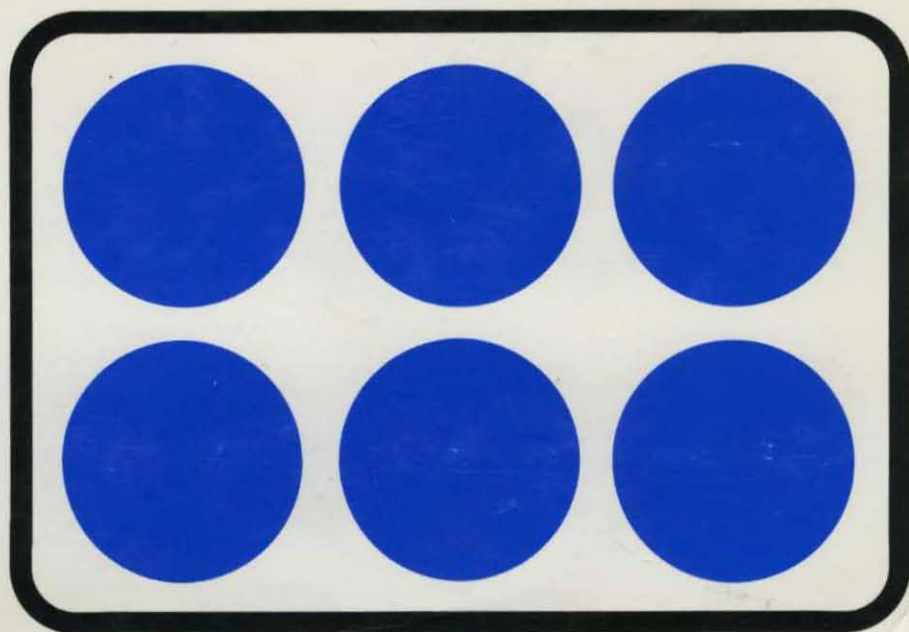


## 1989 DISK/TREND<sup>®</sup> REPORT

RIGID  
DISK  
DRIVES



# 1989 DISK/TREND<sup>®</sup> REPORT

RIGID DISK DRIVES

October, 1989

DISK/TREND, Inc.  
1925 Landings Drive  
Mountain View, California 94043

Telephone: 415/961-6209  
Facsimile: 415/969-2560  
Telex: 171914

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## FOREWORD

This year's DISK/TREND Report counts 58 companies in the rigid disk drive business, five less than a year ago, so the industry's long-term trend toward consolidation seems to have resumed.

U.S. firms still generate three quarters of the industry's revenues, despite the well-publicized management and manufacturing problems a few of the companies experienced during the last year. Perhaps the most encouraging thought is that the free market system works very well for this industry: The companies which get to market early with significant new products do quite well, especially if they also know how to produce disk drives efficiently.

The DISK/TREND Report is now in its thirteenth year, and has been published in three volumes for the last few years. 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

### Changes in market channel definitions

Due to the growth in "aftermarket" distribution of drives in the personal computer market, we have made a change this year in some of our market channel definitions. 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.

We suggest that you read the complete description of these definitions included in definitions section of the report. Because market channel shipment data was organized differently in previous DISK/TREND Reports, it was not possible to show 1989 percentage change figures for PCM/Reseller and OEM/integrator channels in several tables.

### A new DISK/TREND feature: Shipments measured in terabytes

This year's DISK/TREND Report on Rigid Disk Drives includes information on the total capacity of all disk drives shipped. Capacities are measured in terabytes (one terabyte = one million megabytes), and the total capacities for worldwide shipments are shown at the bottom of all shipment tables included in the report:

- \* Summary section tables on total and OEM drives. Graphs displaying capacity shipment projections have also been included.
- \* Unit shipment summary tables in each product group.
- \* Disk diameter shipment breakdown tables in each product group.
- \* IBM and PCM fixed disk drives for mainframes, continuing our practice for several years of including capacity data in this table.

Please note that unformatted capacities are used in all tables above, since the DISK/TREND product groups are based on unformatted capacities for individual drives. The only exception is the table on shipments of IBM and PCM disk drives for mainframes, for which we have used formatted capacities in the past and are continuing to do so, for consistency. We will be interested in your comments on whether this information is useful in your planning activities, and whether it is displayed in the most useful way for your purposes.

SUMMARY: RIGID MAGNETIC DISK DRIVESIndustry size

The industry's long term growth is expected to continue for the five year span covered by this edition of the DISK/TREND Report, but the industry also continues to be a mixture of winners and losers. The industry has more than enough capacity to make the larger diameter drives, the slower drives, and the lower capacity drives for which demand is shrinking. But the growth segments of the market want smaller physical size, faster access and higher capacities, and the industry's growth companies have been adept at sensing the direction of the market and establishing volume production early in the game.

The continuing pattern of abrupt product mix changes makes it difficult for the industry to maintain a smooth growth curve. 1988's worldwide revenues for all rigid disk drives were \$20.4 billion, up 23%, but the expected revenues for 1989 will be only 9.5% higher, at \$22.3 billion. The forecasted 1990 revenues will be up more than 20%, but the 1992 increase will drop to barely 6%.

IBM's well advertised postponement this year of the new "Soquel" drive for mainframe systems, combined with model changeover disruption of low-end drive production, has provided the major dampening influence on this year's revenue growth.

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 the uneven pattern of forecasted growth shown on the tables in this year's DISK/TREND Report.

TABLE 1  
 CONSOLIDATED WORLDWIDE REVENUES  
 RIGID MAGNETIC DISK DRIVES  
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	5,724.4	8,853.5	5,826.2	9,164.3	7,485.8	11,578.8	9,384.4	14,138.8	9,419.5	14,783.0
Other U.S. Captive	970.2	1,715.1	1,067.5	1,935.9	1,439.7	2,472.1	1,582.6	2,669.5	1,700.1	2,905.4
<b>TOTAL U.S. CAPTIVE</b>	<b>6,694.6</b>	<b>10,568.6</b>	<b>6,893.7</b>	<b>11,100.2</b>	<b>8,925.5</b>	<b>14,050.9</b>	<b>10,967.0</b>	<b>16,808.3</b>	<b>11,119.6</b>	<b>17,688.4</b>
PCM/Reseller	1,122.4	1,764.4	1,302.8	1,859.1	1,226.5	1,670.6	1,242.2	1,694.0	1,341.7	1,846.3
OEM/Integrator	2,092.7	3,124.5	2,531.8	3,606.1 <sup>3.2</sup>	3,315.9	4,512.2	3,779.2	5,157.0	3,881.6	5,461.3
<b>TOTAL U.S. NON-CAPTIVE</b>	<b>3,215.1</b>	<b>4,888.9</b>	<b>3,834.6</b>	<b>5,465.2<sup>10.75</sup></b>	<b>4,542.4</b>	<b>6,182.8</b>	<b>5,021.4</b>	<b>6,851.0</b>	<b>5,223.3</b>	<b>7,307.6</b>
<b>TOTAL U.S. REVENUES</b>	<b>9,909.7</b>	<b>15,457.5</b>	<b>10,728.3</b>	<b>16,565.4</b>	<b>13,467.9</b>	<b>20,233.7</b>	<b>15,988.4</b>	<b>23,659.3</b>	<b>16,342.9</b>	<b>24,996.0</b>
7.9										
<b>Non-U.S. Manufacturers</b>										
Captive	145.5	2,439.1	298.4	2,754.0	379.3	3,069.5	503.7	3,037.6	588.5	3,049.3
PCM/Reseller	296.8	690.6	440.4	874.9	569.7	1,063.4	502.1	896.2	662.5	1,114.3
OEM/Integrator	564.8	1,836.8	751.8	2,161.8 <sup>4.2</sup>	961.9	2,502.6	1,179.3	2,882.7	1,415.8	3,189.2
<b>TOTAL NON-U.S. REVENUES</b>	<b>1,007.1</b>	<b>4,966.5</b>	<b>1,490.6</b>	<b>5,790.7<sup>14.0</sup></b>	<b>1,910.9</b>	<b>6,635.5</b>	<b>2,185.1</b>	<b>6,816.5</b>	<b>2,666.8</b>	<b>7,352.8</b>
7.0										
<b>Worldwide Recap</b>										
<b>TOTAL WORLDWIDE REVENUES</b>	<b>10,916.8</b>	<b>20,424.0</b>	<b>12,218.9</b>	<b>22,356.1<sup>14.9</sup></b>	<b>15,378.8</b>	<b>26,869.2</b>	<b>18,173.5</b>	<b>30,475.8</b>	<b>19,009.7</b>	<b>32,348.8</b>

### Marketing channels

As expected, last year's slight increase in the number of disk drive manufacturers was only a temporary phenomenon. This edition of the DISK/TREND Report lists 58 companies now in production or with announced products, compared with the 63 included last year.

31 U.S. disk drive manufacturers are now listed, after deleting four companies no longer in drive production. None of the deleted firms had made shipments which were statistically significant. The net increase for the list of 22 Asian manufacturers was two, including Sony, a company widely expected to become a major industry participant. The number of European manufacturers now producing rigid disk drives is now only 5, down three from last year. Nixdorf and Newbury Data stopped rigid disk drive production in 1989, and Lexikon's disk drive product line was displaced by the joint venture of its parent company, Olivetti, and Conner Peripherals.

Users of the DISK/TREND Report should note that 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.

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. An approximation of the OEM value of typical captive drives can be obtained by dividing captive revenues for most types of drives by a factor of 4 to 5.

TABLE 2  
 CONSOLIDATED WORLDWIDE REVENUES  
 RIGID MAGNETIC DISK DRIVES  
 MARKET CLASS REVIEW  
 REVENUE SUMMARY

WORLDWIDE REVENUES BY MANUFACTURER TYPE	-----1988-----		-----Forecast-----							
	-----Revenues-----		-----1989-----		-----1990-----		-----1991-----		-----1992-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
<b>U.S. Manufacturers</b>										
IBM Captive	8,853.5	43.3%	9,164.3	40.9%	11,578.8	43.0%	14,138.8	46.3%	14,783.0	45.6%
	+31.6%		+3.5%		+26.3%		+22.1%		+4.6%	
Other U.S. Captive	1,715.1	8.3%	1,935.9	8.6%	2,472.1	9.2%	2,669.5	8.7%	2,905.4	8.9%
	+18.6%		+12.9%		+27.7%		+8.0%		+8.8%	
PCM/Reseller	1,764.4	8.6%	1,859.1	8.3%	1,670.6	6.2%	1,694.0	5.5%	1,846.3	5.7%
	--		+5.4%		-10.1%		+1.4%		+9.0%	
OEM/Integrator	3,124.5	15.2%	3,606.1	16.1%	4,512.2	16.7%	5,157.0	16.9%	5,461.3	16.8%
	--		+15.4%		+25.1%		+14.3%		+5.9%	
<b>Total U.S. Manufacturers</b>	<b>15,457.5</b>	<b>75.4%</b>	<b>16,565.4</b>	<b>73.9%</b>	<b>20,233.7</b>	<b>75.1%</b>	<b>23,659.3</b>	<b>77.4%</b>	<b>24,996.0</b>	<b>77.0%</b>
	+27.9%		+7.2%		+22.1%		+16.9%		+5.6%	
<b>Non-U.S. Manufacturers</b>										
Captive	2,439.1	11.9%	2,754.0	12.3%	3,069.5	11.4%	3,037.6	9.9%	3,049.3	9.4%
	+7.7%		+12.9%		+11.5%		-1.0%		+4.4%	
PCM/Reseller	690.6	3.3%	874.9	3.9%	1,063.4	3.9%	896.2	2.9%	1,114.3	3.4%
	--		+26.7%		+21.5%		-15.7%		+24.3%	
OEM/Integrator	1,836.8	9.4%	2,161.8	9.9%	2,502.6	9.6%	2,882.7	9.8%	3,189.2	10.2%
	--		+17.7%		+15.8%		+15.2%		+10.6%	
<b>Total Non-U.S. Manufacturers</b>	<b>4,966.5</b>	<b>24.6%</b>	<b>5,790.7</b>	<b>26.1%</b>	<b>6,635.5</b>	<b>24.9%</b>	<b>6,816.5</b>	<b>22.6%</b>	<b>7,352.8</b>	<b>23.0%</b>
	+9.8%		+16.6%		+14.6%		+2.7%		+7.9%	
<b>Worldwide Recap</b>										
Captive	13,007.7	63.7%	13,854.2	62.0%	17,120.4	63.7%	19,845.9	65.1%	20,737.7	64.1%
	+22.8%		+6.5%		+23.6%		+15.9%		+4.5%	
PCM/Reseller	2,455.0	12.0%	2,734.0	12.2%	2,734.0	10.2%	2,590.2	8.5%	2,960.6	9.2%
	--		+11.4%		--		-5.3%		+14.3%	
OEM/Integrator	4,961.3	24.3%	5,767.9	25.8%	7,014.8	26.1%	8,039.7	26.4%	8,650.5	26.7%
	--		+16.3%		+21.6%		+14.6%		+7.6%	
<b>Total All Manufacturers</b>	<b>20,424.0</b>	<b>100.0%</b>	<b>22,356.1</b>	<b>100.0%</b>	<b>26,869.2</b>	<b>100.0%</b>	<b>30,475.8</b>	<b>100.0%</b>	<b>32,348.8</b>	<b>100.0%</b>
	+23.0%		+9.5%		+20.2%		+13.4%		+6.1%	

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

### Product mix

The tide has turned for the low-end fixed disk drives which provided so much of the industry's growth in unit shipments for several years. Shipments of fixed disk drives less than 30 megabytes peaked in 1988 at 7.9 million drives and are expected to decline to 4 million drives in 1992, with a corresponding drop in terabytes shipped each year.

The main application for low-end drives is the personal computer market, and while there is enough overall growth in PCs to sustain significant shipments for this group, higher capacity drives are faring better, due to greater software complexity and heightened user sophistication.

Other groups of fixed disk drives are expected to continue a healthy growth pattern through 1992. In 1989, shipment leadership has passed to the 30-60 megabyte range, stimulated by rapidly growing sales of 286/386 personal computers. This product group is expected to remain the largest of all DISK/TREND groups in unit shipments, with 12.3 million units forecasted for 1992.

Underlying the growth in total unit shipments for all product groups below 500 megabytes is the vitality of the industry's 3.5" product lines. Within these capacity levels, 3.5" will have captured the lead in all product groups by 1992.

However, it should not be forgotten that high-end drives provide a major part of the industry's revenues -- with drives over 500 megabytes expected to generate over half of the total revenues through 1992 and almost half of the total drive capacity shipped during the same period. In these product groups, 5.25" drives will be the shipment leaders within a few years, and a byproduct of that development will be slower revenue growth, due to the lower average prices the smaller drives will command.

Figure 1

# CHANGING PRODUCT MIX

## Worldwide Rigid Disk Drive Revenue

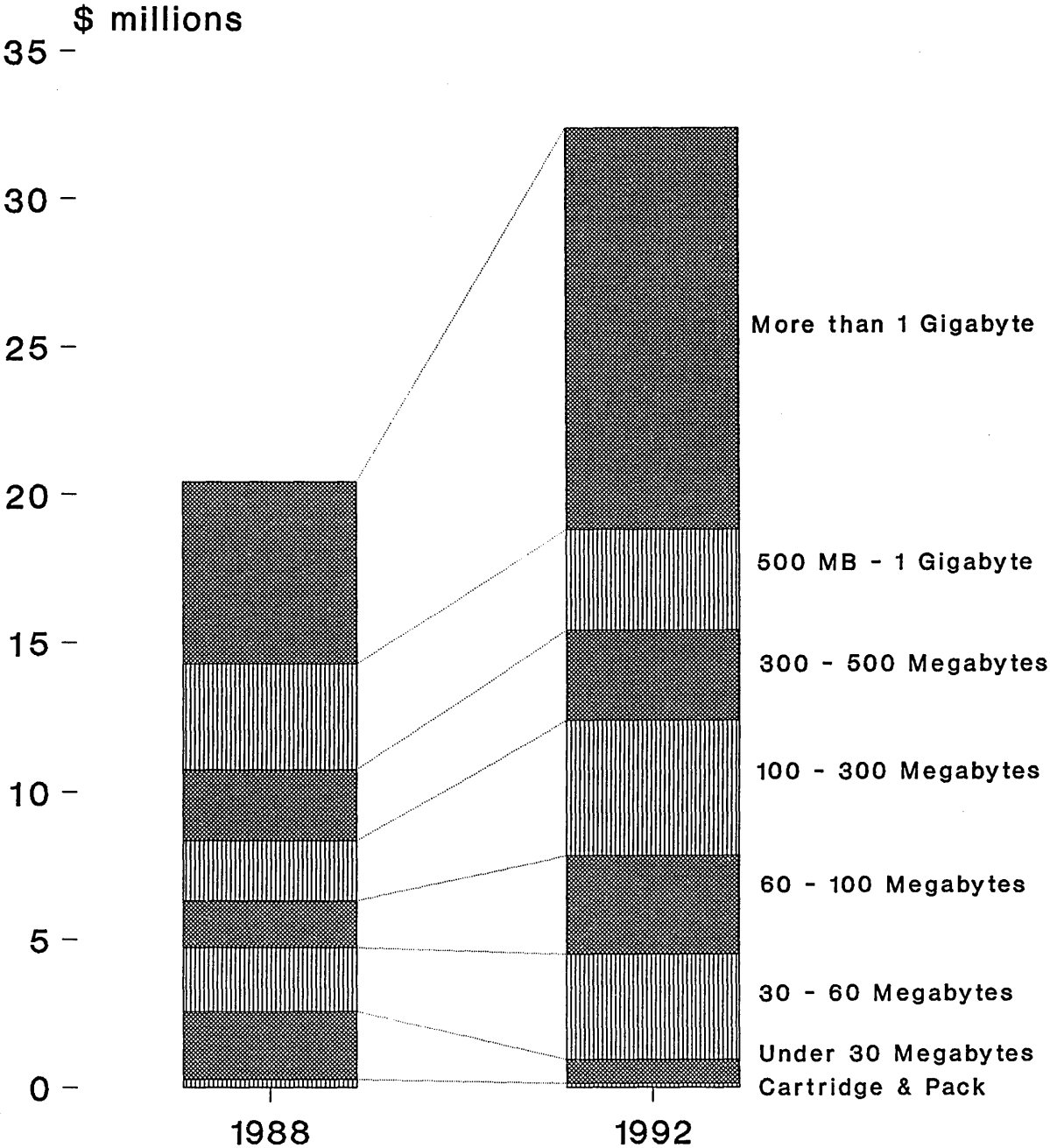




TABLE 3  
 CONSOLIDATED WORLDWIDE REVENUES  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	-----1988-----		-----Forecast-----							
	Revenues		1989		1990		1991		1992	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
DISK CARTRIDGE DRIVES	67.5 -39.8%	.3%	65.4 -3.1%	.3%	70.8 +8.3%	.3%	76.5 +8.1%	.3%	74.8 -2.2%	.2%
DISK PACK DRIVES	194.7 -28.7%	1.0%	120.2 -38.3%	.5%	86.8 -27.8%	.3%	53.3 -38.6%	.2%	40.0 -25.0%	.1%
FIXED DISK DRIVES less than 30 Megabytes	2,274.1 +1.0%	11.1%	1,712.4 -24.7%	7.7%	1,385.1 -19.1%	5.2%	1,082.7 -21.8%	3.6%	800.9 -26.0%	2.5%
FIXED DISK DRIVES 30 - 60 Megabytes	2,178.9 +10.7%	10.7%	2,908.1 +33.5%	13.0%	3,365.3 +15.7%	12.5%	3,574.4 +6.2%	11.7%	3,570.1 --	11.0%
FIXED DISK DRIVES 60-100 Megabytes	1,592.4 +38.3%	7.8%	1,672.4 +5.0%	7.5%	2,156.6 +29.0%	8.0%	2,785.3 +29.2%	9.1%	3,348.5 +20.2%	10.4%
FIXED DISK DRIVES 100 - 300 Megabytes	2,031.0 +50.4%	9.9%	2,314.9 +14.0%	10.4%	2,842.1 +22.8%	10.6%	3,607.5 +26.9%	11.8%	4,556.1 +26.3%	14.1%
FIXED DISK DRIVES 300 - 500 Megabytes	2,404.8 +18.2%	11.8%	2,505.1 +4.2%	11.2%	2,805.2 +12.0%	10.4%	2,914.0 +3.9%	9.6%	3,024.6 +3.8%	9.3%
FIXED DISK DRIVES 500 Megabytes to 1 GB	3,539.5 +46.6%	17.3%	3,847.4 +8.7%	17.2%	4,120.5 +7.1%	15.3%	3,826.0 -7.1%	12.6%	3,398.8 -11.2%	10.5%
FIXED DISK DRIVES more than 1 Gigabyte	6,141.1 +21.5%	30.1%	7,210.2 +17.4%	32.2%	10,036.8 +39.2%	37.4%	12,556.1 +25.1%	41.1%	13,535.0 +7.8%	41.8%
Total Worldwide Revenue	20,424.0 +23.0%	100.0%	22,356.1 +9.5%	100.0%	26,869.2 +20.2%	100.0%	30,475.8 +13.4%	100.0%	32,348.8 +6.1%	100.0%
% U.S. Mfg.	75.6%		74.0%		75.3%		77.6%		77.2%	

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

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

UNIT SHIPMENTS IN THOUSANDS	-----1988-----		-----Forecast-----							
	---Shipments---		-----1989-----		-----1990-----		-----1991-----		-----1992-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
DISK CARTRIDGE DRIVES	65.7 -27.7%	.4%	112.1 +70.6%	.5%	164.9 +47.1%	.7%	209.2 +26.9%	.7%	234.0 +11.9%	.7%
DISK PACK DRIVES	24.8 -26.6%	.1%	14.6 -41.1%	.1%	10.6 -27.4%	--	6.9 -34.9%	--	4.7 -31.9%	--
FIXED DISK DRIVES less than 30 Megabytes	7,946.6 +17.4%	44.7%	6,858.2 -13.7%	33.0%	6,105.0 -11.0%	24.6%	5,195.0 -14.9%	18.0%	4,095.0 -21.2%	12.5%
FIXED DISK DRIVES 30 - 60 Megabytes	5,839.7 +40.8%	32.9%	8,227.7 +40.9%	39.5%	10,035.0 +22.0%	40.4%	11,440.0 +14.0%	39.5%	12,360.0 +8.0%	37.7%
FIXED DISK DRIVES 60-100 Megabytes	1,669.4 +59.9%	9.4%	2,202.8 +32.0%	10.6%	3,414.5 +55.0%	13.7%	4,920.0 +44.1%	17.0%	6,540.0 +32.9%	20.0%
FIXED DISK DRIVES 100 - 300 Megabytes	1,176.2 +122.4%	6.6%	1,888.7 +60.6%	9.1%	2,815.0 +49.0%	11.3%	3,995.0 +41.9%	13.8%	5,550.0 +38.9%	16.9%
FIXED DISK DRIVES 300 - 500 Megabytes	550.2 +129.1%	3.1%	804.2 +46.2%	3.9%	1,165.7 +45.0%	4.7%	1,510.0 +29.5%	5.2%	1,815.0 +20.2%	5.5%
FIXED DISK DRIVES 500 Megabytes to 1 GB	303.5 +56.7%	1.7%	418.7 +38.0%	2.0%	680.0 +62.4%	2.7%	910.0 +33.8%	3.1%	1,118.0 +22.9%	3.4%
FIXED DISK DRIVES more than 1 Gigabyte	190.4 +32.5%	1.1%	276.8 +45.4%	1.3%	458.4 +65.6%	1.8%	745.0 +62.5%	2.6%	1,060.0 +42.3%	3.2%
Total Worldwide Shipments	17,766.5 +34.7%	100.0%	20,803.8 +17.1%	100.0%	24,849.1 +19.4%	100.0%	28,931.1 +16.4%	100.0%	32,776.7 +13.3%	100.0%
% U.S. Mfg.	81.8%		80.0%		76.2%		72.9%		69.7%	
Total Capacity (Terabytes)	1,769.9		2,337.1		3,341.3		4,529.8		5,840.2	

