 BPI	32729 BPI	24437 BPI	24437 BPI
Recording code	20581 FCI	20581 FCI	21919 FCI	16291 FCI	16291 FCI
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
	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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	35600 BPI	35600 BPI	23441 BPI	23441 BPI
Recording code	23733 FCI 2,7 RLL	23733 FCI 2,7 RLL	23733 FCI 2,7 RLL	15627 FCI 2,7 RLL	15627 FCI 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

## 1990 DISK/TREND REPORT



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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	31800 BPI	31800 BPI	31800 BPI	31800 BPI
Recording code	15627 FCI 2,7 RLL	21200 FCI 2,7 RLL	21200 FCI 2,7 RLL	21200 FCI 2,7 RLL	21200 FCI 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

## 1990 DISK/TREND REPORT

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				

## 1990 DISK/TREND REPORT

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	

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES	DMA TECHNOLOGIES
RF71	RA90	RA92	360	370
8	9	9	1	1
Captive	Captive	Captive	OEM	OEM
Fixed	Fixed	Fixed	--	--
130 mm OD 40 mm ID Thin Film	9" Thin Film	9" Thin Film	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Thin Film
Ferrite	Thin Film	Thin Film	Ferrite	Ferrite
DEC	DEC	DEC	ST412	ST412
U: 532 F: 400	U: 1,607 F: 1,216	U: 1,987 F: 1,506	--	--
--	--	--	U: 12.75	U: 25.0
F: 25,000	F: 35,328	F: 35,328	U: 10,416	U: 10,416
8	13	13	2	2
1	1	1	1	1
1331	2649	3099	612	1224
1355	1750	2045	612	1222
22784 BPI 15189 FCI 2,7 RLL	22839 BPI 15226 FCI 2,7 RLL	22839 BPI 15226 FCI 2,7 RLL	10894	10894
3600	3600	3400	MFM	MFM
3600	3600	3400	3473	3473
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Embedded	Dedicated Surf.	Dedicated Surf.	Open Loop	Open Loop
21.0	17.5	16	98 (including settling)	85 (including settling)
8.3	8.3	8.8	8.6	8.6
29.3	27	24.8	106.6	93.6
1500	2800	2800	625	625
	8/88	3/90	5/84	5/88
	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				

## 1990 DISK/TREND REPORT

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: 15	U: 20,160	F: 15	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					

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT



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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	21719 BPI		15600	14200 BPI
Recording code	12218 FCI	14479 FCI	MFM	MFM	9466 FCI
Rotational speed (RPM)	2,7 RLL*	2,7 RLL*			2,7 RLL
	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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Oxide Coated	25 mm ID Oxide Coated	40 mm ID 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	95 mm OD	130 mm OD	130 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	25 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID 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

## 1990 DISK/TREND REPORT

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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID 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	10200	10200	20400 BPI	20400 BPI
Recording code	22178 FCI 1,7 RLL	MFM	MFM	13600 FCI 2,7 RLL	13600 FCI 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		

## 1990 DISK/TREND REPORT

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				

## 1990 DISK/TREND REPORT



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	130 mm OD	130 mm OD	130 mm OD	210 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID 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	19295 BPI	19295 BPI	19295 BPI	9867
Recording code	14471 FCI 1,7 RLL	14471 FCI 1,7 RLL	14471 FCI 1,7 RLL	14471 FCI 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

## 1990 DISK/TREND REPORT

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	95 mm OD	10.5" OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	4.0" ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID 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	29571 BPI	12790	19295 BPI	19295 BPI
Recording code	22178 FCI	22178 FCI	MFM	14471 FCI	14471 FCI
Rotational speed (RPM)	1,7 RLL	1,7 RLL		1,7 RLL	1,7 RLL
	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

## 1990 DISK/TREND REPORT

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	210 mm OD	10.5" OD	10.5" OD	130 mm OD
Recording medium	4.0" ID Oxide Coated	100 mm ID Oxide Coated	4.0" ID Oxide Coated	4.0" ID Oxide Coated	40 mm ID 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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
M2361A	M2372K/KS	M2381K/KP	F6425H	F6425M4/N4
8	8	8	9	9
OEM	OEM	OEM	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
10.5" OD 4.0" ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	10.5" OD 4.0" ID Oxide Sputtered	10.5" OD 4.0" ID Oxide Sputtered
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Modified SMD	Mod. SMD, SCSI	Mod. SMD, IPI-2	Fujitsu	Fujitsu
U: 689.8	U: 823.9	U: 555.7	F: 1,890	F: 1,260
--	--	--	--	--
U: 40,960	U: 40,960	U: 49,728	F: 47,476	F: 47,476
10	13.5	7.5	16	12
2	2/1	2/1	2	2
1682	1490	1490	2654	2360
880	1193	1193	1350	1160
18620 BPI 12413 FCI 2,7 RLL	20766 BPI 13844 FCI 2,7 RLL	25211 BPI 18908 FCI 1,7 RLL	24440 BPI 18330 FCI 1,7 RLL	24989 BPI 16659 FCI 2,7 RLL
3600	3600	3620	3620	3620
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
18	16	16	16	17
8.3	8.3	8.3	8.3	8.3
26.3	24.3	24.3	24.3	25.3
2458	2458	3000	3000	3000
2Q85	9/87	1Q88	12/88	3Q86
			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	130 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	100 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID 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	46635 BPI	25211 BPI	25211 BPI	22764 BPI
Recording code	24980 FCI 1,7 RLL	34976 FCI 1,7 RLL	18908 FCI 1,7 RLL	18908 FCI 1,7 RLL	17073 FCI 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		