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

## 1989 DISK/TREND REPORT

Figure 2

# CAPACITY SHIPMENT SUMMARY

Worldwide Shipments in Terabytes

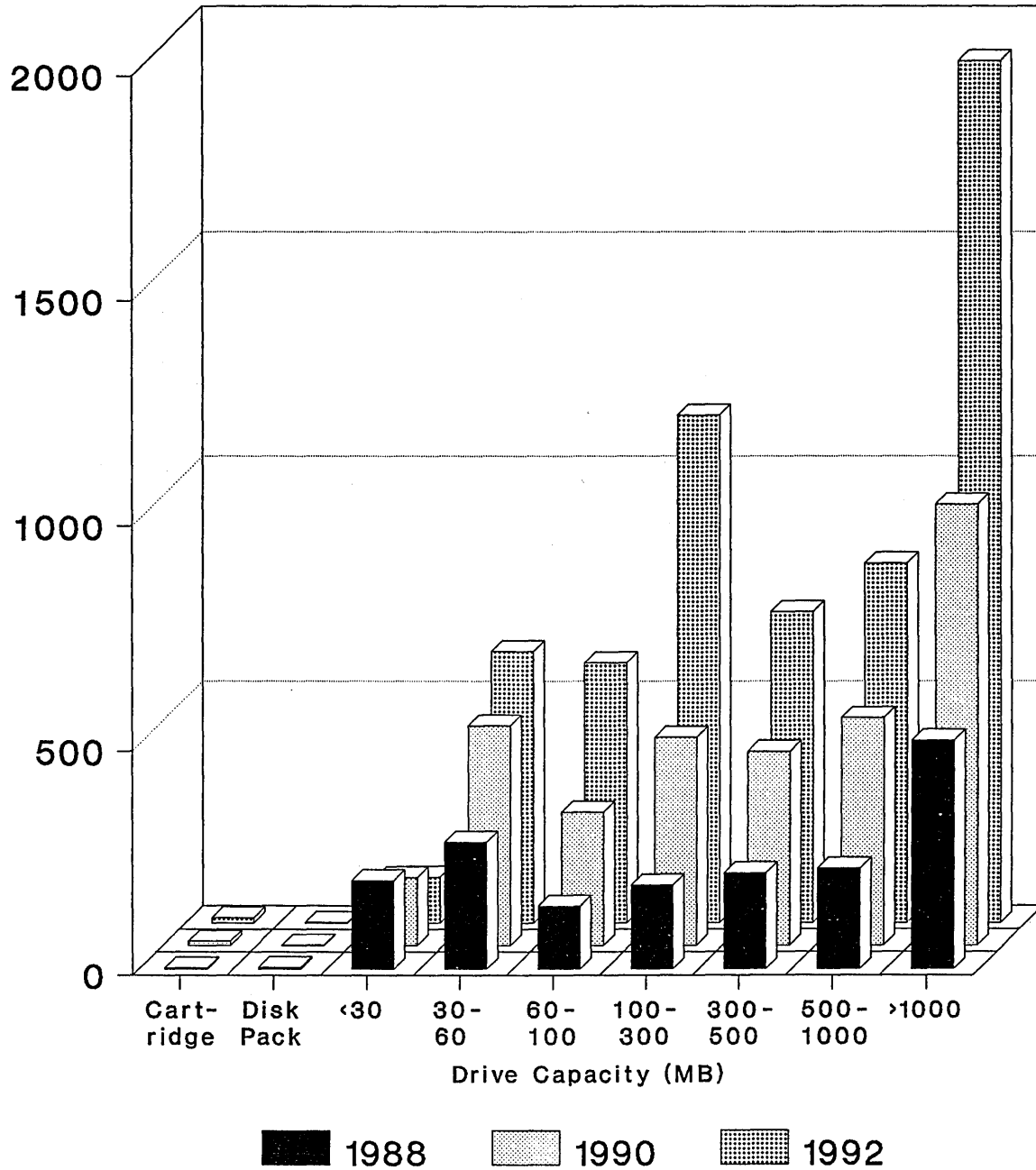


TABLE 5  
 CONSOLIDATED WORLDWIDE SHIPMENTS  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPMENTS IN TERABYTES	-----1988-----		-----Forecast-----							
	---Shipments---		-----1989-----		-----1990-----		-----1991-----		-----1992-----	
	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%	Tbytes	%
DISK CARTRIDGE DRIVES	1.8 +17.6%	.1%	4.7 +161.9%	.2%	7.6 +59.2%	.2%	10.3 +35.4%	.2%	11.5 +12.1%	.2%
DISK PACK DRIVES	4.0 -35.5%	.2%	2.3 -41.2%	.1%	1.9 -18.5%	.1%	1.0 -43.5%	--	.8 -21.8%	--
FIXED DISK DRIVES less than 30 Megabytes	198.4 +46.5%	11.2%	171.2 -13.7%	7.3%	152.6 -10.9%	4.6%	129.8 -14.9%	2.9%	102.3 -21.2%	1.8%
FIXED DISK DRIVES 30 - 60 Megabytes	283.8 +64.6%	16.0%	396.5 +39.7%	17.0%	490.0 +23.6%	14.7%	559.0 +14.1%	12.3%	605.0 +8.2%	10.4%
FIXED DISK DRIVES 60-100 Megabytes	140.9 +66.9%	8.0%	189.4 +34.4%	8.1%	297.9 +57.3%	8.9%	433.1 +45.4%	9.6%	579.8 +33.9%	9.9%
FIXED DISK DRIVES 100 - 300 Megabytes	189.0 +113.2%	10.7%	286.1 +51.4%	12.2%	465.1 +62.5%	13.9%	719.3 +54.7%	15.9%	1,128.3 +56.8%	19.3%
FIXED DISK DRIVES 300 - 500 Megabytes	215.3 +119.7%	12.2%	311.5 +44.7%	13.3%	434.5 +39.5%	13.0%	564.6 +29.9%	12.5%	694.1 +22.9%	11.9%
FIXED DISK DRIVES 500 Megabytes to 1 GB	225.4 +64.6%	12.7%	312.3 +38.6%	13.4%	508.4 +62.8%	15.2%	674.0 +32.6%	14.9%	801.0 +18.8%	13.7%
FIXED DISK DRIVES more than 1 Gigabyte	511.0 +51.5%	28.9%	662.7 +29.7%	28.4%	982.9 +48.3%	29.4%	1,438.3 +46.3%	31.7%	1,917.1 +33.3%	32.8%
Total Capacity (Terabytes)	1,769.9 +66.8%	100.0%	2,337.1 +32.0%	100.0%	3,341.3 +43.0%	100.0%	4,529.8 +35.6%	100.0%	5,840.2 +28.9%	100.0%
% U.S. Mfg.	77.4%		75.1%		75.0%		75.5%		75.0%	

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

OEM market

When using data from this year's DISK/TREND Report on OEM shipments and revenues, please note that changes have been made in market channel definitions. The previous "OEM" channel designation has been changed to "OEM/Integrator," and now includes only drives sold to traditional system manufacturers, plus sales to system integrators and value-added resellers which assemble complete systems. The previous "PCM" designation has been changed to "PCM/Reseller," and has been broadened to include 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. This section covers only drives sold in the "OEM/Integrator" market channel.

This year's DISK/TREND Report includes information on the storage capacity shipped each year, as measured in terabytes, and this data has provided some interesting insights on the OEM market. For example, the total capacity of 100-300 megabyte drives shipped each year in the 1990-92 period is expected to be greater than for any other fixed disk drive product group, even though unit shipment quantities will be higher for other groups. Of course, by 1992, the 100-300 megabyte group will also be the leader in OEM drive revenues, derived mostly from 3.5" drives.

The new capacity shipment data also highlights the growth of OEM shipments of drives with more than 1 gigabyte capacity, which will provide an estimated 23.7% of total capacity shipped for 1992. The forecasted rapid growth of 5.25" drives in this group will provide most of the momentum by 1992, with 65% of total unit shipments for the product group.

OEM drive producers have led the way in the industry's movement to drives with smaller disks, and no end is in sight. Starting with the

first shipment of the Seagate 5.25" 6 megabyte drive in 1980, OEM drive manufacturers have been pushing 5.25" drives into higher and higher capacity ranges, culminating with this year's introduction of drives with more than one gigabyte capacity, including a 5,400 RPM model.

The full size 5.25" form factor, in turn, lost shipment leadership to half high 5.25" drives in all fixed disk drive product groups below 300 megabytes, and the half high 5.25" drives have now passed leadership on to 3.5" models. After introduction in 1983, the rapid rise of 3.5" drives for personal computer applications has captured more than half of all unit shipments for drives below 300 megabytes, and the 3.5" format is expected to have a major impact on OEM drive shipments in the 300-500 megabyte range by 1992. Further proof of the vitality of this trend is found in the early shipments this year of OEM 2.5" drives, which are expected to provide almost half of OEM/Integrator fixed disk drive shipments below 30 megabytes by 1992.

The loss of OEM market share for United States disk drive manufacturers which was underway in the 1984-85 period was reversed in 1986-87. The reasons are probably found in the vigorous rate of new product introductions by U.S. manufacturers, primarily in small diameter disk drives, and in the dramatic movement in the dollar/yen exchange rate.

After holding over 80% of worldwide OEM disk drive unit shipments for many years, U.S. manufacturers dropped to 66.7% in 1985, but gained in 1986 and reached 78.4% in 1987. The U.S. percentage share of the OEM/Integrator market (which no longer includes PC aftermarket sales) is holding at 72.5% in 1988-89, but is expected to decline, as shipments of low-end drives by non-U.S. manufacturers to their domestic markets increases.

## **1989 DISK/TREND REPORT**

TABLE 6  
 OEM WORLDWIDE REVENUES  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 REVENUE SUMMARY

WORLDWIDE REVENUES ALL MANUFACTURERS	-----1988-----		-----Forecast-----							
	---Revenues---		-----1989-----		-----1990-----		-----1991-----		-----1992-----	
	\$M	%	\$M	%	\$M	%	\$M	%	\$M	%
DISK CARTRIDGE DRIVES	47.7 --	1.0%	51.1 +7.1%	.9%	56.4 +10.4%	.8%	60.9 +8.0%	.8%	59.5 -2.3%	.7%
DISK PACK DRIVES	129.5 --	2.6%	84.0 -35.1%	1.4%	66.0 -21.4%	.9%	48.5 -26.5%	.6%	36.8 -24.1%	.4%
FIXED DISK DRIVES less than 30 Megabytes	849.3 --	17.2%	690.5 -18.7%	12.1%	593.8 -14.0%	8.5%	478.6 -19.4%	5.9%	389.6 -18.6%	4.5%
FIXED DISK DRIVES 30 - 60 Megabytes	914.5 --	18.4%	1,310.0 +43.2%	22.7%	1,537.3 +17.4%	22.0%	1,707.9 +11.1%	21.4%	1,733.1 +1.5%	20.2%
FIXED DISK DRIVES 60-100 Megabytes	367.9 --	7.4%	452.6 +23.0%	7.9%	769.4 +70.0%	11.0%	1,057.9 +37.5%	13.1%	1,264.4 +19.5%	14.6%
FIXED DISK DRIVES 100 - 300 Megabytes	711.1 --	14.4%	900.4 +26.6%	15.6%	1,303.1 +44.7%	18.6%	1,784.9 +37.0%	22.2%	2,145.8 +20.2%	24.8%
FIXED DISK DRIVES 300 - 500 Megabytes	798.1 --	16.1%	874.9 +9.6%	15.2%	937.4 +7.1%	13.3%	1,059.2 +13.0%	13.2%	1,082.8 +2.2%	12.5%
FIXED DISK DRIVES 500 Megabytes to 1 GB	584.6 --	11.7%	607.9 +4.0%	10.5%	808.9 +33.1%	11.6%	810.1 --	10.1%	770.1 -4.9%	8.9%
FIXED DISK DRIVES more than 1 Gigabyte	558.6 --	11.2%	796.5 +42.6%	13.7%	942.5 +18.3%	13.3%	1,031.7 +9.5%	12.7%	1,168.4 +13.2%	13.4%
Total Worldwide Revenues	4,961.3 --	100.0%	5,767.9 +16.3%	100.0%	7,014.8 +21.6%	100.0%	8,039.7 +14.6%	100.0%	8,650.5 +7.6%	100.0%
% U.S. Mfg.	62.9%		62.5%		64.3%		64.1%		63.1%	

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

TABLE 7  
 OEM WORLDWIDE SHIPMENTS  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 UNIT SHIPMENT SUMMARY

UNIT SHIPMENTS IN THOUSANDS	-----1988-----		-----1989-----		-----1990-----		-----Forecast-----		-----1992-----	
	Units	%	Units	%	Units	%	Units	%	Units	%
DISK CARTRIDGE DRIVES	51.4	.6%	88.3	.8%	132.5	.9%	166.0	1.0%	183.0	1.0%
	--		+71.8%		+50.1%		+25.3%		+10.2%	
DISK PACK DRIVES	20.2	.2%	12.2	.1%	9.3	.1%	6.6	--	4.5	--
	--		-39.6%		-23.8%		-29.0%		-31.8%	
FIXED DISK DRIVES less than 30 Megabytes	4,016.9	45.7%	3,384.4	31.1%	3,323.0	23.5%	2,844.0	17.0%	2,410.0	12.8%
	--		-15.7%		-1.8%		-14.4%		-15.3%	
FIXED DISK DRIVES 30 - 60 Megabytes	2,840.0	32.2%	4,406.5	40.4%	5,785.0	40.8%	6,955.0	41.3%	7,693.0	40.4%
	--		+55.2%		+31.3%		+20.2%		+10.6%	
FIXED DISK DRIVES 60-100 Megabytes	607.1	6.9%	933.1	8.5%	1,707.5	12.0%	2,494.0	14.8%	3,165.0	16.7%
	--		+53.7%		+83.0%		+46.1%		+26.9%	
FIXED DISK DRIVES 100 - 300 Megabytes	728.7	8.3%	1,262.9	11.6%	2,003.1	14.2%	2,768.0	16.4%	3,585.0	18.8%
	--		+73.3%		+58.6%		+38.2%		+29.5%	
FIXED DISK DRIVES 300 - 500 Megabytes	361.2	4.1%	495.3	4.6%	621.5	4.3%	841.0	5.0%	987.0	5.2%
	--		+37.1%		+25.5%		+35.3%		+17.4%	
FIXED DISK DRIVES 500 Megabytes to 1 GB	141.1	1.6%	226.5	2.0%	415.0	3.0%	507.0	3.0%	591.0	3.1%
	--		+60.5%		+83.2%		+22.2%		+16.6%	
FIXED DISK DRIVES more than 1 Gigabyte	43.5	.4%	106.3	.9%	188.2	1.2%	271.8	1.5%	390.0	2.0%
	--		+144.4%		+77.0%		+44.4%		+43.5%	
Total Worldwide Shipments	8,810.1	100.0%	10,915.5	100.0%	14,185.1	100.0%	16,853.4	100.0%	19,008.5	100.0%
	--		+23.9%		+30.0%		+18.8%		+12.8%	
% U.S. Mfg.	72.5%		72.5%		69.4%		66.0%		62.9%	
Total Capacity (Terabytes)	707.6	100.0%	1,066.5	100.0%	1,707.6	100.0%	2,372.5	100.0%	3,093.3	100.0%

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



Figure 3

# CAPACITY SHIPMENT SUMMARY

## OEM Worldwide Shipments in Terabytes

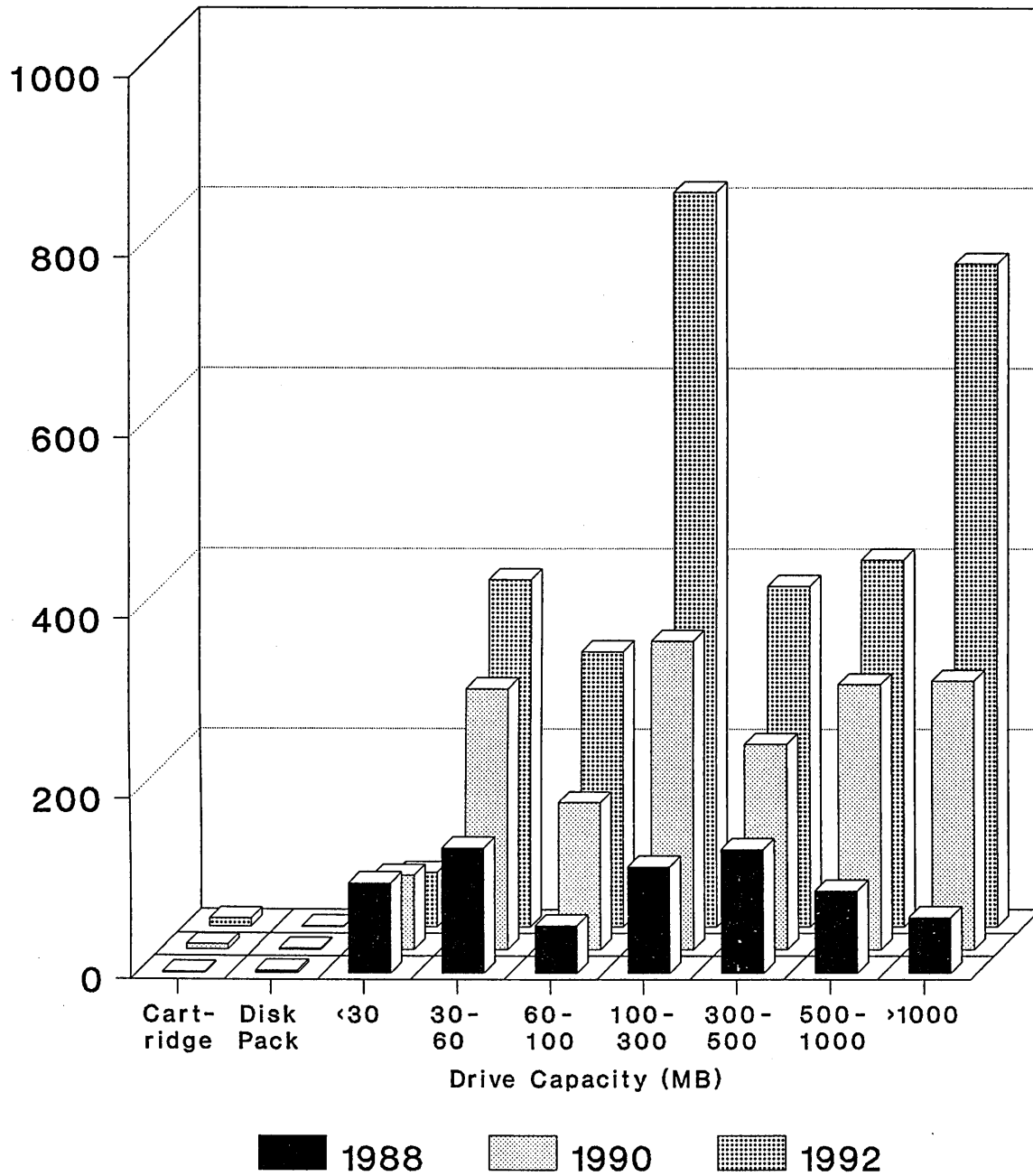


TABLE 8  
 OEM WORLDWIDE SHIPMENTS  
 RIGID DISK DRIVES  
 PRODUCT CATEGORY REVIEW  
 CAPACITY SHIPMENT SUMMARY

CAPACITY SHIPPED IN TERABYTES	-----1988-----		-----1989-----		-----1990-----		-----Forecast-----		-----1992-----	
	Capacity Units	%	Units	%	Units	%	Units	%	Units	%
DISK CARTRIDGE DRIVES	1.3 --	.2%	3.6 +168.8%	.3%	6.0 +63.0%	.4%	8.0 +34.3%	.3%	8.8 +10.3%	.3%
DISK PACK DRIVES	3.1 --	.4%	1.8 -42.0%	.2%	1.5 -18.5%	--	1.0 -29.1%	.1%	.8 -21.7%	--
FIXED DISK DRIVES less than 30 Megabytes	100.3 --	14.3%	84.5 -15.7%	7.9%	83.0 -1.7%	4.9%	71.1 -14.4%	3.0%	60.2 -15.3%	2.0%
FIXED DISK DRIVES 30 - 60 Megabytes	139.1 --	19.7%	214.8 +54.4%	20.3%	289.2 +34.6%	17.0%	347.7 +20.2%	14.7%	384.6 +10.6%	12.5%
FIXED DISK DRIVES 60-100 Megabytes	53.2 --	7.5%	86.6 +62.7%	8.1%	163.1 +88.3%	9.6%	240.0 +47.2%	10.2%	305.2 +27.2%	9.9%
FIXED DISK DRIVES 100 - 300 Megabytes	118.6 --	16.8%	191.5 +61.4%	18.0%	342.6 +78.9%	20.1%	531.8 +55.2%	22.4%	814.2 +53.1%	26.3%
FIXED DISK DRIVES 300 - 500 Megabytes	137.9 --	19.5%	190.6 +38.3%	17.9%	228.5 +19.9%	13.3%	311.2 +36.2%	13.1%	377.7 +21.4%	12.2%
FIXED DISK DRIVES 500 Megabytes to 1 GB	91.7 --	12.9%	157.3 +71.6%	14.7%	294.7 +87.3%	17.3%	363.1 +23.2%	15.3%	406.4 +11.9%	13.1%
FIXED DISK DRIVES more than 1 Gigabyte	62.0 --	8.7%	135.2 +118.0%	12.6%	298.6 +120.8%	17.4%	498.2 +66.8%	20.9%	735.0 +47.5%	23.7%
Total Capacity (Terabytes)	707.6 --	100.0%	1,066.5 +50.7%	100.0%	1,707.6 +60.1%	100.0%	2,372.5 +38.9%	100.0%	3,093.3 +30.4%	100.0%
% U.S. Mfg.		67.3%		67.0%		68.9%		68.2%		68.7%

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

TABLE 9  
1988 ESTIMATED MARKET SHARES  
WORLDWIDE REVENUES OF ALL RIGID MAGNETIC DISK DRIVES  
(Value of non-U.S. currencies estimated at average 1988 rates)

	CAPTIVE		PCM		OEM		TOTAL INDUSTRY	
	\$M	%	\$M	%	\$M	%	\$M	%
<b>U.S. MANUFACTURERS</b>								
Century Data	--	--	7.2	.3	36.7	.7	43.9	.2
Conner Peripherals	--	--	12.6	.5	241.2	4.9	253.8	1.2
Data General	106.8	.8	--	--	--	--	106.8	.5
Digital Equipment	906.8	7.0	--	--	--	--	906.8	4.4
Hewlett-Packard	407.1	3.1	1.1	--	12.4	.2	420.6	2.1
Ibis	--	--	--	--	49.5	1.0	49.5	.2
IBM	8,853.5	68.1	--	--	120.4	2.4	8,973.9	43.9
Imprimis	76.2	.6	5.3	.2	1,027.3	20.7	1,108.8	5.4
Maxtor	--	--	66.1	2.7	238.8	4.8	304.9	1.5
Memorex	--	--	94.4	3.8	--	--	94.4	.5
Micropolis	--	--	113.9	4.6	235.4	4.7	349.3	1.7
Microscience International	--	--	--	--	77.3	1.6	77.3	.4
Miniscribe	--	--	205.8	8.4	364.5	7.3	570.3	2.8
Plus Development	--	--	66.1	2.7	--	--	66.1	.3
Priam	--	--	34.8	1.4	81.8	1.6	116.6	.6
Quantum	--	--	17.3	.7	87.5	1.8	104.8	.5
Seagate Technology	--	--	945.0	38.5	401.6	8.1	1,346.6	6.6
Storage Technology	--	--	161.6	6.6	--	--	161.6	.8
Unisys	218.3	1.7	--	--	--	--	218.3	1.1
Western Digital	--	--	13.6	.6	117.8	2.4	131.4	.6
Other U.S.	--	--	19.6	.8	32.3	.7	51.8	.3
<b>U.S. Total</b>	<b>10,568.6</b>	<b>81.2</b>	<b>1,764.4</b>	<b>71.9</b>	<b>3,124.5</b>	<b>63.0</b>	<b>15,457.5</b>	<b>75.7</b>
<b>NON-U.S. MANUFACTURERS</b>								
Fuji Electric	--	--	--	--	36.9	.7	36.9	.2
Fujitsu	879.1	6.8	215.2	8.8	595.1	12.0	1,689.4	8.3
Hitachi	247.4	1.9	380.3	15.5	257.1	5.2	884.8	4.3
Isot	16.0	.1	--	--	215.6	4.3	231.6	1.1
JVC (Victor Company)	--	--	--	--	39.9	.8	39.9	.2
Kyocera	--	--	--	--	72.0	1.5	72.0	.4
Lexicon	44.4	.3	--	--	3.3	.1	47.7	.2
Mitsubishi	36.0	.3	20.3	.8	6.9	.1	63.2	.3
NEC	916.6	7.0	--	--	319.0	6.4	1,235.6	6.0
Nixdorf	78.0	.6	--	--	--	--	78.0	.4
Northern Telecom	33.5	.3	--	--	34.7	.7	68.2	.3
Rodime	--	--	45.0	1.8	84.2	1.7	129.2	.6
Seiko Epson	12.0	.1	--	--	12.6	.3	24.6	.1
Toshiba	160.8	1.2	1.4	.1	91.8	1.9	254.0	1.2
Other Non-U.S.	15.3	.1	28.4	1.2	67.7	1.4	111.4	.5
<b>Non-U.S. Total</b>	<b>2,439.1</b>	<b>18.8</b>	<b>690.6</b>	<b>28.1</b>	<b>1,836.8</b>	<b>37.0</b>	<b>4,966.5</b>	<b>24.3</b>
<b>WORLDWIDE TOTAL</b>	<b>13,007.7</b>	<b>100.0</b>	<b>2,455.0</b>	<b>100.0</b>	<b>4,961.3</b>	<b>100.0</b>	<b>20,424.0</b>	<b>100.0</b>

Note: 1. Drives sold in the PCM market by other than the original manufacturer are valued at PCM price levels 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"  
 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	O								14	
Areal Technology	O				2,3		3			
Cardiff Peripherals	O						3			
Century Data	P,O	8	14					8,14	8	8
Comport	O				3	3				
Conner Peripherals	O			3	3		3			
Data General	C							14	8,14	
DDC Pertec	O						8	8	8	8
Digital Equipment	C		14				5	5,14	14	8
DMA Technologies	O	5								
Hewlett-Packard	C,O			3		5	5	5,8	5,8	5
Ibis	O									14
IBM	C,O			3	3,5	3,5	3,5,8,14	3,5,8,14	8,14	14
Imprimis (Control Data)	O,C		8,14		5	5	3,5,8	5,8	5,8,14	5,8,14
Kalok	O			3	3	3				
Maxtor	O					5	3,5	5	5	5
MFM Technology	O	5								
Micropolis	O				5	5	5	5	5	5
Microscience International	O			3,5	3,5	3,5	3,5			
Miltope	O			5	5		3,5	5		
Miniscribe	O			3	3,5	5	5	5	5	
Northern Telecom	O						8	8	8	8
Plus Development	P,O			3	3					
PrairieTek	O			2	2					
Priam	O					5	5,8	5,8	5	
Quantum	O				3	3,5	3			
Seagate Technology	O			3,5	3,5	3,5	3,5			
Storage Technology	P,O									14
SyQuest Technology	P,O	3,5								
Unisys	C								14	14
Western Digital	P,O			3	3					
<b>Asian Manufacturers</b>										
Alps Electric	O			3	3					
Fuji Electric	O			3	3					
Fujitsu	C,P,O			3	3,5	5,8	3,5,8	5,8,10,14	5,8,10	8,10
Goldstar Telecommunication	C,O			3,5	3,5					
Hitachi	C,P,O			3,5	3,5,8	5,8	3,5,8	5,8	5,8,14	8,14
Hysung Computer	C,O					5	5			
JVC (Victor Company)	O			2,3	3					
Kyocera	O			3	3					
Magtron	P,O						5			
Matsushita Com. Ind.	O			3	3	3				
Mitsubishi Electric	C,O				3,5	5	3,5,8	8	8	
Mitsumi Electric	O			3						
NEC	C,O		14	3,5	3,5	5	3,5,8	5,8	5,8,14	8,14
Peripheral Technology	O				3	3				
Ricoh	C,O	5								
Samsung Electronics	C,O				3					
Seiko Epson	C,O			3	3	3				
Sony	C,O					3				
Teac	O			5	5					
Tokico	C,O				3	3				
Toshiba	C,O			3	3	3,5	3,5,8	5,8	5,8	
Y-E Data	O				3	3				
<b>European Manufacturers</b>										
ISOT	C,O	14	14	5,8				14		
Kovo	C,O		14							
Rodime	P,O			3	3	3,5	3,5			
Sagem	O			5	5		5			
Siemens	C,O						5	5	5	

TECHNICAL REVIEWCompeting technologies

Magnetic disk drive technology continues to advance, but the opportunities for indefinite expansion of areal density are disappearing as flying heights approach zero. It is a matter of when, rather than if, some of the technologies competing with magnetic disk drive technology achieve footholds in markets now dominated by magnetic rigid disk drives.

The serious contenders are:

- \* Optical disk drives
- \* Bubble memories
- \* High capacity flexible disk drives
- \* Semiconductor memories

All have already established themselves in applications where characteristics such as speed, removability, or environmental tolerance give them unique advantages. Semiconductor memory, in particular, has advanced down the learning curve at a faster rate than rigid magnetic drive technology, though progress is slowing as the complexity of product and process technology increases. New forms of non-volatile semiconductor memory, notably ferroelectric technology, may turn out to be the ultimate challenger to rotating disk data storage, but displacement will be gradual and dependent upon performance and price comparisons in specific applications for disk drives.

The advantages of magnetic disk recording have classically depended upon continually improving recording densities, which translate directly into lower cost. 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.

Great competitive strength is now derived from the size of the worldwide magnetic disk drive industry, which includes scores of well established manufacturers and an amazing diversity of products. System manufacturers, employing thousands of engineers making their data storage selection decisions, are comfortable and familiar with the magnetic disk drive industry, know the system integration requirements for disk drives, and have well established opinions on the credibility of specific manufacturers, based on extensive actual experience. These factors provide a high level of momentum for magnetic disk drives which will not be undercut by any potential alternative products soon, or without good reason.

Among the technological newcomers, it is reasonable to expect those with outstanding strengths for specific applications to be successful in gradually developing selected niche markets. Today's leading candidates for commercial success are discussed in the following sections.

\* Optical disk drives: Because they use track densities approaching 16,000 tracks per inch, 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 differing technologies, 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 is no longer capable of coping 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 standards except in the read-only area. Write-once drives are largely non-standardized, but 5.25" rewritable drives appear likely to be largely standardized using a format worked out by various national and international standards bodies. Conflict still exists for 3.5" rewritable formats.

- \* 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, but there appears to be 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.

Obviously, the market for this generation of 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 engineering design firms, 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: The possibility for real inroads into the market for magnetic disk drives exists with rewritable optical disk systems, when cost-effective drives with improved performance are available. Magneto-optical recording has seen development activity for more than twenty years, and "phase change" optical recording has attracted considerable attention during the past few years. 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.

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.

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 discusses media with 100,000 cycles as being a future practical product. Phase change erasable media could be in the marketplace as early as 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.



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 5,000 drives shipped in 1988. While adequate media supplies have been a problem, some producers have committed to the heavy investment required to establish volume production capability. Rewritable drives are now being produced by Canon, Sony, and Ricoh (using an Olympus mechanism) with 1989 production also expected from Maxoptix and others.

- \* 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. This technological loan will keep CD-ROM costs low. Further, CD-ROM acceptance benefits from industry agreement on the CD standards developed jointly by Sony and Philips. In addition to the 4.72" CD-ROM, which is limited in capability, high performance 12" read-only drives are being shipped by Reference Technology. A 3.5" version of the CD-ROM drive is under development by several firms.

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.

Most read-only optical drives will be used with small systems to provide personal access to large amounts of information. The success of read-only optical disks depends upon the existence and timely development of a data base publishing industry willing to make use of the CD-ROM format. As of mid-1989, there were about 700 titles available on CD-ROM, and while few, if any of these, seem likely to generate high volume sales, the increasing number of titles is generating interest among end users and creating drive sales. One exception to the low volume pattern is game titles. These appeared in Japan in 1988 and will be offered in the U.S. in 1989.

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 drop-outs, who wanted more immediate returns on their investments. Bubbles' markets were obviously not the mainstream data storage applications dominated by magnetic disk and tape drives. As expected by disk and tape manufacturers, but not by many bubble manufacturers, the older products were well established, mostly multiple sourced, and getting better all the time.

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.

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

Bubble memories for both military and industrial applications are also manufactured by Magnesys, which was formed in 1983. In 1988, Magnesys licensed Science Applications International Corp. (SAIC), a defense contractor, as a second manufacturing source for its bubble memories. 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 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 ferroelectric 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 Carnegie Mellon University and in Japan have shown promise, but much remains to be done to make VBL a practical technology. In the industrial sector, Magnesy has begun commercial development of VBL memory technology.

- \* 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 production in 1989. These high capacity floppy drives could compete in the very low end of potential magnetic and optical disk drive markets. 10 and 20 megabyte 5.25" flexible disk drives available in the market over the past several years have achieved only marginal success. However, 3.5" drives with capacity in the 20 megabyte range have been announced by Brier Technology and Insite Peripherals for 1989 shipment, and several firms in Japan are working on 16 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. Insite's 3.5" drive uses standard magnetic media with a visible servo pattern on the disk surface, combined with optical tracking methods. Unfortunately, none of the new high capacity flexible disk drive formats are compatible with each other.

Perpendicular recording for flexible disks has the potential to increase capacity without any significant increases in track density. By using a sputtered thin film or a barium ferrite coating on a Mylar substrate, perpendicular recording disks could achieve linear densities of at least 50,000 BPI. Higher track densities achieved through embedded servo techniques or optical tracking methods could increase capacities by a factor of four or more. Barium ferrite seems to have the edge at the moment because of problems with head wear and stiction associated with contact recording on sputtered thin films.

Toshiba has disclosed the existence of a development project for a 16 megabyte (unformatted) 3.5" drive based on barium ferrite as the recording material. It uses 35,080 BPI and 542 TPI format. In addition to Toshiba, Sony and Matsushita Electric have revealed programs for 3.5" drives and media using perpendicular recording.

It is likely that the largest limitation to the development of markets for the very high capacity floppy will be media availability. Success would require that media be produced by the millions of units, which would be difficult with today's batch sputtering processes, and durability remains a problem for thin film media used with head in-contact floppy disk drives.

Another major problem is that of incompatibility. So far, none of the proposed drives being considered are interchangeable with each other. It would be very unusual for a data storage product based upon removable media to be successful without widespread interchangeability of media between various manufacturer's drives.

An interesting development is the introduction of flexible media drives that combine optical and magnetic technologies. Bernoulli Optical Systems (BOSCO), Insite Peripherals and several other firms have active development programs for such products. Such drives might offer significant competition in various applications due to favorable drive and media costs.

BOSCO is a joint venture between Iomega and ICI, and has been developing an optical disk drive using flexible media. The 5.25" write-once drive uses the Bernoulli principle, as do other Iomega products, to position and stabilize the disk relative to the head. The drive is unusual in another way: It has independent single stage rotary actuators and heads on each side of the media.

- \* Stretched surface recording: SSR, as this technique is commonly known, was devised by the 3M Corporation over the last several years. 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 makes the product head crash proof. 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, will 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 for several years. Most, though not all, of these efforts have become inactive. As of mid-1989, no SSR drives or media had been announced, though 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 role in large and small systems where it serves as a substitute for rigid drives where 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 1 megabit configurations, are expected to become available in 4 megabit sizes in the early 1990s and readily available in 16 megabit configurations by the mid-1990s. Sample 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 probably a mistake to assume 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 ferroelectric memory chips and a form of EPROM known as flash memory. Ferroelectric memories make use of the properties of the electrically reversible polarization of ferroelectric materials to form a capacitor, which is required in the circuitry of semiconductor memories. Proper design can produce a 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 ferroelectric chips are substantially the same as used for CMOS, which is a well understood technology. Ramtron, which has been the most visible developer of ferroelectric memory technology, has licensed it to NMB Semiconductor company, ITT and Seiko. Ramtron and NMB are jointly developing a 4 megabit ferroelectric memory chip. Krysalis Corporation plans to offer sample 16 kilobit ferroelectric chips by the end of 1989, organized as 2048 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 Kbit ferroelectric 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.

Ferroelectric memories will probably find acceptance in '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. Ferroelectric memory will probably compete with magnetic drives in applications where the environment is stressful and rapid access is required. This includes military, industrial, and some high value commercial applications, but does not embrace the broader classes of non-volatile memory requirements served by rotating memory.

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 a megabit per chip. They are being developed by Intel, 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. There is also a limit to the number of times the memory device can be rewritten. At present, flash memory chips degrade beyond useability after about 10,000 write/erase cycles. To the extent that rotating disk drives storing non-changing or rarely changing data are used with computers embedded in process oriented equipment, they may eventually become vulnerable to inroads from flash memories.

- \* 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 throughout the world.

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 mem-

ories 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 are 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

Ever since IBM introduced the first rigid magnetic disk drives, drive technology has continually been improved by contributions from other firms as well as IBM. Until recently, IBM contributions have been outstripped by a legion of aggressive competitors, especially in the area of small diameter drives. 1989 product introductions have seen a resurgence in IBM contributions, such as IBM's 320 megabyte 3.5" drive, with more to follow shortly. The critical areas are discussed below.

- \* Head flying height: For high performance, high capacity rigid disk drives, head flying height is well under ten microinches. For some product development efforts, such as the single disk, 3.5" 100 megabyte drive being developed by Areal Technology, it is under five microinches. Several firms are attempting to design a drive in which there is no measurable flying height. Because head flying height is a major determinant of 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 flying heights under five microinches. 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 higher performance, smaller heads. These pressures, in turn, drove the development of composite and digital application metal-in-gap heads to the product stage.

Conventional and composite ferrite heads are 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.



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 most 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 heads. Metal-in-gap heads appear particularly appropriate for microsliders that, in conjunction with thinner disks, allow more disks per drive while remaining within standard form factors.

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 (Imprimis), Applied Magnetics and Read-Rite. However, metal-in-gap heads have proven capable of operation in many of the applications originally targeted by thin film heads, so the demand for thin film heads has been much slower to develop than many prospective producers had hoped. Most thin film heads will be used in drives having very high areal densities, and 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.

Heads capable of reading or writing multiple tracks are not in use yet, but may be employed when small diameter drives used in mainframe applications enter the marketplace. Multi-track heads will be used to improve performance by increasing the amount of data available as a result of a single head movement, since the cylinder size will be effectively increased by simultaneous access to multiple tracks.

- \* 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, sputtered or plated 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, has begun shipping drives with thin film media, some of it IBM's own product.

For several years, there has been a stampede by numerous established and new firms to install production capability for thin film disks. Most have aimed at the market for 5.25" and smaller disk drives, and the managements involved recognize 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. Existing 5.25" and 3.5" drives with less than 100 megabyte capacity need higher density than oxide disks offer.

Things got started in 1981, with adoption of plated media by Irwin International, IMI, New World, Evotek, SyQuest, and Texas Instruments, all for 5.25" or smaller disk drives, and Ibis, for 14" drives. Ampex was the major supplier for the bulk of the plated disks used through 1984. Several other companies also installed production capacity for plated disk production, but few remain in the business today. Many would-be manufacturers of plated disks lacked adequate process control and were unable to sustain high production yields or to meet delivery commitments on a consistent basis. The industry now requires that plated disks be supplied with a sputtered overcoat to provide lubrication and mechanical protection at the head-disk interface. Organic compounds are often used as surface lubricants with the overcoat.

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" and 3.5" media because the bulk of the near term demand is in those sizes.

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 the effect of reducing demand in a market already overcrowded with manufacturers.

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 will be using glass or glass/ceramic as a substrate material. Glass substrates are 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 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. Several of the highest performance small drives operate at over 1,000 TPI, but such precision is costly. The industry still has plenty of room for innovation in this area. IBM introduced a triple density version of the 3380 in the last half of 1987 that uses an estimated 2,100 TPI, and in 1989, Northern Telecom introduced a drive that operates at 2,270 TPI. Some firms are investigating the use of optical tracking techniques to obtain higher TPI, and IBM has shown the feasibility of creating media with very narrow tracks. However, considerable work will have to be done to develop heads capable of working with such narrow track widths.
- \* Perpendicular recording: Today's disk drives all use longitudinal recording, making use of magnetic domains oriented parallel to the surface of the recording medium. 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.

A very large amount of development activity in perpendicular recording has been underway in Japan, 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 was introduced by Northern Telecom in 1989. This 8" drive offers 2.26 gigabyte capacity.

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 is the first manufacturer to use the Censtor technology in an announced product.

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, a startup firm working with perpendicular recording, 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, and volumetric efficiencies, compared to single large drives. Options such as caching and multiple data pathing can also be added.

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 will 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 5400 RPM appeared in 1989 when Imprimis announced a family of one gigabyte 5.25" drives operating at 5400 RPM. Hitachi had earlier announced a 5.25" 600 megabyte drive operating at 4876 RPM and IBM announced a 320 megabyte (formatted) 3.5" drive rotating at 4318 RPM at the 1989 Spring Comdex show. Other firms will also announce short latency drives.

The use of parallel transfer from multiple heads to achieve data rates to 12 megabytes 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 time is 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.

- \* Form factor: Sub-3.5" drives will become an increasingly significant part of the market. Driven by the demands of manufacturers of notebook computers, laptop computers, and portable word processing equipment, small footprint, low power drive designs will proliferate over the next several years. The first of these, a 2.5" 20 megabyte drive from PrairieTek, has already gone into production. While it was too late to catch the first wave of design-ins for laptop computers, PrairieTek and other 2.5" drive competitors should be able to exploit a growing market for notebook computers. Several firms, both U.S. and Japanese, have active design programs underway. Competition in providing higher capacity and thinner (3/4" or less) profiles in 3.5" and 2.5" disk diameter drives will be keen.
- \* Interfaces: There is a notable 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 controllers and PC/AT controllers are the most prevalent. 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 25 to 30 percent of the drives shipped in 1989. However, PC/AT interfaces far outnumber SCSI interfaces in the personal computer market, and an increasing number of disk drives used in PC applications have the controller embedded within the disk drive.

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

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

Examples:

- \* Drives sold by IBM, Hewlett-Packard or Toshiba 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 by 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 PCM/Reseller and OEM/Integrator shipments are included in the non-captive sales channel.

Examples:

- \* Shipments by NEC are non-captive, except for drives sold with systems made by the parent company or other subsidiaries.
- \* Shipments by Siemens are non-captive if sold with Siemens manufactured systems.

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 drive manufacturer, except when drives are produced on a contract manufacturing basis with a design supplied by the disk drive manufacturer which finally sells the drive to a third party.

Examples:

- \* Drives produced by Maxtor.
- \* Drives sold by Quantum but made to Quantum designs by Matsushita Kotobuki Electronics.

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 dealers and distributors.

Examples:

- \* Disk drive-on-a-card products such as those of Plus Development.
- \* Disk drives sold by Storage Technology to end users of IBM systems.
- \* On an arbitrary basis, drives manufactured by Fujitsu, Hitachi, or Unisys and resold in the PCM market by other companies are included in PCM totals, in order to avoid distortion of total industry PCM activity.

#### 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, 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 or OEM levels. Prices used for leased drives are on an "if sold" basis, at captive or PCM levels, as appropriate. All prices are in 1989 constant dollars, unless otherwise noted.

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.

### 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 Europe-based system manufacturer is included in worldwide totals, even if the drive is integrated into a system within the U.S.
- \* An OEM shipment to a U.S. based system manufacturer is included in U.S. totals, even if the drive is integrated into a system in Hong Kong, 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:

- \* Priam and Micropolis are considered U.S. manufacturers, even though each firm manufactures some 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.



APPLICATION CLASSIFICATION

Shipments of disk drives are analyzed by attachment to the following classes of equipment:

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

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

Personal computers: Attached to a general purpose microcomputer normally used by a single user. Examples: IBM PS/2 model 70, Apple Macintosh.

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

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 or 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 DRIVESCoverage

Examples of disk drives in this group include:

14" disk diameter

ISOT	CM 5400, CM 5410
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8" disk diameter

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

3.9" disk diameter

SyQuest Technology	SQ306RD, SQ312RD
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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. In fact, 14" drives have been phased out, except for Eastern Bloc production.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	31.4	39.5	50.5	61.2	63.3
All manufacturers	67.5	65.4	70.8	76.5	74.8

Following the pattern of several years, 1988 worldwide revenues for disk cartridge drives failed to achieve even the reduced estimates used in last year's DISK/TREND Report. Revenues for 1988 declined almost 40%, to \$67.5 million, and unit shipments dropped 27.7%, to 65,700 drives.

However, the outlook is better for disk cartridge drives in 1989, with worldwide unit sales forecasted to jump to 112,100 drives, with all of the growth coming from the higher capacity 5.25" models introduced during the past few years.

SyQuest remains the leader in non-captive shipments, with 42,000 drives in 1988, for 65.5% of the worldwide unit total. Almost half of SyQuest's total were 5.25" 44 megabyte drives, which are rapidly replacing the firm's original 3.9" models.

Older 14" and 8" captive disk cartridge drive programs by Digital Equipment, Control Data and other companies have been phased out, accounting for the continuing sharp drop 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 avail-

ability of announced products, shipment of many unreliable disk drives, and several failed programs.

With this history, it is entirely understandable that many system manufacturers which previously used 14" disk cartridge drives in small office and engineering systems, and would have liked to continue with removable disk drives in smaller sizes, tired of waiting and switched to fixed disk drives.

### Marketing trends

5.25" drives will have provided 87.9% of 1989's worldwide shipments for drives in this product group, and the share for 5.25" is expected to increase to 97.1% in 1990. Eastern Bloc production of older 14" drives is dropping rapidly, and SyQuest's 3.9" shipments are forecasted to end in 1990.

Average annual shipment growth for 5.25" drives is forecasted at 78% for the 1989-92 period, with most of the increase derived from drives with capacities over 40 megabytes. 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.

## **1989 DISK/TREND REPORT**

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. Most of the 14" drives still in production use variations to the older 2314 technology.

The smaller drives introduced to date incorporate elements of the older technologies, but utilize head designs similar to Winchester heads, sometimes with "mini" sliders. All of the existing 8" drives use oxide coated disks, while the various 5.25" and 3.9" models use oxide or 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 lower 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" drives will decline 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)-----									
	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	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	3.9	5.9	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	3.9	5.9	--	--	--	--	--	--	--	--
PCM/Reseller	4.1	5.9	7.5	9.5	7.7	11.2	9.8	14.0	10.5	15.3
OEM/Integrator	18.1	19.6	28.3	30.0	35.8	39.3	40.0	47.2	38.4	48.0
TOTAL U.S. NON-CAPTIVE	22.2	25.5	35.8	39.5	43.5	50.5	49.8	61.2	48.9	63.3
TOTAL U.S. REVENUES	26.1	31.4	35.8	39.5	43.5	50.5	49.8	61.2	48.9	63.3
<b>Non-U.S. Manufacturers</b>										
Captive	--	8.0	--	4.8	--	3.2	--	1.6	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	3.5	28.1	5.6	21.1	6.0	17.1	7.8	13.7	6.5	11.5
TOTAL NON-U.S. REVENUES	3.5	36.1	5.6	25.9	6.0	20.3	7.8	15.3	6.5	11.5
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE REVENUES	29.6	67.5	41.4	65.4	49.5	70.8	57.6	76.5	55.4	74.8
OEM Average Price (\$000)	.6	.9	.4	.6	.4	.4	.4	.4	.3	.3

TABLE 12  
DISK CARTRIDGE DRIVES  
UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1988		Forecast							
	Shipments		1989		1990		1991		1992	
	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	.4	.6	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	.4	.6	--	--	--	--	--	--	--	--
PCM/Reseller	8.7	12.7	18.2	23.2	22.0	32.0	30.0	43.0	35.0	51.0
OEM/Integrator	33.5	34.4	68.7	69.8	102.0	112.0	123.0	145.0	128.0	160.0
TOTAL U.S. NON-CAPTIVE	42.2	47.1	86.9	93.0	124.0	144.0	153.0	188.0	163.0	211.0
TOTAL U.S. SHIPMENTS	42.6	47.7	86.9	93.0	124.0	144.0	153.0	188.0	163.0	211.0
<b>Non-U.S. Manufacturers</b>										
Captive	--	1.0	--	.6	--	.4	--	.2	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	5.0	17.0	8.0	18.5	10.0	20.5	12.0	21.0	13.0	23.0
TOTAL NON-U.S. SHIPMENTS	5.0	18.0	8.0	19.1	10.0	20.9	12.0	21.2	13.0	23.0
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE SHIPMENTS	47.6	65.7	94.9	112.1	134.0	164.9	165.0	209.2	176.0	234.0
Total Capacity (Terabytes)	1.4	1.8	4.2	4.7	6.3	7.6	8.2	10.3	8.8	11.5
<b>Cumulative Shipments</b>										
IBM	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0	53.3	79.0
Non-IBM	1,038.3	1,787.7	1,133.2	1,899.8	1,267.2	2,064.7	1,432.2	2,273.9	1,608.2	2,507.9
WORLDWIDE TOTAL	1,091.6	1,866.7	1,186.5	1,978.8	1,320.5	2,143.7	1,485.5	2,352.9	1,661.5	2,586.9