## 1990 DISK/TREND REPORT



## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

FUJITSU	FUJITSU	FUJITSU	FUJITSU	GOLDSTAR TELE- COMMUNICATION
M2391K	M2392D	M2392K	M2671P	GSH-3026
9	9	9	9	3
OEM	OEM	OEM	OEM, PCM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Thin Film	95 mm OD 25 mm ID Thin Film
Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Modified SMD	Modified SMD	Modified SMD	IPI-2	ST412
U: 1,062	F: 1,842	U: 2,027	U: 2,648	U: 25.6
--	--	--	--	--
U: 50,400	F: 45,792	U: 50,400	U: 66,096	U: 10,416
11	21	21	15	4
1	1	1	1	1
1916	1916	1916	2671	615
1456	1456	1456	2080	753
25055 BPI 18791 FCI 1,7 RLL	22764 BPI 17073 FCI 1,7 RLL	25055 BPI 18791 FCI 1,7 RLL	33310 BPI 24983 FCI 1,7 RLL	15600 MFM
3600	3600	3600	4340	3350
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Stepping Motor
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Open Loop
12	12	12	12	65 (including settling)
8.3	8.3	8.3	6.91	8.9
20.3	20.3	20.3	18.91	73.9
3000	2750	3000	4781	625
1Q90	1Q90	1Q90	2Q90	1989
				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

## 1990 DISK/TREND REPORT

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE			97532D 97532S 97532T	97533D 97533S 97533T	
	7958S	97532E			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.	

## 1990 DISK/TREND REPORT

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	

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
97548E	97548P 97548T	97556E	97556P 97556T	C2201A C2202/03A
8	8	8	8	8
OEM	OEM	OEM	OEM	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Thin Film	130 mm OD 40 mm ID Thin Film	130 mm OD 40 mm ID Thin Film	130 mm OD 40 mm ID Thin Film	130 mm OD 40 mm ID Thin Film
Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
ESDI	SCSI-2	ESDI	SCSI-2	ESDI, HPiB, FL
U: 796	F: 664	U: 793	F: 673	F: 670
--	--	--	--	--
U: 34,143	F: 28,672	U: 42,930	F: 36,864	F: 29,184
16	16	11	11	7
1	1	1	1	1
1457	1447	1680	1670	1457
1666	1666	1863	1863	1667
30552 BPI 20368 FCI 2,7 RLL	30552 BPI 20368 FCI 2,7 RLL	42000 BPI 28000 FCI 2,7 RLL	42000 BPI 28000 FCI 2,7 RLL	30552 BPI 20368 FCI 2,7 RLL
4002	4002	4002	4002	4002
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Embedded
17	16.5	15	15	17
7.49	7.49	7.5	7.5	7.5
24.49	23.99	22.5	22.5	24.5
2500 max.	5000 max.	2875	10000 max.	2500
4Q88	9/89	3Q90	3Q90	1/90

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				

## 1990 DISK/TREND REPORT



## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

HEWLETT- PACKARD	HEWLETT- PACKARD	HEWLETT- PACKARD	HITACHI	HITACHI
97560E	97560P 97560T	C2204A	DK302-2	DK505-2
9	9	9	3	3
OEM	OEM	Captive	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Thin Film	130 mm OD 40 mm ID Thin Film	130 mm OD 40 mm ID Thin Film	95 mm OD 25 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
ESDI	SCSI-2	ESDI, FL	ST412	ST412
U: 1,600	F: 1,367	F: 1,340	U: 25.5	U: 25.62
--	--	--	--	--
U: 42,930	F: 36,864	F: 29,184	U: 10,416	U: 10,416
19	19	7	4	4
1	1	1	1	1
1961	1952	1457	615	615
1863	1865	1667	822	650
42000 BPI 28000 FCI 2,7 RLL	42000 BPI 28000 FCI 2,7 RLL	30552 BPI 20368 FCI 2,7 RLL	13700 MFM	9490 MFM
4002	4002	4002	3550	3550
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Dedicated Surf.	Dedicated Surf.	Embedded	Open Loop	Open Loop
15	13.5	17	85 (including settling) 8.45	85 (including settling) 8.45
7.5	7.5	7.5	93.45	93.45
22.5	21	24.5	625	625
2875	5000 max.	2500		
12/89	5/90	2/90	9/86	3/85
		Drive has 2 spindles	41.3 mm high	41.3 mm high Mfg. by Tokico

## 1990 DISK/TREND REPORT

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	130 mm OD	130 mm OD	130 mm OD	210 mm OD
Recording medium	25 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID 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	

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DK511-8	DK512-8	DK512C-8	DK812S-8	DK312C-20
5	5	5	5	6
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	95 mm OD 25 mm ID Thin Film
Ferrite	Ferrite	Ferrite	Ferrite	MIG
ST412, SCSI	ESDI, SMD	SCSI	SMD	SCSI
U: 85.7	U: 86.1	F: 73.3	U: 85	F: 209
--	--	--	--	--
U: 10,416	U: 20,944	F: 17,920	U: 20,672	F: 19,456
10	5	5	5	10
1	1	1	1	1
823	823	819	823	1076
925	925	925	760	1660
9250	18500 BPI 12333 FCI	18500 BPI 12333 FCI	9650 BPI 6433 FCI	38800 BPI 25866 FCI
MFM	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
3600	3482	3482	3510	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
23	23	23	25	16.8*
8.3	8.6	8.6	8.5	8.3
31.3	31.6	31.6	33.5	25.1
625	1209	1500 max.	1209	1500/4000
2Q84	3/85	1/87	7/83	3Q89
				41.3 mm high  *Assumes 4 reads per each write Read: 16 msec. Write: 20 msec.