TABLE 13  
DISK CARTRIDGE DRIVES  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988				1989				Forecast			1991		1992
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	5.25"	<5.25"	14"	5.25"	5.25"
<b>U.S. MANUFACTURERS</b>														
Captive	--	5.9	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	3.5	2.4	--	--	8.7	.8	--	11.2	--	--	14.0	15.3
OEM/Integrator	--	2.8	10.4	6.4	--	1.4	26.2	2.4	--	38.5	.8	--	47.2	48.0
TOTAL U.S. REVENUES	--	8.7	13.9	8.8	--	1.4	34.9	3.2	--	49.7	.8	--	61.2	63.3
<b>NON-U.S. MANUFACTURERS</b>														
Captive	8.0	--	--	--	4.8	--	--	--	3.2	--	--	1.6	--	--
OEM/Integrator	22.5	--	5.6	--	11.3	--	9.8	--	6.3	10.8	--	--	13.7	--
TOTAL NON-U.S. REVENUES	30.5	--	5.6	--	16.1	--	9.8	--	9.5	10.8	--	1.6	13.7	--
<b>WORLDWIDE RECAP</b>														
Captive	8.0 -48.7%	5.9 -69.3%	--	--	4.8 -40.0%	-- -100.0%	--	--	3.2 -33.3%	--	--	1.6 -50.0%	--	--
PCM/Reseller	--	--	3.5	2.4	--	--	8.7 +148.6%	.8 -66.7%	--	11.2 +28.7%	-- -100.0%	--	14.0 +25.0%	15.3 +9.3%
OEM/Integrator	22.5 --	2.8 --	16.0 --	6.4 --	11.3 -49.8%	1.4 -50.0%	36.0 +125.0%	2.4 -62.5%	6.3 -44.2%	49.3 +36.9%	.8 -66.7%	-- -100.0%	60.9 +23.5%	59.5 -2.3%
Total Revenues	30.5 -38.5%	8.7 -72.2%	19.5 +121.6%	8.8 -60.7%	16.1 -47.2%	1.4 -83.9%	44.7 +129.2%	3.2 -63.6%	9.5 -41.0%	60.5 +35.3%	.8 -75.0%	1.6 -83.2%	74.9 +23.8%	74.8 --
ANNUAL SHARE, BY DIAMETER	45.2%	12.9%	28.9%	13.0%	24.6%	2.1%	68.4%	4.9%	13.4%	85.5%	1.1%	2.1%	97.9%	100.0%

TABLE 14  
DISK CARTRIDGE DRIVES  
WORLDWIDE SHIPMENTS (000)  
BREAKDOWN BY DISK DIAMETER

	1988				Forecast									
	Shipments				1989				1990			1991		1992
	14"	8"	5.25"	<5.25"	14"	8"	5.25"	<5.25"	14"	5.25"	<5.25"	14"	5.25"	5.25"
<b>U.S. MANUFACTURERS</b>														
Captive	--	.6	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	--	--	6.7	6.0	--	--	21.2	2.0	--	32.0	--	--	43.0	51.0
OEM/Integrator	--	1.2	17.2	16.0	--	.6	63.2	6.0	--	110.0	2.0	--	145.0	160.0
TOTAL U.S. SHIPMENTS	--	1.8	23.9	22.0	--	.6	84.4	8.0	--	142.0	2.0	--	188.0	211.0
<b>NON-U.S. MANUFACTURERS</b>														
Captive	1.0	--	--	--	.6	--	--	--	.4	--	--	.2	--	--
OEM/Integrator	9.0	--	8.0	--	4.5	--	14.0	--	2.5	18.0	--	--	21.0	23.0
TOTAL NON-U.S. SHIPMENTS	10.0	--	8.0	--	5.1	--	14.0	--	2.9	18.0	--	.2	21.0	23.0
<b>WORLDWIDE RECAP</b>														
Captive	1.0 -60.0%	.6 -76.0%	--	--	.6 -40.0%	-- -100.0%	--	--	.4 -33.3%	--	--	.2 -50.0%	--	--
PCM/Reseller	--	--	6.7	6.0	--	--	21.2 +216.4%	2.0 -66.7%	--	32.0 +50.9%	-- -100.0%	--	43.0 +34.4%	51.0 +18.6%
OEM/Integrator	9.0	1.2	25.2	16.0	4.5	.6	77.2 +206.3%	6.0 -62.5%	2.5	128.0 +65.8%	2.0 -66.7%	--	166.0 +29.7%	183.0 +10.2%
Total Shipments	10.0 -37.9%	1.8 -77.2%	31.9 +192.7%	22.0 -60.7%	5.1 -49.0%	.6 -66.7%	98.4 +208.5%	8.0 -63.6%	2.9 -43.1%	160.0 +62.6%	2.0 -75.0%	.2 -93.1%	209.0 +30.6%	234.0 +12.0%
ANNUAL SHARE, BY DIAMETER	15.2%	2.7%	48.6%	33.5%	4.5%	.5%	87.9%	7.1%	1.8%	97.0%	1.2%	.1%	99.9%	100.0%
TOTAL CAPACITY (Terabytes)	.1	--	1.2	.3	--	--	4.5	.1	--	7.5	--	--	10.3	11.5

TABLE 15  
DISK CARTRIDGE DRIVES  
APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	10.7	16.3	21.1	9.0
PERSONAL COMPUTERS Business and professional, single user	40.6	61.9	182.5	78.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	8.1	12.3	11.7	5.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	6.3	9.5	18.7	8.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	65.7	100.0	234.0	100.0

TABLE 16  
 DISK CARTRIDGE DRIVES  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 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	--	--	18.0	20.0	38.0	80.5	--	--	20.0	22.0	42.0	65.5
ISOT	--	--	--	--	--	--	8.5	--	--	--	8.5	13.3
RICOH	--	--	5.0	--	5.0	10.6	--	--	8.0	--	8.0	12.5
Other U.S.	--	1.0	3.2	--	4.2	8.9	--	1.2	3.9	--	5.1	7.9
Other Non-U.S.	--	--	--	--	--	--	.5	--	--	--	.5	.8
TOTAL	--	1.0	26.2	20.0	47.2	100.0	9.0	1.2	31.9	22.0	64.1	100.0



DISK PACK DRIVES

**1989 DISK/TREND REPORT**





DISK PACK DRIVESCoverage

Examples of disk drives in this group include:

14" disk diameter

Century Data	T306
Digital Equipment	RA60
Imprimis (Control Data)	9762, 9766
ISOT	ES 5066, ES 5067
Kovo (Aritma)	4080, 5080
NEC	N7745

9" disk diameter

Imprimis (Control Data)	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 is the major large disk pack drive still in production. Among the large disk pack files introduced in more recent years, the Digital Equipment RA60 (14" 205 MB using 6 data surfaces) is the sole survivor, except for Eastern Bloc products.

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.

Control Data's 9" "RSD," or 9710, is functionally similar to the 80 megabyte SMD except for smaller size and lower price. Its size is matched to the Control Data "FSD" 9" family of fixed disk drives. The continuing Eastern Bloc production of drives equivalent to the older IBM 2314 is also included in this product group.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	111.4	44.2	19.6	2.2	--
All manufacturers	194.7	120.2	86.8	53.3	40.0

After years of declining shipments, disk pack drives are now approaching the last few years of production, with the exception of continuing low-level production in the Eastern Bloc. Worldwide unit shipments in 1988 were only 24,800 drives, with a further reduction to 14,600 units expected this year.

Imprimis' shipments of 14" and 9" disk pack drives accounted for 50% of the 1988 worldwide non-captive total, with 10,100 units. Bulgarian production by ISOT of disk pack drives using 2314 and SMD technology accounted for most of the remainder.

Marketing trends

The future is expected to bring continuous decline for all types of disk pack drives, sold through both captive and OEM distribution channels. Even Eastern Bloc production is expected to suffer a slow decline, as Bulgarian shipments of fixed disk drives increase.

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

5.25" and 3.5" models -- offering lower price, improved reliability, and smaller size.

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

#### Technical trends

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

#### Forecasting assumptions

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

TABLE 17  
DISK PACK DRIVES  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	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	43.8	53.2	18.8	24.2	7.8	10.4	--	--	--	--
TOTAL U.S. CAPTIVE	43.8	53.2	18.8	24.2	7.8	10.4	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	38.3	58.2	13.0	20.0	6.4	9.2	1.5	2.2	--	--
TOTAL U.S. NON-CAPTIVE	38.3	58.2	13.0	20.0	6.4	9.2	1.5	2.2	--	--
TOTAL U.S. REVENUES	82.1	111.4	31.8	44.2	14.2	19.6	1.5	2.2	--	--
<b>Non-U.S. Manufacturers</b>										
Captive	--	12.0	--	12.0	--	10.4	--	4.8	--	3.2
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	71.3	--	64.0	--	56.8	--	46.3	--	36.8
TOTAL NON-U.S. REVENUES	--	83.3	--	76.0	--	67.2	--	51.1	--	40.0
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE REVENUES	82.1	194.7	31.8	120.2	14.2	86.8	1.5	53.3	--	40.0
OEM Average Price (\$000)	5.4	6.4	5.4	6.9	5.3	7.1	3.8	7.3	--	8.2

TABLE 18  
DISK PACK DRIVES  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		-----Forecast-----							
	Shipments		1989		1990		1991		1992	
	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	3.3	4.0	1.4	1.8	.6	.8	--	--	--	--
TOTAL U.S. CAPTIVE	3.3	4.0	1.4	1.8	.6	.8	--	--	--	--
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	7.1	10.6	2.4	3.6	1.2	1.7	.4	.6	--	--
TOTAL U.S. NON-CAPTIVE	7.1	10.6	2.4	3.6	1.2	1.7	.4	.6	--	--
TOTAL U.S. SHIPMENTS	10.4	14.6	3.8	5.4	1.8	2.5	.4	.6	--	--
<b>Non-U.S. Manufacturers</b>										
Captive	--	.6	--	.6	--	.5	--	.3	--	.2
PCM/Reseller	--	--	--	--	--	--	--	--	--	--
OEM/Integrator	--	9.6	--	8.6	--	7.6	--	6.0	--	4.5
TOTAL NON-U.S. SHIPMENTS	--	10.2	--	9.2	--	8.1	--	6.3	--	4.7
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE SHIPMENTS	10.4	24.8	3.8	14.6	1.8	10.6	.4	6.9	--	4.7
Total Capacity (Terabytes)	1.7	4.0	.7	2.3	.4	1.9	--	1.0	--	.8
<b>Cumulative Shipments</b>										
IBM	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6	41.3	72.6
Non-IBM	529.5	960.6	533.3	975.2	535.1	985.8	535.5	992.7	535.5	997.4
WORLDWIDE TOTAL	570.8	1,033.2	574.6	1,047.8	576.4	1,058.4	576.8	1,065.3	576.8	1,070.0

TABLE 19  
DISK PACK DRIVES  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	14"	9"	14"	9"	14"	9"	14"	9"	14"	9"
<b>U.S. MANUFACTURERS</b>										
Captive	53.2	--	24.2	--	10.4	--	--	--	--	--
OEM/Integrator	37.2	21.0	11.1	8.9	5.1	4.1	--	2.2	--	--
TOTAL U.S. REVENUES	90.4	21.0	35.3	8.9	15.5	4.1	--	2.2	--	--
<b>NON-U.S. MANUFACTURERS</b>										
Captive	12.0	--	12.0	--	10.4	--	4.8	--	3.2	--
OEM/Integrator	71.3	--	64.0	--	56.8	--	46.3	--	36.8	--
TOTAL NON-U.S. REVENUES	83.3	--	76.0	--	67.2	--	51.1	--	40.0	--
<b>WORLDWIDE RECAP</b>										
Captive	65.2	--	36.2	--	20.8	--	4.8	--	3.2	--
	-30.8%	--	-44.5%	--	-42.5%	--	-76.9%	--	-33.3%	--
OEM/Integrator	108.5	21.0	75.1	8.9	61.9	4.1	46.3	2.2	36.8	2.2
	--	--	--	--	-17.6%	-53.9%	-25.2%	-46.3%	-20.5%	-46.3%
Total Revenues	173.7	21.0	111.3	8.9	82.7	4.1	51.1	2.2	40.0	2.2
	-29.4%	-22.5%	-35.9%	-57.6%	-25.7%	-53.9%	-38.2%	-46.3%	-21.7%	-46.3%
ANNUAL SHARE, BY DIAMETER	89.2%	10.8%	92.6%	7.4%	95.3%	4.7%	95.9%	4.1%	100.0%	

TABLE 20  
DISK PACK DRIVES  
WORLDWIDE SHIPMENTS (000)  
BREAKDOWN BY DISK DIAMETER

	1988		Forecast							
	14" Shipments	9"	1989		1990		1991		1992	
	14"	9"	14"	9"	14"	9"	14"	9"	14"	
<u>U.S. MANUFACTURERS</u>										
Captive	4.0	--	1.8	--	.8	--	--	--	--	
OEM/Integrator	4.7	5.9	1.3	2.3	.6	1.1	--	.6	--	
TOTAL U.S. SHIPMENTS	8.7	5.9	3.1	2.3	1.4	1.1	--	.6	--	
<u>NON-U.S. MANUFACTURERS</u>										
Captive	.6	--	.6	--	.5	--	.3	--	.2	
OEM/Integrator	9.6	--	8.6	--	7.6	--	6.0	--	4.5	
TOTAL NON-U.S. SHIPMENTS	10.2	--	9.2	--	8.1	--	6.3	--	4.7	
<u>WORLDWIDE RECAP</u>										
Captive	4.6	--	2.4	--	1.3	--	.3	--	.2	
	-35.2%	--	-47.8%	--	-45.8%	--	-76.9%	--	-33.3%	
OEM/Integrator	14.3	5.9	9.9	2.3	8.2	1.1	6.0	.6	4.5	
	--	--	--	--	-17.2%	-52.2%	-26.8%	-45.5%	-25.0%	
Total Shipments	18.9	5.9	12.3	2.3	9.5	1.1	6.3	.6	4.7	
	-28.7%	-19.2%	-34.9%	-61.0%	-22.8%	-52.2%	-33.7%	-45.5%	-25.4%	
ANNUAL SHARE, BY DIAMETER	76.2%	23.8%	84.2%	15.8%	89.6%	10.4%	91.3%	8.7%	100.0%	
TOTAL CAPACITY (Terabytes)	3.5	.4	2.1	.1	1.8	--	1.0	--	.8	



TABLE 21  
DISK PACK DRIVES  
APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	7.3	29.3	47.38	6.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	13.6	54.9	35.73	65.0
PERSONAL COMPUTERS Business and professional, single user	--	--	--	--
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	3.3	13.4	13.99	7.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	.6	2.4	2.9	22.0
CONSUMER AND HOBBY COMPUTERS	--	--	--	--
OTHER APPLICATIONS	--	--	--	--
Total	24.8	100.0	4.7	100.0

TABLE 22  
DISK PACK DRIVES  
MARKET SHARE SUMMARY  
Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
	14"	9"	Total		14"	9"	Total	
IMPRIMIS	2.6	4.1	6.7	94.4	4.2	5.9	10.1	50.0
ISOT	--	--	--	--	9.5	--	9.5	47.0
Other U.S.	.4	--	.4	5.6	.5	--	.5	2.5
Other Non-U.S.	--	--	--	--	.1	--	.1	.5
TOTAL	3.0	4.1	7.1	100.0	14.3	5.9	20.2	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

Goldstar Telecommunication	GSH-520*
Hitachi	DK505-2*
ISOT	ES 5300, CM 5508
Microscience International	HH-825*
Miltope	RDS-1500
NEC	D5126H*
SAGEM	MSA 240-25
Seagate Technology	ST225*, ST225N*
Teac	SD-521*

3.5" disk diameter

Alps Electric	DRP020A**, DRP020Q*
Conner Peripherals	CP3020**, CP3024**
Fuji Electric	FK309-26*, FK311-26**
Fujitsu	M2225D2*
Goldstar Telecommunication	GSH-3026*
Hewlett-Packard	97501B
Hitachi	DK302-2*
IBM	WD-325*
JVC (Victor)	JD-3824T**
Kalok	KL320*
Kyocera	KC20B*
Matsushita Communication Ind.	JU-106**
Microscience International	HH-325*
Miniscribe	8425*, 8425S*, 8425F*
NEC	D3126*
Plus Development	Hardcard 20**, Passport*
Rodime	R0652B*
Seagate Technology	ST125*
Toshiba	MK-132FA*
Western Digital	WD93028-A*

2.5" disk diameter

JVC (Victor)	JD-E2825P**
PrairieTek	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 use plated or sputtered disks.

Most of the drives in the group use head positioning systems driven by stepping motors, with relatively slow average access times, but low costs. Some drives in the group 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, one inch high 20 megabyte drives using single 3.5" disks have appeared, signaling a major future trend. The new PrairieTek 2.5" drive is also the pathfinder for many drives to follow. JVC has already announced a 2.5" drive which is only 3/4" high, and several other manufacturers are expected to introduce similar drives.

#### Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	1,836.7	1,421.3	1,193.7	946.2	687.0
All manufacturers	2,274.1	1,712.4	1,385.1	1,082.7	800.9

This product group experienced its last growth year in 1988, with unit shipments increasing 17.4% and revenues up 1%. But the movement to higher capacities is coming faster than anticipated, as the personal computer market transitions to more powerful processors and adopts more versatile software, and 1989's shipments are in a downward trend.

## **1989 DISK/TREND REPORT**

1989 worldwide unit shipments for the product group are estimated at 6.8 million drives, down 13.7%, and revenues are expected to total only \$1.7 million, a decrease of 24.7%. The largest negative impact on revenues is the effect of reduced captive drive shipments this year, down 38.4%, as IBM cuts production of 3.5" drives at Fujisawa to facilitate a model changeover to 1" high models and as several non-U.S. captive drive manufacturers transition to higher capacity drives.

3.5" drives continue to be dominant in this product group, holding 63.6% of 1988's unit shipments, and are forecasted to provide 75.3% of the 1989 total. However, the continuing decline in 5.25" drive shipments is responsible for most of the current percentage shift in product mix. 3.5" shipments are expected to grow only 1.9% in 1989, with 5,159,300 units.

It seems that the growth potential for 20 megabyte 3.5" drives has been dampened by IBM's inability to stampede its competition with the PS/2 product family. Unfortunately for IBM, too many users liked the older PC XT and PC AT systems and decided they wouldn't discard their old software, their expensive add-in cards, and their 5.25" disk drives.

As a result, the older PC standard continued to prosper without IBM, providing a strong residual market for low-end 5.25" disk drives through both clone manufacturers and the dealer aftermarket. And the many technical and legal delays faced by clone manufacturers in entering the PS/2 compatible market slowed the growth of low-end 3.5" drive shipments. Meanwhile, the inevitable movement to higher capacities has been taking place, and the growth era for 3.5" 20 megabyte drives is now over.

PrairieTek has established the capability to make volume shipments of 2.5" drives in 1989, and it is expected that other manufacturers will also be in production by the first half of 1990. This year's shipments are



estimated at 21,000 drives, below the previous forecast, due to competition from 1" high 3.5" drives.

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. Near term hopes for the 2.5" drive market rest with the expected smaller portable computers, now generally known as "notebook" computers.

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 91.8% of 1988 unit shipments. It is expected that the future will see a modest decline in usage with minicomputers and multi-user systems in favor of higher capacity drives, while a slight percentage increase in consumer and hobby computer applications will occur.

Seagate's complete dominance of the half high 5.25" market continued to be the main reason for the company's leadership in non-captive shipments for this product group. Seagate shipped 2,855,000 drives in 1988, 43.1% of the worldwide total. Miniscribe's 1.8 million drives, 28% of the worldwide total for the product group, were all 3.5" models, almost five times the quantity of 3.5" drives in this group shipped by Seagate. It should be noted that the Miniscribe shipments mentioned above and included in Table 28 are strictly DISK/TREND's estimate of net shipments, a somewhat uncertain venture considering Miniscribe's internal counting problems during 1988.

### Marketing trends

DISK/TREND forecasts for this product group now indicate an average annual decline in worldwide unit shipments of 15.7% during 1990-92, with 1992's shipment total down to slightly more than 4 million drives. Even during the decline in total shipments, fundamental changes are expected in product mix. It is expected that the share of the group's shipments held by 3.5" drives will peak at 87.1% in 1990. By 1992, 3.5" drives will be down to 62.9%, while the share held by 2.5" drives will have grown to 36%.

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.

IBM's captive shipments of 3.5" drives with capacities below 30 megabytes have declined in 1989, due to a model changeover to 1" high 3.5" drives, which have not yet been introduced. It is believed that IBM's shipments of 3.5" 20 megabyte drives will continue to decline, as the firm emphasizes personal computers with higher level capabilities for office applications. However, IBM is expected to introduce a 2.5" drive by 1991 for use with notebook computers, thus maintaining a high level of shipments by the firm in this product group.

IBM will not be alone in shifting emphasis from 3.5" to 2.5" drives at the 20 megabyte level. Several manufacturers of OEM drives will join the fray by mid-1990, and the movement to 2.5" will be under way, providing that the system manufacturers move into the latent notebook computer market as rapidly as expected.

The effect of a major new disk form factor on 5.25" drives and smaller will be the same as in the past -- profound change in the product mix:

<u>Worldwide captive &amp; OEM Unit shipments (000)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
5.25" full size	33.7 .4%	24.9 .4%	26.0 .4%	10.0 .2%	-- --
5.25" half high	2,847.1 35.8%	1,653.0 24.1%	488.0 8.0%	110.0 2.1%	45.0 1.1%
3.5"	5,065.5 63.8%	5,159.3 75.2%	5,311.0 87.0%	4,345.0 83.6%	2,570.0 62.8%
2.5"	.1 --	21.0 .3%	280.0 4.6%	730.0 14.1%	1,480.0 36.1%

Full size 5.25" drives have become an insignificant factor in the OEM market. Without Eastern Bloc shipments of full size drives, production of drives in this form factor would have already stopped.

### 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 has been more widely used, 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. The new 2.5" drives (disk with 65 millimeter OD, 20 millimeter ID) have been offered initially with two disks, at 20 megabytes. The newer 2.5" drives in this product

group, however, are expected to use a single disk at that capacity, and the drive height will typically be 3/4".

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 SCSI drives, plus those with embedded controllers for IBM personal computers, are gaining a continually higher percentage of OEM drive shipments. Embedded controllers will also make it possible to take the next step in recording density, since the physical characteristics of drives will be masked from systems.

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 may become a general trend, since several Japanese manufacturers of floppy drives have already started production of 3/4" high 3.5" floppy drives. Since floppy drives have traditionally established form factor standards which are subsequently adopted for rigid disk drives, even thinner hard disk drives are to be expected.

#### Forecasting assumptions

1. IBM will reduce usage of 3.5" drives in this group, in favor of higher capacity drives for office applications. The firm will start shipments of 1" high 3.5" drives by the end of this year, and will start shipments of 2.5" drives by 1991.
2. 2.5 " drives will be available from multiple vendors in the first half of 1990 and will develop a major market with notebook computer applications.