## 1990 DISK/TREND REPORT

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.				

## 1990 DISK/TREND REPORT

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	210 mm OD	210 mm OD	210 mm OD	130 mm OD
Recording medium	100 mm ID	100 mm ID	100 mm ID	100 mm ID	40 mm ID
	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	9650 BPI	18500 BPI	18500 BPI	26000 BPI
Recording code	6433 FCI	6433 FCI	12333 FCI	12333 FCI	17333 FCI
	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					

## 1990 DISK/TREND REPORT

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					

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT



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	224 mm OD	224 mm OD	224 mm OD	14"
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID 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	19560 BPI	35470 BPI	35470 BPI	
Recording code	15000 FCI 1,7 RLL	14670 FCI 1,7 RLL	26602 FCI 1,7 RLL	26602 FCI 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

## 1990 DISK/TREND REPORT

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 2,7 RLL	
Recording code					
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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

HITACHI DATA SYSTEMS	HYOSUNG COMPUTER	HYOSUNG COMPUTER	HYOSUNG COMPUTER	IBIS
7380-K	HC8085	HC8128	HC8170E	2812
9	5	6	6	9
PCM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
9.5"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
Thin Film	Ferrite	Ferrite	Ferrite	Thin Film
IBM	ST412	ST412	ESDI	Custom, ISI
F: 1,890	U: 85.3	U: 127.9	U: 171.5	U: 2,830.0
--	--	--	--	--
F: 47,476	U: 10,416	U: 15,624	U: 20,934	U: 99,840
15	8	8	8	16
2	1	1	1	2
2655	1024	1024	1024	1776
	1053	1053	1053	769
	9290	13935 BPI 9250 FCI	19222 BPI 12815 FCI	32000 BPI 21333 FCI
	MFM	2,7 RLL	2,7 RLL	2,7 RLL
3600	3600	3600	3600	3600
Linear, Voice Coil	Rotary, DC Motor	Rotary, DC Motor	Rotary, DC Motor	Linear, Voice Coil
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
12.5	25	25	25	16
8.3	8.3	8.3	8.3	8.3
20.8	33.3	33.3	33.3	24.3
3000	625	937.5	1250	12000
	1989	1989	1989	4Q87
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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID 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

# 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
4956-G10(40 MB) 4956-H10(40 MB)	5364-001	7541 7542	8530-001,E01	8530-E31
4	4	4	4	4
Captive	Captive	Captive	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	95 mm OD 25 mm ID Oxide Coated	95 mm OD 25 mm ID Oxide Coated	95 mm OD 25 mm ID Thin Film
Ferrite	Ferrite	Ferrite	Ferrite	MIG
ST412	IBM, ST412	Microchannel	Microchannel	PS/2-30, MC
F: 40	F: 41.92	F: 31.3	F: 31.3	F: 30
--	--	--	--	--
F: 8,704	F: 8,192	F: 12,800	F: 12,800	F: 16,384
7	7	4	4	2
1	1	1	1	1
733	733	612	612	922
815	815	841	841	1302
9398	9398	19300	19300	26700 BPI 17800 FCI 2,7 RLL
MFM	MFM			
3600	3600	3600	3600	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil
Dedicated Surf.	Dedicated Surf.	Open Loop	Open Loop	Embedded
40	40	39 (including settling)	39 (including settling)	27
8.3	8.3	8.3	8.3	8.3
48.3	48.3	47.3	47.3	35.3
625	625	937.5	937.5	1275
9/86	6/85	4/89	4/89	9/89
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 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL	35700 BPI 23800 FCI 2,7 RLL
Recording code		MFM			
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