TABLE 23  
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		-----Forecast-----							
	Revenues		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	428.4	630.0	254.1	385.0	224.0	350.0	180.0	279.0	131.5	205.0
Other U.S. Captive	22.0	40.1	17.0	27.2	11.2	19.2	7.5	12.0	--	--
TOTAL U.S. CAPTIVE	450.4	670.1	271.1	412.2	235.2	369.2	187.5	291.0	131.5	205.0
PCM/Reseller	311.7	519.9	291.5	456.7	238.5	338.3	202.0	270.6	135.7	177.2
OEM/Integrator	273.8	646.7	247.5	552.4	227.3	486.2	189.8	384.6	155.2	304.8
TOTAL U.S. NON-CAPTIVE	585.5	1,166.6	539.0	1,009.1	465.8	824.5	391.8	655.2	290.9	482.0
TOTAL U.S. REVENUES	1,035.9	1,836.7	810.1	1,421.3	701.0	1,193.7	579.3	946.2	422.4	687.0
<b>Non-U.S. Manufacturers</b>										
Captive	29.8	210.8	26.5	130.3	5.0	69.0	--	27.1	--	13.0
PCM/Reseller	11.7	24.0	4.0	22.7	2.2	14.8	.9	15.4	1.4	16.1
OEM/Integrator	33.1	202.6	19.8	138.1	18.7	107.6	18.1	94.0	20.2	84.8
TOTAL NON-U.S. REVENUES	74.6	437.4	50.3	291.1	25.9	191.4	19.0	136.5	21.6	113.9
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE REVENUES	1,110.5	2,274.1	860.4	1,712.4	726.9	1,385.1	598.3	1,082.7	444.0	800.9
OEM Average Price (\$000)	.217	.211	.201	.204	.175	.179	.166	.168	.161	.162

TABLE 24  
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		1989		1990		Forecast		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	714.0	1,050.0	462.0	700.0	448.0	700.0	400.0	620.0	320.0	500.0
Other U.S. Captive	11.6	21.1	10.0	16.0	7.0	12.0	5.0	8.0	--	--
TOTAL U.S. CAPTIVE	725.6	1,071.1	472.0	716.0	455.0	712.0	405.0	628.0	320.0	500.0
PCM/Reseller	1,511.3	2,527.7	1,605.0	2,525.0	1,342.0	1,910.0	1,190.0	1,595.0	820.0	1,071.0
OEM/Integrator	1,256.9	3,124.0	1,232.9	2,766.4	1,302.0	2,783.0	1,150.0	2,331.0	970.0	1,905.0
TOTAL U.S. NON-CAPTIVE	2,768.2	5,651.7	2,837.9	5,291.4	2,644.0	4,693.0	2,340.0	3,926.0	1,790.0	2,976.0
TOTAL U.S. SHIPMENTS	3,493.8	6,722.8	3,309.9	6,007.4	3,099.0	5,405.0	2,745.0	4,554.0	2,110.0	3,476.0
<b>Non-U.S. Manufacturers</b>										
Captive	30.5	243.7	27.0	149.8	5.0	80.0	--	41.0	--	20.0
PCM/Reseller	45.4	87.2	18.6	83.0	12.0	80.0	5.0	87.0	8.0	94.0
OEM/Integrator	158.8	892.9	98.7	618.0	101.0	540.0	104.0	513.0	120.0	505.0
TOTAL NON-U.S. SHIPMENTS	234.7	1,223.8	144.3	850.8	118.0	700.0	109.0	641.0	128.0	619.0
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE SHIPMENTS	3,728.5	7,946.6	3,454.2	6,858.2	3,217.0	6,105.0	2,854.0	5,195.0	2,238.0	4,095.0
Total Capacity (Terabytes)	93.2	198.4	86.3	171.2	80.4	152.6	71.3	129.8	55.9	102.3
<b>Cumulative Shipments</b>										
IBM	1,957.4	2,844.9	2,419.4	3,544.9	2,867.4	4,244.9	3,267.4	4,864.9	3,587.4	5,364.9
Non-IBM	13,659.3	24,816.6	16,651.5	30,974.8	19,420.5	36,379.8	21,874.5	40,954.8	23,792.5	44,549.8
WORLDWIDE TOTAL	15,616.7	27,661.5	19,070.9	34,519.7	22,287.9	40,624.7	25,141.9	45,819.7	27,379.9	49,914.7

TABLE 25  
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES  
 WORLDWIDE REVENUES (\$M)  
 BREAKDOWN BY DISK DIAMETER

	1988				Forecast											
	Revenues				1989			1990			1991			1992		
	8"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
<b>U.S. MANUFACTURERS</b>																
IBM Captive	--	--	630.0	--	--	385.0	--	--	350.0	--	--	225.0	54.0	--	120.0	85.0
Other U.S. Captive	--	--	40.1	--	--	27.2	--	--	19.2	--	--	12.0	--	--	--	--
PCM/Reseller	--	362.7	157.2	--	212.9	243.5	.3	62.8	272.7	2.8	15.2	244.0	11.4	7.2	151.2	18.8
OEM/Integrator	--	149.7	496.9	.1	49.5	496.1	6.8	13.9	432.6	39.7	2.4	313.7	68.5	--	158.9	145.9
TOTAL U.S. REVENUES	--	512.4	1,324.2	.1	262.4	1,151.8	7.1	76.7	1,074.5	42.5	17.6	794.7	133.9	7.2	430.1	249.7
<b>NON-U.S. MANUFACTURERS</b>																
Captive	--	69.0	141.8	--	52.7	77.6	--	26.8	42.2	--	--	27.1	--	--	13.0	--
PCM/Reseller	--	--	24.0	--	--	22.7	--	--	14.8	--	--	13.2	2.2	--	11.2	4.9
OEM/Integrator	.5	57.4	144.7	--	24.6	113.5	--	13.7	87.0	6.9	6.5	67.4	20.1	--	46.8	38.0
TOTAL NON-U.S. REVENUES	.5	126.4	310.5	--	77.3	213.8	--	40.5	144.0	6.9	6.5	107.7	22.3	--	71.0	42.9
<b>WORLDWIDE RECAP</b>																
Captive	--	69.0	811.9	--	52.7	489.8	--	26.8	411.4	--	--	264.1	54.0	--	133.0	85.0
	--	-73.7%	+8.2%	--	-23.6%	-39.7%	--	-49.1%	-16.0%	--	-100.0%	-35.8%	--	--	-49.6%	+57.4%
PCM/Reseller	--	362.7	181.2	--	212.9	266.2	.3	62.8	287.5	2.8	15.2	257.2	13.6	7.2	162.4	23.7
	--	--	--	--	-41.3%	+46.9%	--	-70.5%	+8.0%	+833.3%	-75.8%	-10.5%	+385.7%	-52.6%	-36.9%	+74.3%
OEM/Integrator	.5	207.1	641.6	.1	74.1	609.6	6.8	27.6	519.6	46.6	8.9	381.1	88.6	--	205.7	183.9
	--	--	--	--	-64.2%	-5.0%	+6,700.0%	-62.8%	-14.8%	+585.3%	-67.8%	-26.7%	+90.1%	-100.0%	-46.0%	+107.6%
Total Revenues	.5	638.8	1,634.7	.1	339.7	1,365.6	7.1	117.2	1,218.5	49.4	24.1	902.4	156.2	7.2	501.1	292.6
	-61.5%	-35.2%	+29.2%	--	-46.8%	-16.5%	+7,000.0%	-65.5%	-10.8%	+595.8%	-79.4%	-25.9%	+216.2%	-70.1%	-44.5%	+87.3%
ANNUAL SHARE, BY DIAMETER	--	28.1%	71.9%	--	19.8%	79.8%	.4%	8.4%	88.0%	3.6%	2.2%	83.4%	14.4%	.9%	62.6%	36.5%

TABLE 26  
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988 Shipments				Forecast											
	8"	5.25"	3.5"	2.5"	1989			1990			1991			1992		
					5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
<b>U.S. MANUFACTURERS</b>																
IBM Captive	--	--	1,050.0	--	--	700.0	--	--	700.0	--	--	500.0	120.0	--	300.0	200.0
Other U.S. Captive	--	--	21.1	--	--	16.0	--	--	12.0	--	--	8.0	--	--	--	--
PCM/Reseller	--	1,850.1	677.6	--	1,275.0	1,249.0	1.0	380.0	1,515.0	15.0	95.0	1,435.0	65.0	45.0	916.0	110.0
OEM/Integrator	--	738.4	2,385.5	.1	286.4	2,460.0	20.0	84.0	2,472.0	227.0	15.0	1,901.0	415.0	--	993.0	912.0
TOTAL U.S. SHIPMENTS	--	2,588.5	4,134.2	.1	1,561.4	4,425.0	21.0	464.0	4,699.0	242.0	110.0	3,844.0	600.0	45.0	2,209.0	1,222.0
<b>NON-U.S. MANUFACTURERS</b>																
Captive	--	52.3	191.4	--	38.5	111.3	--	18.0	62.0	--	--	41.0	--	--	20.0	--
PCM/Reseller	--	--	87.2	--	--	83.0	--	--	80.0	--	--	75.0	12.0	--	66.0	28.0
OEM/Integrator	.2	240.0	652.7	--	78.0	540.0	--	32.0	470.0	38.0	10.0	385.0	118.0	--	275.0	230.0
TOTAL NON-U.S. SHIPMENTS	.2	292.3	931.3	--	116.5	734.3	--	50.0	612.0	38.0	10.0	501.0	130.0	--	361.0	258.0
<b>WORLDWIDE RECAP</b>																
Captive	--	52.3	1,262.5	--	38.5	827.3	--	18.0	774.0	--	--	549.0	120.0	--	320.0	200.0
	--	-71.6%	-7%	--	-26.4%	-34.5%	--	-53.2%	-6.4%	--	-100.0%	-29.1%	--	--	-41.7%	+66.7%
PCM/Reseller	--	1,850.1	764.8	--	1,275.0	1,332.0	1.0	380.0	1,595.0	15.0	95.0	1,510.0	77.0	45.0	982.0	138.0
	--	--	--	--	-31.1%	+74.2%	--	-70.2%	+19.7%	+1,400.0%	-75.0%	-5.3%	+413.3%	-52.6%	-35.0%	+79.2%
OEM/Integrator	.2	978.4	3,038.2	.1	364.4	3,000.0	20.0	116.0	2,942.0	265.0	25.0	2,286.0	533.0	--	1,268.0	1,142.0
	--	--	--	--	-62.8%	-1.3%	--	-68.2%	-1.9%	+1,225.0%	-78.4%	-22.3%	+101.1%	-100.0%	-44.5%	+114.3%
Total Shipments	.2	2,880.8	5,065.5	.1	1,677.9	5,159.3	21.0	514.0	5,311.0	280.0	120.0	4,345.0	730.0	45.0	2,570.0	1,480.0
	-80.0%	-17.8%	+55.2%	--	-41.8%	+1.9%	--	-69.4%	+2.9%	+1,233.3%	-76.7%	-18.2%	+160.7%	-62.5%	-40.9%	+102.7%
ANNUAL SHARE, BY DIAMETER	--	36.2%	63.8%	--	24.5%	75.2%	.3%	8.4%	87.0%	4.6%	2.3%	83.6%	14.1%	1.1%	62.8%	36.1%
TOTAL CAPACITY (Terabytes)	--	71.8	126.6	--	41.7	128.9	.5	12.8	132.7	7.0	3.0	108.6	18.2	1.1	64.2	37.0



TABLE 27  
FIXED DISK DRIVES, LESS THAN 30 MEGABYTES  
APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection			
	Units (000)	%	Units (000)	%		
MAINFRAME/SUPERMINI General purpose	--	--	--	--	—	
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	148.6	1.9	26	24.6	.6	—
PERSONAL COMPUTERS Business and professional, single user	7,294.9	91.8	94.34	3,615.9	88.3	88.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	200.3	2.5	2.05	131.0	3.2	4.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	148.6	1.9	1.3	184.3	4.5	2.7
CONSUMER AND HOBBY COMPUTERS	151.8	1.9	2.03	126.9	3.1	5.0
OTHER APPLICATIONS	--	--	—	12.3	.3	.3
Total	7,946.7	100.0		4,095.0	100.0	

TABLE 28  
 FIXED DISK DRIVES, LESS THAN 30 MEGABYTES  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments											
	To United States Destinations					Worldwide						
	Units (000)					Units (000)						
	8"	5.25"	3.5"	<3.5"	Total	%	8"	5.25"	3.5"	<3.5"	Total	%
SEAGATE	--	1289.0	124.0	--	1413.0	47.5	--	2480.0	375.0	--	2855.0	43.1
MINISCRIBE	--	--	630.0	--	630.0	21.2	--	--	1855.6	--	1855.6	28.0
WESTERN DIGITAL	--	--	397.1	--	397.1	13.4	--	--	447.7	--	447.7	6.8
NEC	--	2.4	--	--	2.4	.1	--	206.0	80.0	--	286.0	4.3
CONNER	--	--	159.0	--	159.0	5.4	--	--	219.0	--	219.0	3.3
JVC	--	--	10.0	--	10.0	.3	--	--	190.0	--	190.0	2.9
KYOCERA	--	--	105.0	--	105.0	3.5	--	--	150.0	--	150.0	2.3
MICROSCIENCE	--	25.0	1.6	--	26.6	.9	--	98.0	4.9	--	102.9	1.6
Other U.S.	--	5.5	136.9	.1	142.5	4.8	--	10.5	160.9	.1	171.5	2.6
Other Non-U.S.	--	--	86.8	--	86.8	2.9	.2	34.0	319.9	--	354.1	5.1
TOTAL	--	1321.9	1650.4	.1	2972.4	100.0	.2	2828.5	3803.0	.1	6631.8	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

Fujitsu	M2241, M2242
Goldstar Telecommunication	GSH-540*
Hitachi	DK511-5, DK521-5*
IBM	4956
Imprimis (Control Data)	94155-48, 94205-51*
Micropolis	1333A
Microscience International	HH-1050*, HH-830*
Miltope	RDS-5000
Mitsubishi Electric	MR533*, MR535*
NEC	D5127H*, D5146H*
Sagem	MSA 240-50
Seagate Technology	ST4053, ST251*
Teac	SD-540*

3.5" disk diameter

Alps Electric	DRQ040A**
Areal Technology	BP 50**
Comport	2040*, 2041*
Conner Peripherals	CP340*, CP3040**
Fuji Electric	FK303-52*, FK312A-50R**
Fujitsu	M2226D2*, M2611S**
Hitachi	DK302-3*
IBM	8550-031
JVC	JD-3848H*, JD-E3848V**
Kalok	KL330*
Kyocera	KC 30B*
Matsushita Communication Ind.	JU-128*
Microscience International	4050*
Miniscribe	8438*, 8438F*
Mitsubishi Electric	MR335*
NEC	D3142*
Peripheral Technology	PT251S*
Plus Development	Hardcard 40**, Passport*
Quantum	40S*, 40AT*
Rodime	R03055*
Samsung Electronics	SHD2040*
Seagate Technology	ST138*, ST157A*
Sony	SRD2040Z*
Tokico	TD3041C*, TD3042C**
Toshiba	MK-133FA*, MK-134FA*
Western Digital	WD93038-X*
Y-E Data	YD-3042*

2.5" disk diameter

Areal Technology  
PrairieTek

MD-2050\*  
240

\*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 will lead 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 and quickly became the leader for high-end laptop portables.

Perhaps providing a glimpse of the future, a new manufacturer, Areal Technology, has announced a 3.5" drive with 50 megabyte capacity, using only one side of a single 3.5" disk. 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.

The first 2.5" drive at the 40 megabyte level has been announced by PrairieTek, using two platters in a 1" high drive -- a first step for a

product form factor expected to become a major part of the industry in future years.

### Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	1,567.2	2,001.7	2,201.8	2,217.2	2,121.4
All manufacturers	2,178.9	2,908.1	3,365.3	3,574.4	3,570.1

Total shipments of drives in the 30-60 megabyte range increased by more than 40% in 1988, and 1989's rapidly growing shipments are expected to be up by the same amount. This product group has now become the industry's largest, in terms of total unit shipments, with 8.2 million drives forecast for 1989. Worldwide revenue growth for 1989 will also be much higher than for any other fixed disk drive group, with an expected increase of 33.5%.

Shipments for all marketing channels are up in 1989, but 3.5" OEM drives are providing most of the expansion, especially from U.S. drive manufacturers, which will increase shipments of 3.5" drives to the OEM/integrator market in 1989 by almost 1.5 million units.

System manufacturers have responded to the trend to smaller personal computer packaging by combining 3.5" drives with the improved capacities available in this product group, a combination seen as a significant improvement by end users when buying upgraded systems. This trend has been stronger than anticipated earlier, and the 1989 increase in unit shipments for 3.5" drives in the 30-60 megabyte range is expected to be up 132%, totaling 5.6 million drives.



IBM is expected to phase out production of 5.25" drives in this product group in 1990, but the firm's shipments of 30 megabyte (formatted) drives is forecasted to increase 30% in 1989, despite the disruption of production at Fujisawa created by changeover to higher performance 1" high models using single platters. 1989 shipments by non-U.S. producers of both captive and non-captive 3.5" drives are expected to be up almost a million drives, led by major increases from NEC, an established manufacturer of small hard disk drives, and from Sony, a new entrant in the rigid disk drive business.

In 1988, Seagate accounted for 49.7% of the product group's worldwide unit shipments of non-captive drives, a total of 2,566,000 drives. More than 80% of Seagate's shipments were 5.25" models, but the company nevertheless also shipped more 3.5" drives in this capacity range than any other manufacturer. Miniscribe again held second place with 8.7% and Conner's growing shipments secured third place with 7.3%. The Miniscribe estimates above and in Table 34 are DISK/TREND estimates, which may be revised if the pending restatement of Miniscribe financial reports indicates the need.

87.3% of 1988 total worldwide shipments of drives in this product group were used in single user personal computer applications. The 5.6% used with minicomputers and multi-user micros in 1988 is expected to be cut in half by 1992, in favor of higher capacity drives, while modest increases are expected in dedicated application non-office markets and with home computers.

#### Marketing trends

Despite the striking growth in shipments for this product group which

has occurred during the last few years, at least three more years of major increases are forecasted. An average annual increase of 14.6% in worldwide shipments is expected during 1990-92, even though the average annual revenue increase for the same period is estimated at only 7.3%.

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 by lower average prices for all drives. Underlying all of these changes is the continuous upward movement in the average capacity of disk drives used with personal computers. This product group has been benefiting from that trend during the last few years, and will eventually suffer from the same trend in the future as average capacities move up.

3.5" drives already dominate the product group in 1989, but 1990's shipments of 3.5" drives are expected to reach 8.3 million units, 82.7% of the worldwide total. More growth for the 3.5" form factor will follow, but at a slower rate, as 2.5" drives repeat the downsizing cycle the industry has come to expect.

<u>Worldwide captive &amp; OEM Unit shipments (000)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
5.25" full size	327.4 5.6%	180.7 2.2%	67.0 .7%	20.0 .2%	5.0 --
5.25" half high	3,084.3 52.8%	2,407.0 29.3%	1,573.0 15.7%	802.0 7.0%	265.0 2.2%
3.5"	2,428.0 41.6%	5,639.0 68.5%	8,300.0 82.7%	10,303.0 90.0%	11,320.0 91.6%
2.5"	-- --	1.0 --	95.0 .9%	315.0 2.8%	770.0 6.2%

Also contributing to the product mix changes in this group is the growing 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, the growing tendency of system manufacturers to bundle a hard disk drive with most PC models and the movement to small footprint personal computers favors future growth for the 3.5" and smaller drives in this capacity range.

#### Technical trends

The same technical developments that are pushing drives below 30 megabytes in capacity toward single disk configurations are having a similar impact on this product group: The pressure to cut costs by reducing the parts count. The first of the single disk 3.5" drives in the 40-50 megabyte range is 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, it is expected that most new drives will offer embedded controllers, with the choice of leading interfaces such as SCSI, PC AT and others.

Higher areal density has also made smaller box sizes practical. The first 2.5" drives in the product group are now being offered, with the Areal Technology drive designed to provide 50 megabytes (formatted), using a single disk in a 3/4" high box. Although most other manufacturers will

not be as aggressive in pushing the limits of the technology during the next few years, several other drives will probably be introduced within the next year.

#### 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. Volume shipments of 2.5" drives will start in 1990.

TABLE 29  
FIXED DISK DRIVES, 30 - 60 MEGABYTES  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM Captive	302.1	438.7	312.0	460.0	451.5	685.0	455.0	700.0	416.0	650.0
Other U.S. Captive	.9	.9	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	303.0	439.6	312.0	460.0	451.5	685.0	455.0	700.0	416.0	650.0
PCM/Reseller	346.2	562.1	492.5	704.3	447.3	637.9	405.2	579.1	372.6	527.0
OEM/Integrator	416.6	565.5	596.7	837.4	637.1	878.9	669.7	938.1	659.2	944.4
TOTAL U.S. NON-CAPTIVE	762.8	1,127.6	1,089.2	1,541.7	1,084.4	1,516.8	1,074.9	1,517.2	1,031.8	1,471.4
TOTAL U.S. REVENUES	1,065.8	1,567.2	1,401.2	2,001.7	1,535.9	2,201.8	1,529.9	2,217.2	1,447.8	2,121.4
<u>Non-U.S. Manufacturers</u>										
Captive	56.2	226.9	72.0	357.7	83.3	404.9	92.0	444.0	103.4	486.0
PCM/Reseller	21.1	35.8	46.7	76.1	63.2	100.2	90.8	143.4	112.6	174.0
OEM/Integrator	78.0	349.0	147.3	472.6	228.5	658.4	287.6	769.8	325.6	788.7
TOTAL NON-U.S. REVENUES	155.3	611.7	266.0	906.4	375.0	1,163.5	470.4	1,357.2	541.6	1,448.7
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE REVENUES	1,221.1	2,178.9	1,667.2	2,908.1	1,910.9	3,365.3	2,000.3	3,574.4	1,989.4	3,570.1
OEM Average Price (\$000)	.317	.322	.294	.297	.266	.266	.245	.246	.225	.225

TABLE 30  
FIXED DISK DRIVES, 30 - 60 MEGABYTES  
UNIT SHIPMENT SUMMARY

	DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)									
	1988		Forecast							
	Shipments		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	345.0	500.0	380.0	560.0	600.0	910.0	650.0	1,000.0	640.0	1,000.0
Other U.S. Captive	.6	.6	--	--	--	--	--	--	--	--
TOTAL U.S. CAPTIVE	345.6	500.6	380.0	560.0	600.0	910.0	650.0	1,000.0	640.0	1,000.0
PCM/Reseller	1,363.6	2,235.1	1,838.5	2,641.7	1,753.0	2,500.0	1,650.0	2,365.0	1,593.0	2,268.0
OEM/Integrator	1,316.5	1,808.8	2,032.5	2,830.6	2,400.0	3,318.0	2,738.0	3,842.0	2,943.0	4,222.0
TOTAL U.S. NON-CAPTIVE	2,680.1	4,043.9	3,871.0	5,472.3	4,153.0	5,818.0	4,388.0	6,207.0	4,536.0	6,490.0
TOTAL U.S. SHIPMENTS	3,025.7	4,544.5	4,251.0	6,032.3	4,753.0	6,728.0	5,038.0	7,207.0	5,176.0	7,490.0
<b>Non-U.S. Manufacturers</b>										
Captive	47.0	177.1	80.0	389.5	98.0	473.0	115.0	555.0	138.0	650.0
PCM/Reseller	50.8	86.9	136.0	230.0	232.0	367.0	359.0	565.0	485.0	749.0
OEM/Integrator	244.3	1,031.2	499.8	1,575.9	858.0	2,467.0	1,168.0	3,113.0	1,437.0	3,471.0
TOTAL NON-U.S. SHIPMENTS	342.1	1,295.2	715.8	2,195.4	1,188.0	3,307.0	1,642.0	4,233.0	2,060.0	4,870.0
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE SHIPMENTS	3,367.8	5,839.7	4,966.8	8,227.7	5,941.0	10,035.0	6,680.0	11,440.0	7,236.0	12,360.0
Total Capacity (Terabytes)	162.3	283.8	237.7	396.5	289.3	490.0	325.5	559.0	353.4	605.0
<b>Cumulative Shipments</b>										
IBM	804.1	1,168.0	1,184.1	1,728.0	1,784.1	2,638.0	2,434.1	3,638.0	3,074.1	4,638.0
Non-IBM	6,993.8	11,112.2	11,580.6	18,779.9	16,921.6	27,904.9	22,951.6	38,344.9	29,547.6	49,704.9
WORLDWIDE TOTAL	7,797.9	12,280.2	12,764.7	20,507.9	18,705.7	30,542.9	25,385.7	41,982.9	32,621.7	54,342.9

TABLE 31  
 FIXED DISK DRIVES, 30 - 60 MEGABYTES  
 WORLDWIDE REVENUES (\$M)  
 BREAKDOWN BY DISK DIAMETER

	1988		Forecast											
	Revenues		1989			1990			1991			1992		
	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
<b>U.S. MANUFACTURERS</b>														
IBM Captive	150.0	288.7	60.0	400.0	--	10.0	675.0	--	--	700.0	--	--	650.0	--
Other U.S. Captive	.9	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	454.0	108.1	441.6	262.7	--	302.5	335.4	--	151.2	410.4	17.5	50.6	437.4	39.0
OEM/Integrator	341.4	224.1	211.7	624.9	.8	100.3	747.0	31.6	41.8	833.3	63.0	12.1	812.3	120.0
TOTAL U.S. REVENUES	946.3	620.9	713.3	1,287.6	.8	412.8	1,757.4	31.6	193.0	1,943.7	80.5	62.7	1,899.7	159.0
<b>NON-U.S. MANUFACTURERS</b>														
Captive	68.2	158.7	24.0	333.7	--	5.4	399.5	--	--	444.0	--	--	463.6	22.4
PCM/Reseller	20.4	15.4	32.0	44.1	--	10.5	89.7	--	6.0	133.8	3.6	--	166.5	7.5
OEM/Integrator	66.8	282.2	23.4	449.2	--	11.2	645.3	1.9	4.8	742.6	22.4	--	742.0	46.7
TOTAL NON-U.S. REVENUES	155.4	456.3	79.4	827.0	--	27.1	1,134.5	1.9	10.8	1,320.4	26.0	--	1,372.1	76.6
<b>WORLDWIDE RECAP</b>														
Captive	219.1 -59.2%	447.4 +336.9%	84.0 -61.7%	733.7 +64.0%	--	15.4 -81.7%	1,074.5 +46.4%	--	-- -100.0%	1,144.0 +6.5%	--	--	1,113.6 -2.7%	22.4 --
PCM/Reseller	474.4 --	123.5 --	473.6 -.2%	306.8 +148.4%	--	313.0 -33.9%	425.1 +38.6%	--	157.2 -49.8%	544.2 +28.0%	21.1 --	50.6 -67.8%	603.9 +11.0%	46.5 +120.4%
OEM/Integrator	408.2 --	506.3 --	235.1 -42.4%	1,074.1 +112.1%	.8	111.5 -52.6%	1,392.3 +29.6%	33.5 +4,087.5%	46.6 -58.2%	1,575.9 +13.2%	85.4 +154.9%	12.1 -74.0%	1,554.3 -1.4%	166.7 +95.2%
Total Revenues	1,101.7 -31.2%	1,077.2 +200.6%	792.7 -28.0%	2,114.6 +96.3%	.8	439.9 -44.5%	2,891.9 +36.8%	33.5 +4,087.5%	203.8 -53.7%	3,264.1 +12.9%	106.5 +217.9%	62.7 -69.2%	3,271.8 +.2%	235.6 +121.2%
ANNUAL SHARE, BY DIAMETER	50.6%	49.4%	27.3%	72.7%	--	13.1%	85.9%	1.0%	5.7%	91.3%	3.0%	1.8%	91.6%	6.6%