# 1990 DISK/TREND REPORT



## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
WDA-L40	WDL-330P	WDL-330R	WDP-L40	WDS-L40
4	4	4	4	4
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film
MIG	MIG	MIG	MIG	MIG
PC AT	PC XT	Microchannel	PC XT	SCSI-2
F: 40	U: 35.4 F: 30.0	U: 35.4 F: 30.1	F: 40	U: 51.8 F: 40.8
--	--	--	--	--
F: 19,968	F: 16,896	F: 16,384	F: 19,968	F: 19,968
2	2	2	2	2
1	1	1	1	1
1038	920	928	1038	1038
1517	1344	1344	1517	1517
31700 BPI 21133 FCI 2,7 RLL	26600 BPI 17333 FCI 2,7 RLL	26600 BPI 17333 FCI 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL
3600	3600	3600	3600	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Embedded	Embedded	Embedded	Embedded	Embedded
16	23	19	16	16
8.3	8.3	8.3	8.3	8.3
24.3	31.3	27.3	24.3	24.3
1500	1050/1250	1275	1500	1500
6/90	4/90	4/90	6/90	6/90
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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
7561 7562	8550-061 8570-A61,E61 8570-061,B61 5551-TOA 8555-061 8573-061	8560-071 8580-071 5571-TOA	8565-061	WD-380
5	5	5	5	5
Captive	Captive	Captive	Captive	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	130 mm OD 40 mm ID Oxide Coated	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film
Ferrite	Ferrite	Ferrite	Ferrite	MIG
Microchannel	SCSI, MC	ESDI	SCSI, MC	Microchannel
F: 60.8	F: 60.8	F: 70	F: 60	U: 103.5 F: 80
--	--	--	--	--
F: 13,312	F: 13,312	F: 18,432	F: 16,384	F: 18,815
6	6	7	4	4
1	1	1	1	1
762	762	583	920	1063
1169	1169	648	1302	1517
21700 BPI 14466 FCI 2,7 RLL	21700 BPI 14466 FCI 2,7 RLL	18942 BPI 12628 FCI 2,7 RLL	26700 BPI 17800 FCI 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL
3600	3600	3600	3600	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Embedded	Embedded	Dedicated Surf.	Embedded	Embedded
27	27	30	23	16
8.3	8.3	8.3	8.3	8.3
35.3	35.3	38.3	31.3	24.3
1050	1050	1250	1250	1500
4/89	5/88	2Q87	3/90	3/90
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	95 mm OD	95 mm OD	65 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID Thin Film	25 mm ID 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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
WDS-380	WDS-387	0671-284	4967-2CA 4967-2CB	5360-BXX
5	5	6	6	6
OEM	OEM	OEM	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	130 mm OD 40 mm ID Thin Film	14" Oxide Coated	14" Oxide Coated
MIG	Ferrite	Ferrite	Ferrite	Ferrite
SCSI	SCSI	ESDI, SCSI	IBM	IBM
U: 103.5 F: 80	F: 60.8	U: 284	F: 200.2	F: 200.2
--	--	--	--	--
F: 18,815	F: 16,384	U: 21,080	F: 25,088	F: 25,088
4	4	11	7	7
1	1	1	2	2
1063	933	1225	1140	1140
1517	1302	1168	485	485
31700 BPI 17333 FCI 2,7 RLL	26700 BPI 17800 FCI 2,7 RLL	21384 BPI 14256 FCI 2,7 RLL	9751 MFM	9751 MFM
3600	3600	3283	2964	2964
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Embedded	Embedded	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
16	23	21.5	25	25
8.3	8.3	9.14	10.1	10.1
24.3	31.3	30.64	35.1	35.1
1500	1275	1250	1500	1500
12/89	8/89	1Q88	7/83	7/83
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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
8102-A15	8570-121,821 8570-A21,121 8573-121 5551-TOB 8580-A21,121 8565-121	8580-111 5571-TOB	9332-200 9332-220 9332-A11	9332-240 9332-250
6	6	6	6	6
Captive	Captive	Captive	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
210 mm OD 100 mm ID Oxide Coated	95 mm OD 25 mm ID Thin Film	130 mm OD 40 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated	210 mm OD 100 mm ID Oxide Coated
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
IBM	SCSI, MC	ESDI	IPI-3	SCSI
F: 129.7	F: 120.5	F: 115	F: 200.3	F: 200.3
--	--	--	--	--
F: 16,384	F: 16,384	F: 18,432	F: 37,376	F: 37,376
11	8	7	4	4
1	1	1	1	1
720	920	915	1346	1346
850	1302	1000	1096	1096
8770	26700 BPI 17800 FCI	19159 BPI 12772 FCI	23100 BPI 17325 FCI	23100 BPI 17325 FCI
MFM	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
3125	3600	3600	3119	3119
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Dedicated Surf.	Embedded	Dedicated Surf.	Embedded	Embedded
27	23	28	19.5	19.5
9.6	8.3	8.3	9.62	9.62
36.6	31.3	36.3	29.12	29.12
1031	1250	1250	2500	2500
4/84	5/88	4Q87	8/86	2Q87
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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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 1,7 RLL	26700 BPI 17800 FCI 2,7 RLL	26700 BPI 17800 FCI 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL
Recording code					
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

## 1990 DISK/TREND REPORT



## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
WDA-3160	WDS-3158	WDS-3160	0661-371	0661-467
6	6	6	7	7
OEM	OEM	OEM	Captive, OEM	Captive, OEM
Fixed	Fixed	Fixed	Fixed	Fixed
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film
MIG	Ferrite	MIG	MIG	MIG
PC AT	SCSI	SCSI	SCSI-2	SCSI-2
U: 206.4 F: 160	F: 120.5	F: 160	U: 371 F: 320.1	U: 467 F: 400
--	--	--	--	--
F: 18,815	F: 16,384	F: 18,815	F: 24,576	F: 24,576
8	8	8	14	14
1	1	1	1	1
1021	925	1063	949	1199
1517	1302	1517	1201.5	1469
31700 BPI 21133 FCI 2,7 RLL	26700 BPI 17800 FCI 2,7 RLL	31700 BPI 21133 FCI 2,7 RLL	37341 BPI 28006 FCI 1,7 RLL	38427 BPI 28820 FCI 1,7 RLL
3600	3600	3600	4317.8	4316
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Embedded	Embedded	Embedded	Dedicated Surf.	Dedicated Surf.
16	23	16	12.5	11.5
8.3	8.3	8.3	6.95	6.95
24.3	31.3	24.3	19.45	18.45
1500	1275	1500	4000 max.	5000 max.
6/90	5/88	12/89	8/89	8/90
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

# 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

MEDIA: Generic type

Nominal disk diameter

Recording medium

DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

IBM	IBM	IBM	IBM	IBM
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
9	9	9	9	9
Captive	Captive	Captive	Captive	Captive
Fixed	Fixed	Fixed	Fixed	Fixed
14"	14"	10.8"	10.8"	14"
Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
IBM	IBM	IBM	IBM	IBM
F: 1,260.4	F: 3,781.4	F: 1,892	F: 3,784	F: 855.9
--	--	--	--	--
F: 47,476	F: 47,476	F: 56,664	F: 56,664	F: 36,352
15	15	15	15	6
2	2	2	2	2
1770	5310	2226	4452	3924
2089	2089	2235	2235	1600
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
3620	3620	4260	4260	3623
Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Rotary, Voice Coil
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
12	16	9.5	12.5	18
8.3	8.3	7.1	7.1	8.28
24.3	24.3	16.6	19.6	26.28
3000	3000	4200	4200	3000
10/87 (A,B)	10/87	12/89	12/89	8/86
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

## 1990 DISK/TREND REPORT



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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	20 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	25610 BPI	32331 BPI	38145 BPI	38145 BPI
Recording code	26443 FCI 2,7 RLL	17073 FCI 2,7 RLL	21855 FCI 2,7 RLL	25430 FCI 2,7 RLL	25430 FCI 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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID 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

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

KOVO (ARITMA)	KYOCERA	KYOCERA	KYOCERA	KYOCERA
Aritma 5080	KC 20A	KC 20B	KC 30A	KC 30B
2	3	3	4	4
OEM	OEM	OEM	OEM	OEM
3336-11	Fixed	Fixed	Fixed	Fixed
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
Oxide Coated	Thin Film	Oxide Coated	Thin Film	Oxide Coated
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
IBM	ST412	ST412	ST412	ST412
--	U: 25.5	U: 25.5	U: 38.4*	U: 38.4*
F: 200.0	--	--	--	--
F: 13,030	U: 10,416	U: 10,416	U: 15,624*	U: 15,624*
19	4	4	4	4
1	1	1	1	1
815	616	615	616	615
370	835	800	835	800
4040	12268	13464	18402 BPI 12268 FCI	20196 BPI 13464 FCI
MFM	MFM	MFM	2,7 RLL*	2,7 RLL*
3600	3600	3600	3600	3600
Linear, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Dedicated Surf.	Open Loop	Open Loop	Open Loop	Open Loop
30	65 (including settling)	62 (including settling)	65 (including settling)	62 (including settling)
8.3	8.3	8.3	8.3	8.3
38.3	73.3	70.3	73.3	70.3
806	625	625	937.5*	937.5*
1986	1987	1987	1987	1987
	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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	29589 BPI	29589 BPI	39939 BPI	39939 BPI
Recording code	19726 FCI 2,7 RLL	19726 FCI 2,7 RLL	19726 FCI 2,7 RLL	26626 FCI 2,7 RLL	26626 FCI 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

## 1990 DISK/TREND REPORT

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	130 mm OD	130 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film	25 mm ID 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	20320 BPI	20320 BPI	30625 BPI	30625 BPI
Recording code	13546 FCI 2,7 RLL	13546 FCI 2,7 RLL	13546 FCI 2,7 RLL	22969 FCI 1,7 RLL	22969 FCI 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	95 mm OD	95 mm OD	95 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID 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	23202 BPI	30625 BPI	30625 BPI	9934
Recording code	15468 FCI	15468 FCI	22969 FCI	22969 FCI	MFM
Rotational speed (RPM)	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL	
	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	

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film	40 mm ID 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	28910 BPI		14901 BPI	9280
Recording code	17486 FCI 2,7 RLL	21682 FCI 1,7 RLL	1,7 RLL	9934 FCI 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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID 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				

## 1990 DISK/TREND REPORT



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		

## 1990 DISK/TREND REPORT

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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID	40 mm ID	40 mm ID	40 mm ID	40 mm ID
	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		52088 BPI	47566 BPI
Recording code		35674 FCI		39066 FCI	35674 FCI
		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				

## 1990 DISK/TREND REPORT

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	210 mm OD	210 mm OD	130 mm OD	130 mm OD
Recording medium	63.5 mm ID Thin Film	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID 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 2,7 RLL	25211 BPI 18908 FCI 1,7 RLL	25211 BPI 18908 FCI 1,7 RLL	10890	10890
Recording code				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		

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MFM TECHNOLOGY	MICROLAB
20/20 Micro-Magnum	20/R Micro-Magnum	5/5 Micro-Magnum	5/R Micro-Magnum	DFW 5025
1	1	1	1	3
OEM	OEM	OEM	OEM	OEM
5.25" Cartridge	5.25" Cartridge	5.25" Cartridge	5.25" Cartridge	Fixed
130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated	130 mm OD 40 mm ID Oxide Coated
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
ST506	ST506	ST506	ST506	ST412
U: 24.25	--	U: 6.4	--	U: 25.6
U: 24.25	U: 24.25	U: 6.4	U: 6.75	--
U: 10,640	U: 10,640	U: 10,032	F: 10,890	U: 10,416
4	2	4	2	4
1	1	1	1	1
1120	1120	320	311	615
1250	1250	454	454	588
11080	11080	8725	8617	9827
MFM	MFM	MFM	MFM	MFM
3248	3248	3443	3443	3600
Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor
Embedded	Embedded	Embedded	Embedded	
40	40	40	40	65
9.2	9.2	8.7	8.7	8.3
49.2	49.2	48.7	48.7	73.3
625	625	625	625	625
1990	1987	1986	1986	9/88
				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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID 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					