TABLE 32  
 FIXED DISK DRIVES, 30 - 60 MEGABYTES  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988		Forecast											
	Shipments		1989			1990			1991			1992		
	5.25"	3.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"	5.25"	3.5"	2.5"
<b>U.S. MANUFACTURERS</b>														
IBM Captive	150.0	350.0	60.0	500.0	--	10.0	900.0	--	--	1,000.0	--	--	1,000.0	--
Other U.S. Captive	.6	--	--	--	--	--	--	--	--	--	--	--	--	--
PCM/Reseller	1,912.0	323.1	1,732.0	909.7	--	1,210.0	1,290.0	--	630.0	1,710.0	25.0	220.0	1,988.0	60.0
OEM/Integrator	1,103.7	705.1	648.2	2,181.4	1.0	355.0	2,873.0	90.0	160.0	3,472.0	210.0	50.0	3,692.0	480.0
TOTAL U.S. SHIPMENTS	3,166.3	1,378.2	2,440.2	3,591.1	1.0	1,575.0	5,063.0	90.0	790.0	6,182.0	235.0	270.0	6,680.0	540.0
<b>NON-U.S. MANUFACTURERS</b>														
Captive	34.3	142.8	12.5	377.0	--	3.0	470.0	--	--	555.0	--	--	618.0	32.0
PCM/Reseller	45.2	41.7	80.0	150.0	--	35.0	332.0	--	20.0	535.0	10.0	--	724.0	25.0
OEM/Integrator	165.9	865.3	55.0	1,520.9	--	27.0	2,435.0	5.0	12.0	3,031.0	70.0	--	3,298.0	173.0
TOTAL NON-U.S. SHIPMENTS	245.4	1,049.8	147.5	2,047.9	--	65.0	3,237.0	5.0	32.0	4,121.0	80.0	--	4,640.0	230.0
<b>WORLDWIDE RECAP</b>														
Captive	184.9 -57.4%	492.8 +67.6%	72.5 -60.8%	877.0 +78.0%	--	13.0 -82.1%	1,370.0 +56.2%	--	-- -100.0%	1,555.0 +13.5%	--	--	1,618.0 +4.1%	32.0 --
PCM/Reseller	1,957.2 --	364.8 --	1,812.0 -7.4%	1,059.7 +190.5%	--	1,245.0 -31.3%	1,622.0 +53.1%	--	650.0 -47.8%	2,245.0 +38.4%	35.0 --	220.0 -66.2%	2,712.0 +20.8%	85.0 +142.9%
OEM/Integrator	1,269.6 --	1,570.4 --	703.2 -44.6%	3,702.3 +135.8%	1.0 --	382.0 -45.7%	5,308.0 +43.4%	95.0 +9,400.0%	172.0 -55.0%	6,503.0 +22.5%	280.0 +194.7%	50.0 -70.9%	6,990.0 +7.5%	653.0 +133.2%
Total Shipments	3,411.7 +8.3%	2,428.0 +145.1%	2,587.7 -24.2%	5,639.0 +132.2%	1.0 --	1,640.0 -36.6%	8,300.0 +47.2%	95.0 +9,400.0%	822.0 -49.9%	10,303.0 +24.1%	315.0 +231.6%	270.0 -67.2%	11,320.0 +9.9%	770.0 +144.4%
ANNUAL SHARE, BY DIAMETER	58.4%	41.6%	31.5%	68.5%	--	16.4%	82.7%	.9%	7.2%	90.0%	2.8%	2.2%	91.6%	6.2%
TOTAL CAPACITY (Terabytes)	169.9	113.8	128.9	267.6	--	82.0	403.3	4.7	41.1	502.1	15.7	13.5	553.0	38.5



TABLE 33  
 FIXED DISK DRIVES, 30 - 60 MEGABYTES  
 APPLICATIONS SUMMARY  
 Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection		
	Units (000)	%	Units (000)	%	
MAINFRAME/SUPERMINI General purpose	--	--	--	--	
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	329.4	5.6	346.1	2.8	3.11 1.5
PERSONAL COMPUTERS Business and professional, single user	5,100.9	87.3	10,790.3	87.3	92.06 90
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	173.4	3.0	309.0	2.5	2.4 1.3
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	171.1	2.9	667.4	5.4	2.11 4.0
CONSUMER AND HOBBY COMPUTERS	63.7	1.1	222.5	1.8	1.32 3.0
OTHER APPLICATIONS	--	--	24.7	.2	-- .2
Total	5,839.8	99.9	12,360.0	100.0	

TABLE 34  
 FIXED DISK DRIVES, 30 - 60 MEGABYTES  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
	5.25"	3.5"	Total		5.25"	3.5"	Total	
SEAGATE	1295.0	318.0	1613.0	54.2	2146.0	420.0	2566.0	49.7
MINISCRIBE	330.0	21.9	351.9	11.8	413.1	34.3	447.4	8.7
CONNER	--	300.4	300.4	10.1	--	375.6	375.6	7.3
NEC	6.4	4.0	10.4	.3	120.4	197.0	317.4	6.1
IMPRIMIS	206.4	--	206.4	6.9	286.4	--	286.4	5.5
FUJITSU	1.4	10.7	12.1	.4	1.7	181.5	183.2	3.5
RODIME	--	107.6	107.6	3.6	--	165.6	165.6	3.2
MICROSCIENCE	72.0	--	72.0	2.4	160.0	--	160.0	3.1
KYOCERA	--	105.0	105.0	3.5	--	150.0	150.0	2.9
Other U.S.	5.2	131.2	136.4	4.6	10.2	198.3	208.5	4.2
Other Non-U.S.	30.2	29.8	60.0	2.2	89.0	212.9	301.9	5.8
TOTAL	1946.6	1028.6	2975.2	100.0	3226.8	1935.2	5162.0	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

Fujitsu	M2312K, M2321K
Hitachi	DK812S-8
Priam	7050, 803

5.25" disk diameter

Fujitsu	M2243, M2243T*
Hewlett-Packard	7957B
Hitachi	DK511-8, DK512-8
IBM	4956, 667-85
Imprimis (Control Data)	94155-85, 94205-77*
Maxtor	XT-1085
Micropolis	1353, 1373
Microscience International	HH-1075*, HH-1090*
Mitsubishi Electric	MR537S*
NEC	D5147H*, D5452
Quantum	Q280*
Rodime	R05090*
Seagate	ST277N*, ST4096
Toshiba	MK-56FB

3.5" disk diameter

Comport	2082*
IBM	8550-061
Kalok	KL360*
Matsushita Communication Ind.	JU-1391*
Microscience International	4060*
Peripheral Technology	PT-376A*
Quantum	80S*, 80AT*
Rodime	R03085R*
Seagate	ST1096N*, ST1102A*
Tokico	TD3081C
Toshiba	MK-233FB*
Y-E Data	YD-3082*

\*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 underway in 1981 with early entrants such as the 8" Priam and Fujitsu drives, which devel-

oped 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. 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.

#### Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	1,428.2	1,496.6	1,748.6	2,142.1	2,446.5
All manufacturers	1,592.4	1,672.4	2,156.6	2,785.3	3,348.5

Worldwide shipments of fixed disk drives in the 60-100 megabyte range increased 59.9% in 1988, and are expected to grow an additional 32% in 1989, reaching a total of 2.2 million units for the year. Revenue growth for 1988 was only 38.3%, with a drop to 5% in 1989, due to a combination of changes in product mix and marketing channels. Revenues have been held down by lower average unit prices and declining shipments of 5.25" drives to the personal computer aftermarket, despite rapidly growing shipments of 3.5" drives to system manufacturers.

## **1989 DISK/TREND REPORT**

IBM's captive shipments of 60 megabyte (formatted) 3.5" drives with its PS/2 systems will account for more than half of the industry's worldwide shipments of 3.5" drives in 1989. Captive shipments by other manufacturers are just starting this year.

The 60-100 megabyte capacity range was established as a separate DISK/TREND group only last year, primarily in recognition of the rapid growth of 85 megabyte 5.25" drives during the second half of this decade. But disk drive industry successes are temporary phenomena. 8" drive shipments in this group peaked in 1984, and total 5.25" shipments will top out in 1988. 3.5" drive shipments are now off to a fast start, boosted by heavy shipments of IBM's new 60 megabyte drive, with several OEM drives now available and many more coming soon.

The personal computer market has rapidly become the dominant market for 60-100 megabyte drives, absorbing 75.7% of 1988's worldwide unit shipments, as the minicomputer and technical workstation markets moved to higher capacity drives for the preponderance of their purchases. This trend is continuing, with personal computers expected to account for 83% of 1992 shipments.

Seagate's 226,000 5.25" drives gave the company leadership in non-captive unit shipments in 1988, with 20.7% of the worldwide total, passing up Micropolis for the first time. Micropolis and Imprimis were essentially tied for second place, with 15.9% and 15.6%, all 5.25" drives. Quantum appeared again among the leaders with 13.9%, mostly 3.5" drives. Miniscribe is shown with 9.6% share of shipments in Table 40, strictly on the basis of DISK/TREND's estimate, and subject to change if the auditors significantly rewrite the company's financial history.



Marketing trends

Driven by IBM's growing shipments and a sustained surge in the OEM market, shipments for this product group are expected to increase at an average annual rate of 44% for the 1990-92 period. 1992 worldwide shipments are forecasted at 6.5 million drives.

The major cause of growth for drives using 5.25" disks and smaller will continue to be the expanding market for mid-range personal computers, and most of the growth will go to 3.5" drives.

<u>Worldwide captive &amp; OEM Unit shipments (000)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
5.25" full size	839.0 51.0%	555.5 25.2%	269.0 7.9%	101.0 2.1%	28.0 .4%
5.25" half high	355.2 21.6%	386.4 17.6%	354.0 10.3%	276.0 5.6%	161.0 2.5%
3.5"	450.3 27.4%	1,257.5 57.2%	2,791.0 81.8%	4,543.0 92.3%	6,351.0 97.1%

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, which will be employed with drives in this group as suitable heads, disks and other components become available through the pioneering at higher capacities. The packaging techniques developed for one inch high drives with lower capacities also will be 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 to be employed, embedded controllers will be used with most drives, to mask unique individual file organization, with most drive manufacturers offering an optional choice of most interfaces compatible with popular personal computers.

#### Forecasting assumptions

1. IBM's production of 5.25" drives will stop in 1990, while 3.5" shipments will build rapidly. IBM will rely on internal manufacturing for drives in this group, but will supplement internal shortfalls with outside purchases.
2. Growth for OEM 5.25" drives ended in 1988 except for continued growth for half high models through 1989, limited by movement to higher capacities, and by a movement to 3.5" drives.
3. Availability of OEM 3.5" drives will be adequate to satisfy growing demand.

TABLE 35  
FIXED DISK DRIVES, 60-100 MEGABYTES  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>	-----									
IBM Captive	621.9	875.0	644.6	930.0	698.8	1,030.0	820.0	1,240.0	875.0	1,365.0
Other U.S. Captive	13.6	32.6	16.1	39.1	2.2	8.8	6.4	9.6	15.4	26.6
TOTAL U.S. CAPTIVE	635.5	907.6	660.7	969.1	701.0	1,038.8	826.4	1,249.6	890.4	1,391.6
PCM/Reseller	181.2	260.5	140.3	180.1	123.1	159.6	155.1	207.5	240.2	332.5
OEM/Integrator	191.4	260.1	270.7	347.4	462.2	550.2	569.0	685.0	574.1	722.4
TOTAL U.S. NON-CAPTIVE	372.6	520.6	411.0	527.5	585.3	709.8	724.1	892.5	814.3	1,054.9
<b>TOTAL U.S. REVENUES</b>	<b>1,008.1</b>	<b>1,428.2</b>	<b>1,071.7</b>	<b>1,496.6</b>	<b>1,286.3</b>	<b>1,748.6</b>	<b>1,550.5</b>	<b>2,142.1</b>	<b>1,704.7</b>	<b>2,446.5</b>
<b>Non-U.S. Manufacturers</b>	-----									
Captive	3.0	54.8	--	59.4	24.0	156.4	49.5	204.3	73.6	254.4
PCM/Reseller	.9	1.6	8.4	11.2	22.9	32.4	43.3	66.0	70.6	105.6
OEM/Integrator	29.9	107.8	30.6	105.2	82.6	219.2	156.5	372.9	257.6	542.0
TOTAL NON-U.S. REVENUES	33.8	164.2	39.0	175.8	129.5	408.0	249.3	643.2	401.8	902.0
<b>Worldwide Recap</b>	-----									
TOTAL WORLDWIDE REVENUES	1,041.9	1,592.4	1,110.7	1,672.4	1,415.8	2,156.6	1,799.8	2,785.3	2,106.5	3,348.5
<b>OEM Average Price (\$000)</b>	<b>.573</b>	<b>.606</b>	<b>.486</b>	<b>.485</b>	<b>.448</b>	<b>.451</b>	<b>.423</b>	<b>.424</b>	<b>.399</b>	<b>.400</b>

TABLE 36  
FIXED DISK DRIVES, 60-100 MEGABYTES  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		Forecast							
	Shipments		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	402.0	550.0	556.0	800.0	764.0	1,125.0	1,025.0	1,550.0	1,250.0	1,950.0
Other U.S. Captive	5.2	12.5	7.0	17.0	1.0	4.0	8.0	12.0	22.0	38.0
TOTAL U.S. CAPTIVE	407.2	562.5	563.0	817.0	765.0	1,129.0	1,033.0	1,562.0	1,272.0	1,988.0
PCM/Reseller	332.4	480.5	318.0	409.0	298.0	387.0	377.0	504.0	583.0	806.0
OEM/Integrator	339.2	460.3	557.5	739.0	1,035.0	1,238.0	1,346.0	1,624.0	1,440.0	1,813.0
TOTAL U.S. NON-CAPTIVE	671.6	940.8	875.5	1,148.0	1,333.0	1,625.0	1,723.0	2,128.0	2,023.0	2,619.0
TOTAL U.S. SHIPMENTS	1,078.8	1,503.3	1,438.5	1,965.0	2,098.0	2,754.0	2,756.0	3,690.0	3,295.0	4,607.0
<b>Non-U.S. Manufacturers</b>										
Captive	1.0	17.1	--	22.5	24.0	133.0	55.0	227.0	92.0	318.0
PCM/Reseller	1.2	2.2	15.4	21.2	39.0	58.0	86.0	133.0	176.0	263.0
OEM/Integrator	47.0	146.8	62.6	194.1	180.0	469.5	367.0	870.0	644.0	1,352.0
TOTAL NON-U.S. SHIPMENTS	49.2	166.1	78.0	237.8	243.0	660.5	508.0	1,230.0	912.0	1,933.0
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE SHIPMENTS	1,128.0	1,669.4	1,516.5	2,202.8	2,341.0	3,414.5	3,264.0	4,920.0	4,207.0	6,540.0
Total Capacity (Terabytes)	94.8	140.9	131.0	189.4	206.0	297.9	289.5	433.1	375.3	579.8
<b>Cumulative Shipments</b>										
IBM	751.1	1,076.0	1,307.1	1,876.0	2,071.1	3,001.0	3,096.1	4,551.0	4,346.1	6,501.0
Non-IBM	2,267.2	3,338.0	3,227.7	4,740.8	4,804.7	7,030.3	7,043.7	10,400.3	10,000.7	14,990.3
WORLDWIDE TOTAL	3,018.3	4,414.0	4,534.8	6,616.8	6,875.8	10,031.3	10,139.8	14,951.3	14,346.8	21,491.3

TABLE 37  
FIXED DISK DRIVES, 60-100 MEGABYTES  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988			Forecast									
	Revenues			1989			1990			1991		1992	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
<b>U.S. MANUFACTURERS</b>													
IBM Captive	144.0	221.0	510.0	--	160.0	770.0	--	40.0	990.0	--	1,240.0	--	1,365.0
Other U.S. Captive	--	32.6	--	--	39.1	--	--	8.8	--	--	9.6	--	26.6
PCM/Reseller	--	256.2	4.3	--	149.6	30.5	--	101.6	58.0	61.7	145.8	29.9	302.6
OEM/Integrator	6.6	244.8	8.7	5.3	173.7	168.4	--	107.8	442.4	57.7	627.3	24.4	698.0
TOTAL U.S. REVENUES	150.6	754.6	523.0	5.3	522.4	968.9	--	258.2	1,490.4	119.4	2,022.7	54.3	2,392.2
<b>NON-U.S. MANUFACTURERS</b>													
Captive	.8	54.0	--	.8	52.1	6.5	--	36.4	120.0	--	204.3	--	254.4
PCM/Reseller	--	.6	1.0	--	7.7	3.5	--	10.2	22.2	8.5	57.5	4.0	101.6
OEM/Integrator	3.7	89.9	14.2	2.0	39.5	63.7	1.3	24.8	193.1	16.3	356.6	8.4	533.6
TOTAL NON-U.S. REVENUES	4.5	144.5	15.2	2.8	99.3	73.7	1.3	71.4	335.3	24.8	618.4	12.4	889.6
<b>WORLDWIDE RECAP</b>													
Captive	144.8	307.6	510.0	.8	251.2	776.5	--	85.2	1,110.0	--	1,453.9	--	1,646.0
	-6.0%	-24.5%	--	-99.4%	-18.3%	+52.3%	-100.0%	-66.1%	+42.9%	-100.0%	+31.0%	--	+13.2%
PCM/Reseller	--	256.8	5.3	--	157.3	34.0	--	111.8	80.2	70.2	203.3	33.9	404.2
	--	--	--	--	-38.7%	+541.5%	--	-28.9%	+135.9%	-37.2%	+153.5%	-51.7%	+98.8%
OEM/Integrator	10.3	334.7	22.9	7.3	213.2	232.1	1.3	132.6	635.5	74.0	983.9	32.8	1,231.6
	--	--	--	-29.1%	-36.3%	+913.5%	-82.2%	-37.8%	+173.8%	-44.2%	+54.8%	-55.7%	+25.2%
Total Revenues	155.1	899.1	538.2	8.1	621.7	1,042.6	1.3	329.6	1,825.7	144.2	2,641.1	66.7	3,281.8
	-7.6%	-8.2%	--	-94.8%	-30.9%	+93.7%	-84.0%	-47.0%	+75.1%	-56.2%	+44.7%	-53.7%	+24.3%
ANNUAL SHARE, BY DIAMETER	9.7%	56.5%	33.8%	.5%	37.2%	62.3%	.1%	15.3%	84.6%	5.2%	94.8%	2.0%	98.0%

TABLE 38  
 FIXED DISK DRIVES, 60-100 MEGABYTES  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988 Shipments			Forecast									
	8"	5.25"	3.5"	1989			1990			1991		1992	
	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"	5.25"	3.5"
<b>U.S. MANUFACTURERS</b>													
IBM Captive	20.0	130.0	400.0	--	100.0	700.0	--	25.0	1,100.0	--	1,550.0	--	1,950.0
Other U.S. Captive	--	12.5	--	--	17.0	--	--	4.0	--	--	12.0	--	38.0
PCM/Reseller	--	473.5	7.0	--	354.0	55.0	--	265.0	122.0	180.0	324.0	94.0	712.0
OEM/Integrator	3.3	443.0	14.0	2.5	381.0	355.5	--	255.0	983.0	148.0	1,476.0	68.0	1,745.0
TOTAL U.S. SHIPMENTS	23.3	1,059.0	421.0	2.5	852.0	1,110.5	--	549.0	2,205.0	328.0	3,362.0	162.0	4,445.0
<b>NON-U.S. MANUFACTURERS</b>													
Captive	.1	17.0	--	.1	17.4	5.0	--	13.0	120.0	--	227.0	--	318.0
PCM/Reseller	--	.9	1.3	--	15.2	6.0	--	21.0	37.0	18.0	115.0	9.0	254.0
OEM/Integrator	1.5	117.3	28.0	.8	57.3	136.0	.5	40.0	429.0	31.0	839.0	18.0	1,334.0
TOTAL NON-U.S. SHIPMENTS	1.6	135.2	29.3	.9	89.9	147.0	.5	74.0	586.0	49.0	1,181.0	27.0	1,906.0
<b>WORLDWIDE RECAP</b>													
Captive	20.1 -2.4%	159.5 -11.6%	400.0 --	.1 -99.5%	134.4 -15.7%	705.0 +76.3%	-- -100.0%	42.0 -68.7%	1,220.0 +73.0%	-- -100.0%	1,789.0 +46.6%	-- --	2,306.0 +28.9%
PCM/Reseller	-- --	474.4 --	8.3 --	-- --	369.2 -22.2%	61.0 +634.9%	-- --	286.0 -22.5%	159.0 +160.7%	198.0 -30.8%	439.0 +176.1%	103.0 -48.0%	966.0 +120.0%
OEM/Integrator	4.8 --	560.3 --	42.0 --	3.3 -31.2%	438.3 -21.8%	491.5 +1,070.2%	.5 -84.8%	295.0 -32.7%	1,412.0 +187.3%	179.0 -39.3%	2,315.0 +64.0%	86.0 -52.0%	3,079.0 +33.0%
Total Shipments	24.9 -8.8%	1,194.2 +18.1%	450.3 +8,906.0%	3.4 -86.3%	941.9 -21.1%	1,257.5 +179.3%	.5 -85.3%	623.0 -33.9%	2,791.0 +121.9%	377.0 -39.5%	4,543.0 +62.8%	189.0 -49.9%	6,351.0 +39.8%
ANNUAL SHARE, BY DIAMETER	1.5%	71.5%	27.0%	.1%	42.8%	57.1%	--	18.2%	81.8%	7.7%	92.3%	2.9%	97.1%
TOTAL CAPACITY (Terabytes)	1.8	105.4	33.6	.2	84.3	104.7	--	55.9	241.9	34.0	399.0	17.1	562.6

TABLE 39  
FIXED DISK DRIVES, 60-100 MEGABYTES  
APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	--	--	--	--
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	164.4	9.9	392.4	6.0
PERSONAL COMPUTERS Business and professional, single user	1,263.7	75.7	5,454.4	83.4
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	96.3	5.8	268.1	4.1
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	132.6	7.9	392.4	6.0
CONSUMER AND HOBBY COMPUTERS	12.0	.7	26.2	.4
OTHER APPLICATIONS	--	--	6.5	.1
Total	1,669.4	100.0	6,540.0	100.0

TABLE 40  
 FIXED DISK DRIVES, 60-100 MEGABYTES  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	8"	5.25"	3.5"	Total		8"	5.25"	3.5"	Total	
SEAGATE	--	131.0	--	131.0	18.2	--	226.0	--	226.0	20.7
MICROPOLIS	--	121.1	--	121.1	16.8	--	173.0	--	173.0	15.9
IMPRIMIS	--	107.7	--	107.7	15.0	--	169.7	--	169.7	15.6
QUANTUM	--	123.0	16.0	139.0	19.3	--	130.0	21.0	151.0	13.9
MINISCRIBE	--	93.0	--	93.0	12.9	--	104.4	--	104.4	9.6
FUJITSU	.2	5.2	--	5.4	.8	1.5	56.6	--	58.1	5.3
PRIAM	3.3	35.1	--	38.4	5.3	3.3	49.4	--	52.7	4.8
MICROSCIENCE	--	17.0	--	17.0	2.4	--	34.0	--	34.0	3.1
Other U.S.	--	24.4	--	24.4	3.4	--	30.0	--	30.0	2.8
Other Non-U.S.	--	27.6	15.2	42.8	5.9	--	61.6	29.3	90.9	8.3
TOTAL	3.5	685.1	31.2	719.8	100.0	4.8	1034.7	50.3	1089.8	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
-----	--------------------

9" disk diameter

Imprimis	9715-160
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8" disk diameter

DDC Pertec	DX199, DX265
Fujitsu	M2322
Hitachi	DK812S-12, DK814S-17
IBM	9332-200
Mitsubishi Electric	M4870F
NEC	D2257
Northern Telecom	8208X, 8210X
Priam	806
Toshiba	MK186FB

5.25" disk diameter

Digital Equipment	RF30*
Fujitsu	M2245E, M2243R*
Hewlett-Packard	97532E, 97533E
Hitachi	DK512-17, DK522C-10*
IBM	8580-111, 671-284
Imprimis	94166-182, 94221-190*
Magtron	4170*
Maxtor	XT-1140, XT-2190
Micropolis	1554, 1674-7*
Microscience International	HH-1120*, HH-3120*
Miltope	RDS-1720
Mitsubishi Electric	MR5310E*
NEC	D5655*, D5852
Priam	519, 728
Rodime	R05180S*
Sagem	MSA 250-100
Seagate Technology	ST4144R
Siemens	2300
Toshiba	MK-156FB

3.5" disk diameter

Areal Technology	BP 100**
Cardiff Peripherals	F-3193-S*
Conner Peripherals	CP3100*, CP3200*
Fujitsu	M2614S*
IBM	8570-121
Imprimis	94354-200*
Maxtor	LXT-100S*, LXT-200S*
Microscience International	5100*
Miltope	RDS-3200
Mitsubishi Electric	MR3314S*
NEC	D3661*
Quantum	170S*, 210AT*
Rodime	R03259A*
Seagate Technology	ST1144N*
Toshiba	MK-234FB*

\*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>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	1,465.2	1,622.3	1,984.5	2,498.2	3,089.8
All manufacturers	2,031.0	2,314.9	2,842.1	3,607.5	4,556.1

Worldwide shipments for this product group more than doubled in 1988, mostly as the result of the final year of dynamic growth for 5.25" drives, with a 1988 group total of 1,176,200 drives. But 5.25" shipments peaked in 1988, and the 60.6% increase in shipments expected for 1989 will be generated by a fourfold growth in 3.5" drive shipments. Revenues for 1989 are expected to increase only 14%, however, since OEM drives, at lower prices, will constitute a larger share of total shipments.