## 1990 DISK/TREND REPORT



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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID 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	21185 BPI	21231 BPI	31846 BPI	21231 BPI
Recording code	14123 FCI 2,7 RLL	14123 FCI 2,7 RLL	14154 FCI 2,7 RLL	21230 FCI 2,7 RLL	14154 FCI 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	130 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	40 mm ID	40 mm ID	40 mm ID	40 mm ID	40 mm ID
	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	31846 BPI	31846 BPI
Recording code	2,7 RLL	2,7 RLL	21230 FCI	21230 FCI	21230 FCI
Rotational speed (RPM)	3600	3600	2,7 RLL	2,7 RLL	2,7 RLL
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			

## 1990 DISK/TREND REPORT

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					

## 1990 DISK/TREND REPORT

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	10/89
COMMENTS	25.4 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high

## 1990 DISK/TREND REPORT

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	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID 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	25406 BPI	14760 BPI	16896 BPI	17920 BPI
Recording code	16937 FCI 2,7 RLL	16937 FCI 2,7 RLL	9840 FCI 2,7 RLL*	11264 FCI 2,7 RLL	11946 FCI 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			

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT



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	210 mm OD	95 mm OD	95 mm OD	210 mm OD
Recording medium	25 mm ID Oxide Coated	100 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film	100 mm ID 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*	10000	27200 BPI	27200 BPI	14100 BPI
Recording code	13840 FCI 2,7 RLL	MFM	18133 FCI 2,7 RLL	18133 FCI 2,7 RLL	9400 FCI 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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Oxide Coated	25 mm ID 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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	130 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID 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	

## 1990 DISK/TREND REPORT

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	130 mm OD	130 mm OD	130 mm OD	230 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID 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	18759 BPI	19660 BPI	19660 BPI	21400 BPI
Recording code	13073 FCI 2,7 RLL	12506 FCI 2,7 RLL	13106 FCI 2,7 RLL	13106 FCI 2,7 RLL	14266 FCI 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	130 mm OD	230 mm OD	230 mm OD	230 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID 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	30760 BPI	18600 BPI	21400 BPI	21400 BPI
Recording code	23070 FCI 1,7 RLL	23070 FCI 1,7 RLL	12400 FCI 2,7 RLL	14266 FCI 2,7 RLL	14266 FCI 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	

## 1990 DISK/TREND REPORT



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	230 mm OD	230 mm OD	230 mm OD	230 mm OD
Recording medium	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID 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	21400 BPI	26800 BPI	26800 BPI	37800 BPI
Recording code	14266 FCI	14266 FCI	20100 FCI	20100 FCI	28350 FCI
	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	130 mm OD	230 mm OD	230 mm OD	230 mm OD
Recording medium	100 mm ID	40 mm ID	100 mm ID	100 mm ID	100 mm ID
	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	45850 BPI	26800 BPI	21400 BPI	26800 BPI
Recording code	14266 FCI	30567 FCI	20100 FCI	14266 FCI	20100 FCI
	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

## 1990 DISK/TREND REPORT

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	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Thin Film	63.5 mm ID 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 10800 FCI 2,7 RLL	16200 BPI 10800 FCI 2,7 RLL
Recording code					
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	200 mm OD	200 mm OD	200 mm OD	200 mm OD
	63.5 mm ID	63.5 mm ID	63.5 mm ID	63.5 mm ID	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	19800 BPI	20300 BPI	23300 BPI	23300 BPI
	13200 FCI	13200 FCI	13533 FCI	15533 FCI	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					

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	130 mm OD	130 mm OD
	63.5 mm ID	25 mm ID	25 mm ID	40 mm ID	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	38880 BPI	38880 BPI	32332 BPI	32332 BPI
	15933 FCI	29160 FCI	29160 FCI	24249 FCI	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 Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID
Recording medium					
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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	65 mm OD	65 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID Thin Film	20 mm ID Thin Film
DRIVE: Heads	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	29307 BPI	29307 BPI	38452 BPI	22500 BPI
Recording code	18150 FCI	19538 FCI	19538 FCI	25634 FCI	15000 FCI
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
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

## 1990 DISK/TREND REPORT



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	95 mm OD	95 mm OD	95 mm OD	65 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID 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	29307 BPI	29307 BPI	37724 BPI	46900 BPI
Recording code	14700 FCI	19538 FCI	19538 FCI	28293 FCI	35175 FCI
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	1,7 RLL	1,7 RLL
	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	95 mm OD	65 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID Thin Film	25 mm ID Thin Film	25 mm ID 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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID	25 mm ID	25 mm ID	25 mm ID	25 mm ID
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	30000 BPI	27746 BPI	30000 BPI	30000 BPI
Recording code	28293 FCI	22500 FCI	20810 FCI	22500 FCI	22500 FCI
Rotational speed (RPM)	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL	1,7 RLL
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	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high
	*Varies by zone	*Varies by zone	*Varies by zone	*Varies by zone	*Varies by zone
	Ramp loaded heads				

## 1990 DISK/TREND REPORT

## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

QUANTUM	QUANTUM	QUANTUM	QUANTUM	RICOH
330AT ProDrive	330S ProDrive	425AT ProDrive	425S ProDrive	RH5130
7	7	8	8	1
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	5.25" Cartridge
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	130 mm OD 40 mm ID Oxide Coated
Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
PC AT	SCSI	PC AT	SCSI	ST412
F: 331.2	F: 331.2	F: 425.8	F: 425.8	--
--	--	--	--	U: 12.75
*	*	*	*	U: 10,416
7	7	9	9	2
1	1	1	1	1
1511	1512	1511	1512	612
1695	1695	1695	1695	612
36923 BPI 27692 FCI 1,7 RLL	36923 BPI 27692 FCI 1,7 RLL	36923 BPI 27692 FCI 1,7 RLL	36923 BPI 27692 FCI 1,7 RLL	10894 MFM
3600	3600	3600	3600	3473
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Embedded
14**	14**	14**	14**	98 (including settling)
8.3	8.3	8.3	8.3	8.6
22.3	22.3	22.3	22.3	106.6
4000 max.	5000 max.	4000 max.	5000 max.	625
--	--	--	--	3Q85
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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	25804 BPI	23875 BPI	26731 BPI	24763 BPI
Recording code	16508 FCI	17202 FCI	15916 FCI	17820 FCI	16508 FCI
	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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	25805 BPI	31884 BPI	31884 BPI	25804 BPI
Recording code	17202 FCI	17202 FCI	23913 FCI	23913 FCI	17202 FCI
	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	1989
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high	25.4 mm high	41.3 mm high
	*Varies by zone	*Varies by zone	*Varies by zone	*Varies by zone	*Varies by zone

## 1990 DISK/TREND REPORT



## MANUFACTURER

## DRIVE

## DISK/TREND GROUP

## MARKET

## MEDIA: Generic type

Nominal disk diameter

Recording medium

## DRIVE: Heads

Interface

## CAPACITY/RECORDING DENSITY

Total capacity (Mbytes) FIXED

REMOVABLE

Capacity per track (Bytes)

Data surfaces per spindle

Heads per data surface

Tracks per surface

Track density (TPI)

Maximum linear density (BPI)

Recording code

Rotational speed (RPM)

## PERFORMANCE

Actuator type

Servo type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

## FIRST CUSTOMER SHIPMENT

## COMMENTS

RODIME	RODIME	RODIME	RODIME	SAGEM
R03259TP	R03259TS	R03414T	R03534T	MSA 252-50
6	6	7	8	4
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Special
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Thin Film	130 mm OD 40 mm ID Thin Film
Ferrite	Ferrite	MIG	MIG	Ferrite
SCSI	SCSI	SCSI	SCSI	SCSI
F: 210.02	F: 210.02	F: 331	F: 426	--
--	--	--	--	F: 50
*	*	F:	*	F: 23,040
9	9	7	9	4
1	1	1	1	1
1216	1216	1635	1568	720
1700	1700	1800	1800	950
26731 BPI 17820 FCI 2,7 RLL	25804 BPI 17202 FCI 2,7 RLL	38000 BPI 28500 FCI 1,7 RLL	38000 BPI 28500 FCI 1,7 RLL	19680 BPI 14760 FCI 1,7 RLL
3600	3600	3600	3600	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.	Dedicated Surf.
18	18	14	14	17
8.3	8.3	8.3	8.3	8.3
26.3	26.3	22.3	22.3	25.3
1500	1500	2500	2500	1500
1990	1989	4/91	1990	10/90
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	

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID 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

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	22762 BPI	20400 BPI	20400 BPI	14953
Recording code	15175 FCI	15175 FCI	13600 FCI	13600 FCI	MFM
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	
PERFORMANCE	3600	3600	3528	3528	3600
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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID	25 mm ID	25 mm ID	25 mm ID	25 mm ID
	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	22430 BPI	22430 BPI	14108	20280 BPI
Recording code	14953 FCI	14953 FCI	14953 FCI	MFM	13520 FCI
	2,7 RLL	2,7 RLL	2,7 RLL*		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

## 1990 DISK/TREND REPORT

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	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID 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	22430 BPI	14740 BPI	18897 BPI	9935
Recording code	14953 FCI 2,7 RLL	14953 FCI 2,7 RLL*	9827 FCI 2,7 RLL*	12598 FCI 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

## 1990 DISK/TREND REPORT



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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID	25 mm ID	25 mm ID	25 mm ID	25 mm ID
	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	20400 BPI	20400 BPI	19893 BPI
Recording code	MFM	13262 FCI	13600 FCI	13600 FCI	13262 FCI
		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	41.3 mm high	41.3 mm high
			*Varies by zone	*Varies by zone	

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

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	22638 BPI	22638 BPI	28103 BPI	28103 BPI
Recording code	18735 FCI	15092 FCI	15092 FCI	18735 FCI	18735 FCI
Rotational speed (RPM)	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL
	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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	20400 BPI	21030 BPI	22638 BPI	22638 BPI
Recording code	13600 FCI 2,7 RLL	13600 FCI 2,7 RLL	14020 FCI 2,7 RLL	15092 FCI 2,7 RLL	15092 FCI 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

# 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	29000 BPI	28103 BPI	28103 BPI	28103 BPI
Recording code	19333 FCI	19333 FCI	18735 FCI	18735 FCI	18735 FCI
	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	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film	40 mm ID Thin Film	40 mm ID 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	28103 BPI	19058 BPI	19058 BPI	19213 BPI
Recording code	18735 FCI	18735 FCI	12705 FCI	12705 FCI	12808 FCI
	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

## 1990 DISK/TREND REPORT



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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film	40 mm ID 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	21132 FCI
				2,7 RLL	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		