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" is expected to be down to 40.1%, with 3.5" drives up to 58.5%.

IBM's shipments of 14", 8", 5.25" and 3.5" drives totaled an estimated 252,500 drives in 1988, going up to 350,000 in 1989, more than 70% of worldwide captive shipments for 1988, 73.6% of the captive worldwide unit shipment total. Most non-captive shipments during 1988 and 1989 are still going to system manufacturers; growth in aftermarket sales through PCM/reseller channels will probably take a few more years to develop. The leading application for drives in this group became the personal computer market in 1988, 36.5% of all shipments, which is expected to become almost half of the market by 1992. Minicomputers and multi-user micros, which previously was the dominant application, was down to 35% in 1988, with

non-office systems and workstations retaining approximately the same share, at 21.1%.

A spurt in 1988 shipments totaling 230,100 drives by Imprimis gave the firm 26.9% of worldwide non-captive shipments, mostly 5.25" drives, including both full size and half high models. Micropolis and Maxtor followed with 20.0% and 18.8%

### Marketing trends

1992 unit shipments for this product group are expected to be almost five times the 1988 level. But few of 1992's forecasted 5.5 million drives will be the 5.25" models which provided most of the group's recent growth. 3.5" drive shipments in 1992 are estimated at 5,215,000, 93.9% of the worldwide total.

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 will be built upon the personal computer market, which is rapidly upgrading to more capable processors, being used for applications which need more data storage.

Although some usage of 3.5" drives in this product group with technical workstations has 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 two 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.

Even half high 5.25" drives are peaking in shipments in 1989. Half high drives have been 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 underway.

<u>Worldwide captive &amp; OEM Unit shipments (000)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
5.25" full size	682.1 61.1%	442.3 23.8%	281.0 10.0%	157.0 3.9%	82.0 1.5%
5.25" half high	169.1 15.1%	314.1 16.9%	308.5 11.0%	283.0 7.1%	253.0 4.6%
3.5"	265.3 23.8%	1,105.0 59.3%	2,218.0 79.0%	3,553.0 89.0%	5,215.0 93.9%

Underlying the expected 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, in high volume production only during the last two years, will be acceptable for many workstation applications, but 3.5" drives are becoming the choice for low-end workstations, even though volume production was limited to the 100-110 megabyte range until recently. With 200 megabyte 3.5 inch drives now coming into 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 up to five disks, new head suspensions, embedded controllers, and very fast actuators.

Areal Technology's single disk 3.5" drive offering 100 megabytes (formatted) capacity is the most technically ambitious undertaking among the new products, operating at 57,000 BPI (2,7 RLL) and 1,720 TPI. Ironically, the drive designers had to cut the rotational speed to 1,600 RPM to adhere to the transfer rate limitations of the markets addressed.

The Areal Technology drive is the only 1" high 3.5" model announced so far, but it probably won't be the last. Whether other drives to be offered in the near future use a single disk, such as Areal does, or use two or more disks to achieve the same capacity, there will be a market for 1" high 3.5" drives in this group with 386-based laptop computers as users' appetites for storage continue to grow.

Most drive manufacturers are offering ESDI interfaces with 5.25" drives operating at 10 megabit/second transfer rates, and embedded SCSI controllers are also available with most 5.25" drives. 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 SCSI and embedded controllers compatible with specific personal computers will probably continue to predominate.

Forecasting assumptions

1. Growth in IBM's shipments in this group will continue to be dominated by 3.5" drives.
2. U.S. manufacturers will continue to dominate OEM shipments of 5.25" and 3.5" drives, due to their early market lead and favorable dollar/yen exchange rate.

TABLE 41  
FIXED DISK DRIVES, 100 - 300 MEGABYTES  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	572.6	782.6	534.0	735.6	533.3	746.1	630.0	900.0	812.0	1,190.0
Other U.S. Captive	16.2	31.0	62.1	136.5	76.5	165.2	74.9	159.0	74.5	169.3
TOTAL U.S. CAPTIVE	588.8	813.6	596.1	872.1	609.8	911.3	704.9	1,059.0	886.5	1,359.3
PCM/Reseller	66.9	89.5	66.0	83.9	77.9	96.2	132.3	167.6	217.4	288.5
OEM/Integrator	432.0	562.1	525.9	666.3	770.2	977.0	951.7	1,271.6	1,011.3	1,442.0
TOTAL U.S. NON-CAPTIVE	498.9	651.6	591.9	750.2	848.1	1,073.2	1,084.0	1,439.2	1,228.7	1,730.5
TOTAL U.S. REVENUES	1,087.7	1,465.2	1,188.0	1,622.3	1,457.9	1,984.5	1,788.9	2,498.2	2,115.2	3,089.8
<b>Non-U.S. Manufacturers</b>										
Captive	32.5	386.3	128.2	439.3	119.0	505.6	174.2	551.1	243.9	664.7
PCM/Reseller	23.9	30.5	15.5	19.2	17.2	25.9	29.9	44.9	67.2	97.8
OEM/Integrator	58.9	149.0	60.3	234.1	105.0	326.1	184.2	513.3	270.0	703.8
TOTAL NON-U.S. REVENUES	115.3	565.8	204.0	692.6	241.2	857.6	388.3	1,109.3	581.1	1,466.3
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE REVENUES	1,203.0	2,031.0	1,392.0	2,314.9	1,699.1	2,842.1	2,177.2	3,607.5	2,696.3	4,556.1
OEM Average Price (\$000)	.994	.976	.709	.713	.651	.650	.645	.645	.598	.599

TABLE 42  
FIXED DISK DRIVES, 100 - 300 MEGABYTES  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		-----Forecast-----							
	Shipments		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	195.0	252.5	257.0	350.0	312.5	434.0	420.0	600.0	580.0	850.0
Other U.S. Captive	4.4	8.6	16.6	36.0	18.5	40.0	23.0	47.0	29.0	65.0
TOTAL U.S. CAPTIVE	199.4	261.1	273.6	386.0	331.0	474.0	443.0	647.0	609.0	915.0
PCM/Reseller	68.2	92.9	87.0	110.0	118.0	145.0	228.0	288.0	423.0	561.0
OEM/Integrator	442.4	591.7	746.8	944.5	1,185.0	1,503.0	1,479.0	1,976.0	1,692.0	2,412.0
TOTAL U.S. NON-CAPTIVE	510.6	684.6	833.8	1,054.5	1,303.0	1,648.0	1,707.0	2,264.0	2,115.0	2,973.0
TOTAL U.S. SHIPMENTS	710.0	945.7	1,107.4	1,440.5	1,634.0	2,122.0	2,150.0	2,911.0	2,724.0	3,888.0
<b>Non-U.S. Manufacturers</b>										
Captive	5.5	59.2	28.5	101.5	33.2	153.4	66.0	223.0	117.0	326.0
PCM/Reseller	27.1	34.3	22.8	28.3	26.3	39.5	46.0	69.0	112.0	163.0
OEM/Integrator	51.7	137.0	79.5	318.4	159.1	500.1	283.0	792.0	450.0	1,173.0
TOTAL NON-U.S. SHIPMENTS	84.3	230.5	130.8	448.2	218.6	693.0	395.0	1,084.0	679.0	1,662.0
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE SHIPMENTS	794.3	1,176.2	1,238.2	1,888.7	1,852.6	2,815.0	2,545.0	3,995.0	3,403.0	5,550.0
Total Capacity (Terabytes)	127.5	189.0	188.3	286.1	315.7	465.1	473.2	719.3	712.1	1,128.3
<b>Cumulative Shipments</b>										
IBM	288.4	385.8	545.4	735.8	857.9	1,169.8	1,277.9	1,769.8	1,857.9	2,619.8
Non-IBM	1,290.0	2,034.4	2,271.2	3,573.1	3,811.3	5,954.1	5,936.3	9,349.1	8,759.3	14,049.1
WORLDWIDE TOTAL	1,578.4	2,420.2	2,816.6	4,308.9	4,669.2	7,123.9	7,214.2	11,118.9	10,617.2	16,668.9

TABLE 43  
FIXED DISK DRIVES, 100 - 300 MEGABYTES  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988				Forecast											
	Revenues				1989				1990			1991			1992	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"
<b>U.S. MANUFACTURERS</b>																
IBM Captive	210.1	90.5	212.0	270.0	35.1	70.5	162.5	467.5	34.1	72.0	640.0	--	--	900.0	--	1,190.0
Other U.S. Captive	--	--	31.0	--	--	--	136.5	--	--	165.2	--	--	132.0	27.0	94.5	74.8
PCM/Reseller	--	--	88.5	1.0	--	--	66.7	17.2	--	50.0	46.2	--	47.6	120.0	40.5	248.0
OEM/Integrator	20.2	5.0	462.3	74.6	6.9	1.9	284.0	373.5	--	191.7	785.3	--	126.9	1,144.7	86.0	1,356.0
TOTAL U.S. REVENUES	230.3	95.5	793.8	345.6	42.0	72.4	649.7	858.2	34.1	478.9	1,471.5	--	306.5	2,191.7	221.0	2,868.8
<b>NON-U.S. MANUFACTURERS</b>																
Captive	--	164.3	208.3	13.7	--	60.4	273.6	105.3	34.6	226.2	244.8	20.0	163.1	368.0	85.2	579.5
PCM/Reseller	--	--	22.2	8.3	--	--	4.2	15.0	--	3.1	22.8	--	4.6	40.3	7.2	90.6
OEM/Integrator	--	31.3	107.4	10.3	--	18.4	102.0	113.7	.3	68.4	257.4	--	49.8	463.5	38.4	665.4
TOTAL NON-U.S. REVENUES	--	195.6	337.9	32.3	--	78.8	379.8	234.0	34.9	297.7	525.0	20.0	217.5	871.8	130.8	1,335.5
<b>WORLDWIDE RECAP</b>																
Captive	210.1 -36.7%	254.8 +61.7%	451.3 +67.1%	283.7 --	35.1 -83.3%	130.9 -48.6%	572.6 +26.9%	572.8 +101.9%	68.7 -47.5%	463.4 -19.1%	884.8 +54.5%	20.0 -70.9%	295.1 -36.3%	1,295.0 +46.4%	179.7 -39.1%	1,844.3 +42.4%
PCM/Reseller	-- --	-- --	110.7 --	9.3 --	-- --	-- --	70.9 -36.0%	32.2 +246.2%	-- --	53.1 -25.1%	69.0 +114.3%	-- --	52.2 -1.7%	160.3 +132.3%	47.7 -8.6%	338.6 +111.2%
OEM/Integrator	20.2 --	36.3 --	569.7 --	84.9 --	6.9 -65.8%	20.3 -44.1%	386.0 -32.2%	487.2 +473.9%	.3 -98.5%	260.1 -32.6%	1,042.7 +114.0%	-- -100.0%	176.7 -32.1%	1,608.2 +54.2%	124.4 -29.6%	2,021.4 +25.7%
Total Revenues	230.3 -34.0%	291.1 +13.4%	1,131.7 +54.9%	377.9 +2,658.4%	42.0 -81.8%	151.2 -48.1%	1,029.5 -9.0%	1,092.2 +189.0%	69.0 -54.4%	776.6 -24.6%	1,996.5 +82.8%	20.0 -71.0%	524.0 -32.5%	3,063.5 +53.4%	351.8 -32.9%	4,204.3 +37.2%
ANNUAL SHARE, BY DIAMETER	11.3%	14.3%	55.8%	18.6%	1.8%	6.5%	44.5%	47.2%	2.4%	27.3%	70.3%	.6%	14.5%	84.9%	7.7%	92.3%

Note: 8 inch totals include 9 inch drives.

TABLE 44  
 FIXED DISK DRIVES, 100 - 300 MEGABYTES  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988 Shipments				Forecast											
	14"	8"	5.25"	3.5"	1989				1990			1991			1992	
	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	8"	5.25"	3.5"	8"	5.25"	3.5"	5.25"	3.5"
<b>U.S. MANUFACTURERS</b>																
IBM Captive	12.0	10.5	80.0	150.0	2.0	8.0	65.0	275.0	4.0	30.0	400.0	--	--	600.0	--	850.0
Other U.S. Captive	--	--	8.6	--	--	--	36.0	--	--	40.0	--	--	32.0	15.0	21.0	44.0
PCM/Reseller	--	--	91.5	1.4	--	--	84.0	26.0	--	68.0	77.0	--	70.0	218.0	65.0	496.0
OEM/Integrator	6.3	1.9	498.7	84.8	2.3	.8	374.4	567.0	--	295.0	1,208.0	--	215.0	1,761.0	152.0	2,260.0
TOTAL U.S. SHIPMENTS	18.3	12.4	678.8	236.2	4.3	8.8	559.4	868.0	4.0	433.0	1,685.0	--	317.0	2,594.0	238.0	3,650.0
<b>NON-U.S. MANUFACTURERS</b>																
Captive	--	15.2	39.1	4.9	--	5.8	56.7	39.0	3.4	48.0	102.0	2.0	37.0	184.0	21.0	305.0
PCM/Reseller	--	--	22.6	11.7	--	--	5.3	23.0	--	4.5	35.0	--	7.0	62.0	12.0	151.0
OEM/Integrator	--	13.8	110.7	12.5	--	8.4	135.0	175.0	.1	104.0	396.0	--	79.0	713.0	64.0	1,109.0
TOTAL NON-U.S. SHIPMENTS	--	29.0	172.4	29.1	--	14.2	197.0	237.0	3.5	156.5	533.0	2.0	123.0	959.0	97.0	1,565.0
<b>WORLDWIDE RECAP</b>																
Captive	12.0 -38.1%	25.7 +77.2%	127.7 +105.3%	154.9 --	2.0 -83.3%	13.8 -46.3%	157.7 +23.5%	314.0 +102.7%	7.4 -46.4%	118.0 -25.2%	502.0 +59.9%	2.0 -73.0%	69.0 -41.5%	799.0 +59.2%	42.0 -39.1%	1,199.0 +50.1%
PCM/Reseller	-- --	-- --	114.1 --	13.1 --	-- --	-- --	89.3 -21.7%	49.0 +274.0%	-- --	72.5 -18.8%	112.0 +128.6%	-- --	77.0 +6.2%	280.0 +150.0%	77.0 --	647.0 +131.1%
OEM/Integrator	6.3 --	15.7 --	609.4 --	97.3 --	2.3 -63.5%	9.2 -41.4%	509.4 -16.4%	742.0 +662.6%	.1 -98.9%	399.0 -21.7%	1,604.0 +116.2%	-- -100.0%	294.0 -26.3%	2,474.0 +54.2%	216.0 -26.5%	3,369.0 +36.2%
Total Shipments	18.3 -26.5%	41.4 -21.1%	851.2 +93.9%	265.3 +2,022.4%	4.3 -76.5%	23.0 -44.4%	756.4 -11.1%	1,105.0 +316.5%	7.5 -67.4%	589.5 -22.1%	2,218.0 +100.7%	2.0 -73.3%	440.0 -25.4%	3,553.0 +60.2%	335.0 -23.9%	5,215.0 +46.8%
ANNUAL SHARE, BY DIAMETER	1.6%	3.5%	72.4%	22.5%	.2%	1.2%	40.1%	58.5%	.3%	20.9%	78.8%	.1%	11.0%	88.9%	6.1%	93.9%
TOTAL CAPACITY (Terabytes)	3.8	7.9	138.6	38.6	.8	4.5	123.6	157.1	1.5	124.9	338.6	.3	94.1	624.8	73.2	1,055.1

Note: 8 inch totals include 9 inch drives.

TABLE 45  
FIXED DISK DRIVES, 100 - 300 MEGABYTES

APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection	
	Units (000)	%	Units (000)	%
MAINFRAME/SUPERMINI General purpose	23.1	2.0	5.6	.1
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	411.7	35.0	22.74 1,692.8	30.5
PERSONAL COMPUTERS Business and professional, single user	429.3	36.5	60.22 2,652.7	47.8
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	52.5	4.4	9.93 99.9	1.8
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	247.9	21.1	6.73 1,082.3	19.5
CONSUMER AND HOBBY COMPUTERS	11.6	1.0	.29 11.1	.2
OTHER APPLICATIONS	--	--	.09 5.6	.1
Total	1,176.2	100.1	5,550.2	100.0

TABLE 46  
 FIXED DISK DRIVES, 100 - 300 MEGABYTES  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 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	
IMPRIMIS	--	.2	152.5	4.1	156.8	26.6	--	.3	224.5	5.3	230.1	26.9
MICROPOLIS	--	--	119.8	--	119.8	20.3	--	--	171.1	--	171.1	20.0
MAXTOR	--	--	133.5	3.4	136.9	23.2	--	--	156.5	4.0	160.5	18.8
CONNER	--	--	--	60.9	60.9	10.3	--	--	--	76.9	76.9	9.0
RODIME	--	--	27.6	12.4	40.0	6.8	--	--	42.5	19.1	61.6	7.2
HITACHI	--	1.3	4.2	--	5.5	.9	--	1.8	40.8	--	42.6	5.0
FUJITSU	--	3.7	7.1	--	10.8	1.8	--	7.8	16.9	4.1	28.8	3.4
PRIAM	6.3	1.6	15.8	--	23.7	4.0	6.3	1.6	19.1	--	27.0	3.2
Other U.S.	--	--	12.5	--	12.5	2.3	--	--	19.0	--	19.0	2.2
Other Non-U.S.	--	2.2	20.3	--	22.5	3.8	--	4.2	33.1	1.0	38.3	4.3
<b>TOTAL</b>	<b>6.3</b>	<b>9.0</b>	<b>493.3</b>	<b>80.8</b>	<b>589.4</b>	<b>100.0</b>	<b>6.3</b>	<b>15.7</b>	<b>723.5</b>	<b>110.4</b>	<b>855.9</b>	<b>100.0</b>

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

Century Data	AMS 315
Data General	6236
Digital Equipment	RA81
Fujitsu	M2294
IBM	5360-BXA, 4967-3CA

10.5" disk diameter

Fujitsu	M2350A, F6421
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9" disk diameter

Imprimis	9715-300, 9715-340
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8" disk diameter

Century Data	C2400, C2476
DDC Pertec	DX332, DX368
Fujitsu	M2333K
Hewlett-Packard	7936H
Hitachi	DK-814S-34
IBM	9332-400, 678-400
Imprimis	9720-368
Mitsubishi Electric	MR4875
NEC	D2268H
Northern Telecom	8308, 8212X
Priam	807
Toshiba	MK-286FC

5.25" disk diameter

Digital Equipment	RA70, RF71
Fujitsu	M2249E/S
Hewlett-Packard	97536E/S, 97544P
Hitachi	DK514-38
IBM	8580-311, 671-387
Imprimis	94181-385H, 94246-383*
Maxtor	XT-4380E/S, XT-8380E/S
Micropolis	1558-15, 1664-7*
Miltope	RDS-3800
Miniscribe	9380E/S
NEC	D5662

5.25" disk diameter (continued)

Priam	638, 738
Siemens	1300, 4410
Toshiba	MK-256FA

3.5" disk diameter

Cardiff Peripherals	F3347E*
IBM	661*

\*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 -- and several are 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.

Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	1,696.5	1,765.0	2,129.8	2,234.5	2,296.4
All manufacturers	2,404.8	2,505.1	2,805.2	2,914.0	3,024.6

As expected, worldwide revenues for 300-500 megabyte drives topped \$2.4 billion in 1988, up 18.2%, and unit shipments achieved the highest percentage growth of any product group, up 129.1%, to 550,200 drives. But the shift in product mix to 5.25" drives will result in a revenue increase estimated at only 4.2% in 1989, even with a forecasted 46.2% growth in unit shipments for the entire product group. Gains in total revenue have been hurt by the lower average price of the smaller drives, plus a substantial migration to higher capacities for 8" and 14" captive drives.

The big news in this product group during the last two years has been the intense competition by at least a dozen manufacturers for an OEM drive market recognized by all to be a major sales opportunity. After initial skepticism regarding the Maxtor 380 megabyte 5.25" drive, first shipped in 1984, thirteen firms had started production by 1988.

Unfortunately, several of the producers of OEM 380 megabyte drives significantly overestimated the potential size of the 1988 market, and some quoted unrealistically low prices in their quest for market share, turning a growing market into a losing business.

But despite the industry's planning problems, 1988 worldwide shipments of 5.25" drive shipments in this group totaled 365,900 units in 1988, very close to the DISK/TREND estimates during the last two years, of which 288,700 were non-captive drives. Although the migration to 760 megabyte models is already underway, 5.25" drives in this group are nevertheless expected to achieve an overall shipment total of 660,900 units this year.

IBM continues to maintain a major interest in the range of products represented by this group. Although the company's shipments of 14" and 8" drives are now declining, production of the IBM "Lee" 5.25" drive, with

formatted capacity of 315 megabytes, has increased from an estimated 50,000 units last year to an expected 90,000 drives in 1989.

IBM's introduction this year of a 3.5" drive in this product group has revealed an interesting change in direction in 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" 320 megabyte (formatted) 3.5" drive, for which IBM started production in the third quarter of 1989. The drive is being 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.

Fujitsu lost its previous lead in non-captive shipments for this product group to three U.S. companies which captured leadership in 5.25" drive shipments. Imprimis led in 1988 with shipments of 113,300 drives, including both 8" and 5.25" models, for 28.4% of the worldwide total, followed by Micropolis with 18.8% and Maxtor with 15.5%.

Minicomputer and multi-user micro applications, including network file servers, continued to lead with 43.5% of all unit shipments for the product group in 1988, and further growth to 58.5% in 1992 is expected. Technical workstations will also secure a growing share, but mainframes and superminis, which accounted for 19.3% of the units shipped in 1988, will drop sharply as older drives are discontinued.

#### Marketing trends

Substantial continuing growth for this product group is expected, but not for the 14" and 8"-9" drives which dominated shipments until last

year. Even the 5.25" drives which have provided most of the current growth are forecasted to peak in 1991, the victim of the migration by many system manufacturers to capacities above the range included in this group, plus sharply increasing shipments of the 3.5" drives expected from many drive manufacturers next year. One result of these product mix changes will be lower average prices, holding down revenue increases for the group to an annual average of only 5.5% for the 1990-92 time period.

With its headstart in production of high capacity 3.5" drives, IBM's shipments are expected to reach 400,000 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, none of which have yet been announced, 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 a double capacity version planned for next year.

Running counter to the worldwide trend, OEM shipments of 14" drives by non-U.S. manufacturers have been growing, and that growth is forecasted to continue through 1990, before starting a slow decline -- a trend caused entirely by Eastern Bloc shipments of 317 megabyte 3350-type drives for mainframe applications.

#### 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 underway 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, Imprimis and Micropolis, have elected to 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 will probably limit participation in the half high field to those firms already active with lower capacity 5.25" drives employing fast actuators.

The advent of 3.5" drives in this group is expected to have a major impact, with 3.5" comprising over 60% of the 1992 shipment forecast. While many manufacturers are still sweating out the design and manufacturing startup problems associated with 3.5" drives at the 200 megabyte level, it is predictable that most will eventually also offer drives in 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, run length limited encoding methods, intelligent interfaces, and extensive use of VLSI in drive electronics. IBM's new Lightning drive uses 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 by more than a third.

In 1987, limited availability of thin film heads for 5.25" drives in this group caused severe problems for several companies, but the industry

experienced greatly improved availability of required components during the last year. In the case of thin film heads, which many in the industry assumed would be necessary for small diameter drives in this product group, the drive manufacturers have found current sourcing to be more predictable -- and many have decided to utilize the newer MIG heads, as a competitive alternative.

#### Forecasting assumptions

1. Total shipments of 14", 9" and 8" drives will continue to decline.
2. Sustained growth for technical workstations, LANs, general purpose mini/micros and specialized systems will create significant growth for both captive and OEM 5.25" drives, as well as the newer 3.5" drives.