## 1990 DISK/TREND REPORT

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	130 mm OD	230 mm OD	210 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID 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	19600 BPI	10000	15185 BPI	31674 BPI
Recording code	14666 FCI	13066 FCI	MFM	10123 FCI	21116 FCI
	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	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	

## 1990 DISK/TREND REPORT

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	210 mm OD	210 mm OD	130 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID 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	14981 BPI	19816 BPI	32750 BPI	33344 BPI
Recording code	13210 FCI 2,7 RLL	9987 FCI 2,7 RLL	13210 FCI 2,7 RLL	24562 FCI 1,7 RLL	22229 FCI 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	

## 1990 DISK/TREND REPORT



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	210 mm OD	210 mm OD	210 mm OD	210 mm OD
Recording medium	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID 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	24200 BPI	25409 BPI	32202 BPI	32202 BPI
Recording code	14658 FCI	16133 FCI	16939 FCI	24151 FCI	24151 FCI
	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	200 mm OD	200 mm OD	200 mm OD	95 mm OD
Recording medium	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	25 mm ID 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 2,7 RLL
Recording code	MFM	MFM	MFM	MFM	
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

## 1990 DISK/TREND REPORT

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			Subsystem: 10,080 to 30,240 in 2.52 increments		
Total capacity (Mbytes) FIXED	F: 1,260	F: 1,260		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 10160 FCI	15240 BPI 10160 FCI	15240 BPI 10160 FCI	*	15240 BPI 10160 FCI
Recording code	2,7 RLL	2,7 RLL	2,7 RLL	2,7 RLL	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

## 1990 DISK/TREND REPORT

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

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID 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	13600	9383	18766 BPI	18766 BPI
Recording code	18962 FCI 2,7 RLL	MFM	MFM	12510 FCI 2,7 RLL	12510 FCI 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			

## 1990 DISK/TREND REPORT

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	95 mm OD	95 mm OD	210 mm OD	130 mm OD
Recording medium	100 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film	100 mm ID Oxide Coated	40 mm ID 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	28443 BPI	28443 BPI	19300 BPI	32200 BPI
Recording code	6000 FCI 2,7 RLL	18962 FCI 2,7 RLL	18962 FCI 2,7 RLL	12867 FCI 2,7 RLL	24150 FCI 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					

## 1990 DISK/TREND REPORT



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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	22175 BPI	21278 BPI	22175 BPI	22175 BPI
Recording code	14783 FCI	14783 FCI	14185 FCI	14783 FCI	14783 FCI
	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	95 mm OD	65 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	20 mm ID Thin Film	25 mm ID Thin Film	25 mm ID 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	21278 BPI	35970 BPI	31576 BPI	31576 BPI
Recording code	14783 FCI	14185 FCI	23980 FCI	21057 FCI	21057 FCI
	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

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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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID	25 mm ID	25 mm ID	25 mm ID	25 mm ID
	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	22391 BPI	32513 BPI	34750 BPI	34750 BPI
Recording code	28006 FCI	14927 FCI	21675 FCI	23166 FCI	23166 FCI
	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

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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	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	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	32513 BPI	32513 BPI	32513 BPI	34750 BPI
Recording code	14927 FCI 2,7 RLL	21675 FCI 2,7 RLL	21675 FCI 2,7 RLL	21675 FCI 2,7 RLL	23166 FCI 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

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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	95 mm OD	95 mm OD	95 mm OD	
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	
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	20600 BPI	22000 BPI	27500 BPI	
Recording code	23166 FCI 2,7 RLL	13733 FCI 2,7 RLL	14667 FCI 2,7 RLL	18333 FCI 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	

## 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.

<u>Country</u>	<u>Currency</u>	<u>Currency units per U.S. dollar</u>
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

## **1990 DISK/TREND REPORT**

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,

## 1990 DISK/TREND REPORT

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	Net income: (\$119,730,000)
	(FY ending 9/30/89)	

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

## 1990 DISK/TREND REPORT

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.

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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.

## 1990 DISK/TREND REPORT

MAXTOR CORPORATION  
150 River Oaks Parkway  
San Jose, CA 95134

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

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

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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	Net income: (\$25,400,000)
(FY ending 6/30/89)	

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-

## 1990 DISK/TREND REPORT

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                      Net income: \$47,212,000  
(FY ending 3/31/90)

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 sales: \$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

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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

Net income: \$34,300,000

(FY ending 6/30/89)

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                      Net income: (\$2,615,000)  
(FY ending 1/31/90)

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.

## 1990 DISK/TREND REPORT



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	Net income: (\$41,484,000)
(FY ending 9/30/89)	

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	Net income: \$838,830,000
	(FY ending 9/30/89)	

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 Informationssysteme 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.

# 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 XYY.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.

## **1990 DISK/TREND REPORT**

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:

- o 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.
- o 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.
- o 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 /DQEO command. Similarly, it is possible to extend the input range to add more products, but be sure you move the output range so that there is no overlap.

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

- o There are other 'pop-up' programs resident in the memory of your computer. These should be removed.
- o You have selected too large an output range. Use a smaller output range or delete some of the columns that contain data not relevant to your analysis. If you delete data, be sure that if you save your spreadsheet you use a different file name, otherwise you will overwrite the original file with the modified spreadsheet.
- o If you receive a memory overflow message while loading the data base, the data base is too large for your computer's available memory. You probably will have to remove other resident programs and reload Lotus 1-2-3 and the data base. If your computer doesn't have 640K memory, you will probably get this message.

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.