TABLE 47  
FIXED DISK DRIVES, 300 - 500 MEGABYTES  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>	-----									
IBM Captive	598.5	842.0	602.9	842.0	651.2	917.6	541.8	783.0	473.0	693.0
Other U.S. Captive	149.3	297.5	128.0	234.1	254.6	424.7	314.3	533.4	366.4	627.9
TOTAL U.S. CAPTIVE	747.8	1,139.5	730.9	1,076.1	905.8	1,342.3	856.1	1,316.4	839.4	1,320.9
PCM/Reseller	39.4	50.6	123.2	141.5	166.2	200.4	164.8	213.9	202.1	277.1
OEM/Integrator	379.3	506.4	409.6	547.4	442.9	587.1	522.5	704.2	493.1	698.4
TOTAL U.S. NON-CAPTIVE	418.7	557.0	532.8	688.9	609.1	787.5	687.3	918.1	695.2	975.5
<b>TOTAL U.S. REVENUES</b>	<b>1,166.5</b>	<b>1,696.5</b>	<b>1,263.7</b>	<b>1,765.0</b>	<b>1,514.9</b>	<b>2,129.8</b>	<b>1,543.4</b>	<b>2,234.5</b>	<b>1,534.6</b>	<b>2,296.4</b>
<b>Non-U.S. Manufacturers</b>	-----									
Captive	24.0	413.4	22.5	411.6	36.0	309.0	25.5	289.7	21.6	292.0
PCM/Reseller	1.3	3.2	.4	1.0	7.4	16.1	17.4	34.8	30.2	51.8
OEM/Integrator	88.7	291.7	68.3	327.5	58.1	350.3	59.1	355.0	98.8	384.4
TOTAL NON-U.S. REVENUES	114.0	708.3	91.2	740.1	101.5	675.4	102.0	679.5	150.6	728.2
<b>Worldwide Recap</b>	-----									
<b>TOTAL WORLDWIDE REVENUES</b>	<b>1,280.5</b>	<b>2,404.8</b>	<b>1,354.9</b>	<b>2,505.1</b>	<b>1,616.4</b>	<b>2,805.2</b>	<b>1,645.4</b>	<b>2,914.0</b>	<b>1,685.2</b>	<b>3,024.6</b>
<b>OEM Average Price (\$000)</b>	<b>1.9</b>	<b>2.2</b>	<b>1.4</b>	<b>1.8</b>	<b>1.2</b>	<b>1.5</b>	<b>1.1</b>	<b>1.3</b>	<b>1.0</b>	<b>1.1</b>

TABLE 48  
FIXED DISK DRIVES, 300 - 500 MEGABYTES  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		-----Forecast-----							
	Shipments		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b> -----										
IBM Captive	68.4	92.0	94.8	127.0	189.7	262.0	213.0	305.0	215.0	315.0
Other U.S. Captive	14.3	30.2	18.8	33.5	39.1	65.2	53.0	90.0	71.0	121.0
TOTAL U.S. CAPTIVE	82.7	122.2	113.6	160.5	228.8	327.2	266.0	395.0	286.0	436.0
PCM/Reseller	28.0	35.9	88.2	103.8	136.0	165.0	156.0	203.0	213.0	292.0
OEM/Integrator	213.9	279.9	302.7	398.7	381.0	505.5	505.0	682.0	523.0	741.0
TOTAL U.S. NON-CAPTIVE	241.9	315.8	390.9	502.5	517.0	670.5	661.0	885.0	736.0	1,033.0
TOTAL U.S. SHIPMENTS	324.6	438.0	504.5	663.0	745.8	997.7	927.0	1,280.0	1,022.0	1,469.0
<b>Non-U.S. Manufacturers</b> -----										
Captive	2.0	29.4	2.5	44.1	4.5	39.0	3.3	41.0	4.0	52.0
PCM/Reseller	.6	1.5	.2	.5	6.0	13.0	15.0	30.0	28.0	48.0
OEM/Integrator	36.4	81.3	33.9	96.6	34.8	116.0	45.5	159.0	91.0	246.0
TOTAL NON-U.S. SHIPMENTS	39.0	112.2	36.6	141.2	45.3	168.0	63.8	230.0	123.0	346.0
<b>Worldwide Recap</b> -----										
TOTAL WORLDWIDE SHIPMENTS	363.6	550.2	541.1	804.2	791.1	1,165.7	990.8	1,510.0	1,145.0	1,815.0
Total Capacity (Terabytes)	141.9	215.3	209.4	311.5	293.2	434.5	369.5	564.6	438.0	694.1
<b>Cumulative Shipments</b> -----										
IBM	232.7	357.8	327.5	484.8	517.2	746.8	730.2	1,051.8	945.2	1,366.8
Non-IBM	725.7	1,186.5	1,172.0	1,863.7	1,773.4	2,767.4	2,551.2	3,972.4	3,481.2	5,472.4
WORLDWIDE TOTAL	958.4	1,544.3	1,499.5	2,348.5	2,290.6	3,514.2	3,281.4	5,024.2	4,426.4	6,839.2

TABLE 49  
FIXED DISK DRIVES, 300 - 500 MEGABYTES  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988			1989				1990				Forecast				1991				1992							
	14"	8"	5.25"	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"				
<b>U.S. MANUFACTURERS</b>																											
IBM Captive	126.0	476.0	240.0	34.0	350.0	432.0	26.0	--	159.6	264.0	494.0	--	63.0	--	720.0	--	--	--	693.0	--	--	--	--	693.0			
Other U.S. Captive	161.1	28.0	108.4	17.4	4.4	212.3	--	--	2.2	422.5	--	--	--	491.4	42.0	--	--	506.3	121.6	--	--	--	--	506.3	121.6		
PCM/Reseller	--	--	50.6	--	--	87.5	54.0	--	--	96.4	104.0	--	--	87.4	126.5	--	--	50.9	226.2	--	--	--	--	50.9	226.2		
OEM/Integrator	8.7	187.8	309.9	--	60.0	487.4	--	--	25.5	453.6	108.0	--	8.4	447.2	248.6	--	--	364.0	334.4	--	--	--	--	364.0	334.4		
TOTAL U.S. REVENUES	295.8	691.8	708.9	51.4	414.4	1,219.2	80.0	--	187.3	1,236.5	706.0	--	71.4	1,026.0	1,137.1	--	--	921.2	1,375.2	--	--	--	--	921.2	1,375.2		
<b>NON-U.S. MANUFACTURERS</b>																											
Captive	87.4	252.5	73.5	33.0	140.6	238.0	--	--	64.0	245.0	--	--	32.0	227.7	30.0	--	--	204.0	88.0	--	--	--	--	204.0	88.0		
PCM/Reseller	--	--	3.2	--	--	1.0	--	--	--	9.6	6.5	--	--	13.2	21.6	--	--	10.0	41.8	--	--	--	--	10.0	41.8		
OEM/Integrator	165.5	75.6	50.6	201.5	58.5	67.5	--	220.0	36.7	84.0	9.6	190.0	23.1	100.1	41.8	144.0	18.4	84.0	138.0	144.0	18.4	84.0	138.0	144.0	18.4	84.0	138.0
TOTAL NON-U.S. REVENUES	252.9	328.1	127.3	234.5	199.1	306.5	--	220.0	100.7	338.6	16.1	190.0	55.1	341.0	93.4	144.0	18.4	298.0	267.8	144.0	18.4	298.0	267.8	144.0	18.4	298.0	267.8
<b>WORLDWIDE RECAP</b>																											
Captive	374.5	756.5	421.9	84.4	495.0	882.3	26.0	--	225.8	931.5	494.0	--	95.0	719.1	792.0	--	--	710.3	902.6	--	--	--	--	710.3	902.6		
	-60.6%	+29.2%	+1,019.1%	-77.5%	-34.6%	+109.1%	--	-100.0%	-54.4%	+5.6%	+1,800.0%	--	-57.9%	-22.8%	+60.3%	--	-100.0%	-1.2%	+14.0%	--	--	--	--	-1.2%	+14.0%		
PCM/Reseller	--	--	53.8	--	--	88.5	54.0	--	--	106.0	110.5	--	--	100.6	148.1	--	--	60.9	268.0	--	--	--	--	60.9	268.0		
	--	--	--	--	--	+64.5%	--	--	--	+19.8%	+104.6%	--	--	-5.1%	+34.0%	--	--	-39.5%	+81.0%	--	--	--	--	-39.5%	+81.0%		
OEM/Integrator	174.2	263.4	360.5	201.5	118.5	554.9	--	220.0	62.2	537.6	117.6	190.0	31.5	547.3	290.4	144.0	18.4	448.0	472.4	144.0	18.4	448.0	472.4	144.0	18.4	448.0	472.4
	--	--	--	+15.7%	-55.0%	+53.9%	--	+9.2%	-47.5%	-3.1%	--	-13.6%	-49.4%	+1.8%	+146.9%	-24.2%	-41.6%	-18.1%	+62.7%	-24.2%	-41.6%	-18.1%	+62.7%	-24.2%	-41.6%	-18.1%	+62.7%
Total Revenues	548.7	1,019.9	836.2	285.9	613.5	1,525.7	80.0	220.0	288.0	1,575.1	722.1	190.0	126.5	1,367.0	1,230.5	144.0	18.4	1,219.2	1,643.0	144.0	18.4	1,219.2	1,643.0	144.0	18.4	1,219.2	1,643.0
	-47.9%	+17.8%	+617.2%	-47.9%	-39.8%	+82.5%	--	-23.1%	-53.1%	+3.2%	+802.6%	-13.6%	-56.1%	-13.2%	+70.4%	-24.2%	-85.5%	-10.8%	+33.5%	-24.2%	-85.5%	-10.8%	+33.5%	-24.2%	-85.5%	-10.8%	+33.5%
ANNUAL SHARE, BY DIAMETER	22.8%	42.4%	34.8%	11.4%	24.5%	60.9%	3.2%	7.8%	10.3%	56.2%	25.7%	6.5%	4.3%	47.0%	42.2%	4.8%	.6%	40.3%	54.3%	4.8%	.6%	40.3%	54.3%	4.8%	.6%	40.3%	54.3%

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

TABLE 50  
 FIXED DISK DRIVES, 300 - 500 MEGABYTES  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988 Shipments			1989				1990				Forecast 1991				Forecast 1992			
	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"
<b>U.S. MANUFACTURERS</b>																			
IBM Captive	7.0	35.0	50.0	2.0	25.0	90.0	10.0	--	12.0	60.0	190.0	--	5.0	--	300.0	--	--	--	315.0
Other U.S. Captive	11.0	2.5	16.7	1.1	.4	32.0	--	--	.2	65.0	--	--	--	78.0	12.0	--	--	83.0	38.0
PCM/Reseller	--	--	35.9	--	--	73.8	30.0	--	--	85.0	80.0	--	--	88.0	115.0	--	--	54.0	238.0
OEM/Integrator	1.5	59.1	219.3	--	18.7	380.0	--	--	8.5	407.0	90.0	--	3.0	453.0	226.0	--	--	389.0	352.0
TOTAL U.S. SHIPMENTS	19.5	96.6	321.9	3.1	44.1	575.8	40.0	--	20.7	617.0	360.0	--	8.0	619.0	653.0	--	--	526.0	943.0
<b>NON-U.S. MANUFACTURERS</b>																			
Captive	3.8	15.1	10.5	1.5	8.6	34.0	--	--	4.0	35.0	--	--	2.0	33.0	6.0	--	--	30.0	22.0
PCM/Reseller	--	--	1.5	--	--	.5	--	--	--	8.0	5.0	--	--	12.0	18.0	--	--	10.0	38.0
OEM/Integrator	18.7	30.6	32.0	20.8	25.2	50.6	--	22.0	16.0	70.0	8.0	20.0	10.0	91.0	38.0	16.0	8.0	84.0	138.0
TOTAL NON-U.S. SHIPMENTS	22.5	45.7	44.0	22.3	33.8	85.1	--	22.0	20.0	113.0	13.0	20.0	12.0	136.0	62.0	16.0	8.0	124.0	198.0
<b>WORLDWIDE RECAP</b>																			
Captive	21.8	52.6	77.2	4.6	34.0	156.0	10.0	--	16.2	160.0	190.0	--	7.0	111.0	318.0	--	--	113.0	375.0
	-62.1%	+26.4%	+1,303.6%	-78.9%	-35.4%	+102.1%	--	-100.0%	-52.4%	+2.6%	+1,800.0%	--	-56.8%	-30.6%	+67.4%	--	-100.0%	+1.8%	+17.9%
PCM/Reseller	--	--	37.4	--	--	74.3	30.0	--	--	93.0	85.0	--	--	100.0	133.0	--	--	64.0	276.0
	--	--	--	--	--	+98.7%	--	--	--	+25.2%	+183.3%	--	--	+7.5%	+56.5%	--	--	-36.0%	+107.5%
OEM/Integrator	20.2	89.7	251.3	20.8	43.9	430.6	--	22.0	24.5	477.0	98.0	20.0	13.0	544.0	264.0	16.0	8.0	473.0	490.0
	--	--	--	+3.0%	-51.1%	+71.3%	--	+5.8%	-44.2%	+10.8%	--	-9.1%	-46.9%	+14.0%	+169.4%	-20.0%	-38.5%	-13.1%	+85.6%
Total Shipments	42.0	142.3	365.9	25.4	77.9	660.9	40.0	22.0	40.7	730.0	373.0	20.0	20.0	755.0	715.0	16.0	8.0	650.0	1,141.0
	-41.5%	+15.4%	+711.3%	-39.5%	-45.3%	+80.6%	--	-13.4%	-47.8%	+10.5%	+832.5%	-9.1%	-50.9%	+3.4%	+91.7%	-20.0%	-60.0%	-13.9%	+59.6%
ANNUAL SHARE, BY DIAMETER	7.6%	25.9%	66.5%	3.1%	9.7%	82.2%	5.0%	1.9%	3.5%	62.6%	32.0%	1.3%	1.3%	50.0%	47.4%	.9%	.4%	35.8%	62.9%
TOTAL CAPACITY (Terabytes)	18.6	55.7	140.9	10.1	31.3	255.2	14.8	8.8	15.8	278.4	131.3	7.4	8.0	290.0	259.0	5.9	2.8	252.8	432.4

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

TABLE 51  
FIXED DISK DRIVES, 300 - 500 MEGABYTES  
APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection			
	Units (000)	%	Units (000)	%		
MAINFRAME/SUPERMINI General purpose	106.3	19.3	8.74	72.6	4.0	2.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	239.1	43.5	41.05	1,061.8	58.5	55
PERSONAL COMPUTERS Business and professional, single user	61.2	11.1	18.84	254.1	14.0	22
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	23.5	4.3	15.12	27.2	1.5	3.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	119.3	21.7	16.18	399.3	22.0	18.0
CONSUMER AND HOBBY COMPUTERS	.7	.1	—	--	--	0
OTHER APPLICATIONS	--	--	.07	--	--	0
Total	550.3	100.1		1,815.0	100.0	

TABLE 52  
 FIXED DISK DRIVES, 300 - 500 MEGABYTES  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
IMPRIMIS	--	40.7	42.8	83.5	29.9	--	52.1	61.2	113.3	28.4
MICROPOLIS	--	--	52.6	52.6	18.9	--	--	75.0	75.0	18.8
MAXTOR	--	--	52.6	52.6	18.9	--	--	61.8	61.8	15.5
FUJITSU	2.0	18.5	6.4	26.9	9.6	6.7	26.7	18.0	51.4	12.9
MINISCRIBE	--	--	36.5	36.5	13.1	--	--	40.7	40.7	10.2
Other U.S.	.9	5.0	10.8	16.7	6.0	1.5	7.0	16.5	25.0	6.3
Other Non-U.S.	--	3.8	6.3	10.1	3.6	12.0	3.9	15.5	31.4	7.9
TOTAL	2.9	68.0	208.0	278.9	100.0	20.2	89.7	288.7	398.6	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
Data General	6239, 6357
Digital Equipment	RA82
Hitachi	DKU-97S, DKU-85I-D14
Imprimis	9771, 9772, 9775
NEC	N7761, N7755

10.5" disk diameter

Fujitsu	F6425, M2361A
---------	---------------

9" disk diameter

Hitachi	DK815-5
Imprimis	9715-500
Mitsubishi Electric	E1880B
NEC	D2352, D2462

8" disk diameter

Century Data	C2600, C2800
Data General	6581
DDC Pertec	DX548, DX731
Fujitsu	M2344K/KS
Hewlett-Packard	7937S
IBM	9332-600
Imprimis	9720-736, 9720-850
Northern Telecom	8312, 8412
Toshiba	MK-288FC, 388FA

5.25" disk diameter

Fujitsu	M2263E
Hewlett-Packard	97548P
Hitachi	DK711S-60D
Imprimis	94191-766, 94241-502*
Maxtor	XT-8760E, P2-08S
Micropolis	1568-15
Priam	776
Siemens	5810, 5820
Toshiba	MK-358FA

\*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 past three years several 8" drives with capacities more than 500 megabytes entered the market, and Maxtor's introduction of a 768 megabyte 5.25" drive precipitated a flurry of announcements from many of the same companies currently competing for the 380 megabyte 5.25" market.

#### Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	2,720.4	2,950.8	3,138.5	2,924.8	2,613.4
All manufacturers	3,539.5	3,847.4	4,120.5	3,826.0	3,398.8

The impact of rising 5.25" drive shipments is being felt in this product group during 1989. In 1988, worldwide shipments of both 14" and 8" drives increased almost 50%, but both drive families have started to decline in 1989. In contrast, 5.25" drive shipments, which constituted less than 6% of 1988 total unit shipments, will provide an estimated 37.7% of 1989 shipments.

The evolving product mix is holding down total revenue growth for the group. While worldwide revenues grew 46.6% in 1988 to \$3.5 billion, this year's \$3.8 billion is only an 8.7% increase. The effect of reduced captive shipments of 14" drives and lower OEM shipments of 8"-9" drives is barely being offset by the fast growth of 5.25" OEM drives sold at lower average prices.

## **1989 DISK/TREND REPORT**

Two thirds of 1988 unit shipments were used for mainframe and super-mini applications, but this application area is expected to decrease in the future in percentage share, although growing in unit shipments, as minicomputer and technical workstations increase demand.

Imprimis retained leadership in non-captive shipments for 1988, mostly on the strength of increased 8" drive shipments. The Imprimis total was 60,100 drives, for a 41.1% share of worldwide shipments, followed by Fujitsu with 23.9% and NEC with 10.6%.

### Marketing trends

This product group will continue to provide a contrast of healthy annual increases in unit shipments, averaging 39.7% from 1990 through 1992, with declining annual revenues, dropping an average of 3.7% during the same years. The transition from 14" and 8"-9" drives to 5.25" and 3.5" drives will cause the revenue shortfall, as average prices decline for all distribution channels.

760 megabyte 5.25" drives are the subject of widespread design-in activity by system manufacturers during 1989, with numerous system introductions planned in the coming months. The result will be rapid growth for 5.25" drives in 1990 and 1991. The already large shipments of 5.25" OEM drives will be supplemented by new captive drives, including a program from IBM expected for startup in 1990.

However, growth in 5.25" shipments will slow to a crawl after 1991, 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 will probably be introduced by IBM in 1990, a double capacity version of the 320 megabyte (formatted) "Lightning" drive first shipped in

1989. But many other 3.5" drives will probably follow in 1991, and by 1992 3.5" models are forecasted to account for a third of worldwide unit shipments.

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 through 1991 will consist primarily of refinements to the basic products already introduced. The most difficult, and probably most expensive, challenge in reducing the physical size of high capacity drives is in all aspects of the packaging problem -- more VLSI, thinner disks, higher density heads and more advanced motors. 8"-9" drives have established high standards for performance and reliability, and new specifications for many 5.25" drives already exceed these standards.

The 16 millisecond average positioning time common in the 8"-9" group has been equalled or bettered by many of the new 5.25" drives, and performance will improve beyond this level in the following years.

Forecasting assumptions

1. IBM will continue production of 8" and 14" drives in this capacity range through 1991, but will also start shipments of 5.25" and 3.5" drives in 1990.
2. Production of 8" and 9" drives peaked in 1988.
3. Significant production quantities of 5.25" drives will be available from several vendors during the forecast period, and quantity production of 3.5" drives by multiple vendors will start in 1991.



TABLE 53  
FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE  
REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		-----Forecast-----				1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b>										
IBM Captive	760.2	1,431.1	966.7	1,797.0	1,070.3	1,980.9	1,122.0	1,858.0	980.0	1,530.0
Other U.S. Captive	549.5	984.8	386.9	773.5	274.4	534.0	214.5	397.5	218.0	407.0
TOTAL U.S. CAPTIVE	1,309.7	2,415.9	1,353.6	2,570.5	1,344.7	2,514.9	1,336.5	2,255.5	1,198.0	1,937.0
PCM/Reseller	15.2	17.7	30.0	38.9	46.0	61.3	66.6	93.7	82.0	114.7
OEM/Integrator	215.5	286.8	263.3	341.4	432.8	562.3	441.0	575.6	427.9	561.7
TOTAL U.S. NON-CAPTIVE	230.7	304.5	293.3	380.3	478.8	623.6	507.6	669.3	509.9	676.4
TOTAL U.S. REVENUES	1,540.4	2,720.4	1,646.9	2,950.8	1,823.5	3,138.5	1,844.1	2,924.8	1,707.9	2,613.4
<b>Non-U.S. Manufacturers</b>										
Captive	--	521.3	22.8	626.5	40.0	715.0	47.5	635.0	36.0	534.0
PCM/Reseller	--	--	1.8	3.6	10.2	20.4	16.6	31.7	22.9	43.0
OEM/Integrator	157.7	297.8	148.7	266.5	146.5	246.6	141.6	234.5	123.5	208.4
TOTAL NON-U.S. REVENUES	157.7	819.1	173.3	896.6	196.7	982.0	205.7	901.2	182.4	785.4
<b>Worldwide Recap</b>										
TOTAL WORLDWIDE REVENUES	1,698.1	3,539.5	1,820.2	3,847.4	2,020.2	4,120.5	2,049.8	3,826.0	1,890.3	3,398.8
OEM Average Price (\$000)	4.0	4.1	2.6	2.7	1.9	1.9	1.6	1.6	1.3	1.3

TABLE 54  
FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		-----Forecast-----							
	---Shipments---		-----1989-----		-----1990-----		-----1991-----		-----1992-----	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<b>U.S. Manufacturers</b> -----										
IBM Captive	36.8	68.0	49.0	90.0	72.8	123.0	136.3	205.0	172.0	260.0
Other U.S. Captive	35.5	64.5	25.4	52.3	27.8	54.0	36.0	66.5	47.0	87.0
TOTAL U.S. CAPTIVE	72.3	132.5	74.4	142.3	100.6	177.0	172.3	271.5	219.0	347.0
PCM/Reseller	4.1	5.1	14.5	19.1	26.0	35.0	43.5	61.5	62.0	87.0
OEM/Integrator	53.9	71.2	111.0	141.0	237.5	306.0	286.0	372.0	337.0	442.0
TOTAL U.S. NON-CAPTIVE	58.0	76.3	125.5	160.1	263.5	341.0	329.5	433.5	399.0	529.0
TOTAL U.S. SHIPMENTS	130.3	208.8	199.9	302.4	364.1	518.0	501.8	705.0	618.0	876.0
<b>Non-U.S. Manufacturers</b> -----										
Captive	--	24.8	1.2	29.8	2.0	43.0	2.5	50.0	2.0	61.0
PCM/Reseller	--	--	.5	1.0	5.0	10.0	10.5	20.0	17.0	32.0
OEM/Integrator	40.4	69.9	50.0	85.5	65.3	109.0	81.6	135.0	88.2	149.0
TOTAL NON-U.S. SHIPMENTS	40.4	94.7	51.7	116.3	72.3	162.0	94.6	205.0	107.2	242.0
<b>Worldwide Recap</b> -----										
TOTAL WORLDWIDE SHIPMENTS	170.7	303.5	251.6	418.7	436.4	680.0	596.4	910.0	725.2	1,118.0
Total Capacity (Terabytes)	125.2	225.4	185.6	312.3	322.4	508.4	438.0	674.0	517.5	801.0
Cumulative Shipments		225.3		312.2		508.3		673.9		800.8
IBM	133.6	281.2	182.6	371.2	255.4	494.2	391.7	699.2	563.7	959.2
Non-IBM	368.7	687.6	571.3	1,016.3	934.9	1,573.3	1,395.0	2,278.3	1,948.2	3,136.3
WORLDWIDE TOTAL	502.3	968.8	753.9	1,387.5	1,190.3	2,067.5	1,786.7	2,977.5	2,511.9	4,095.5

TABLE 55  
FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988			1989			1990				Forecast				1992			
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"
<b>U.S. MANUFACTURERS</b>																		
IBM Captive	1,186.6	244.5	--	1,226.5	570.5	--	1,293.4	387.5	240.0	60.0	703.5	147.0	595.0	412.5	180.0	--	600.0	750.0
Other U.S. Captive	701.2	283.6	--	445.2	328.3	--	180.0	130.0	224.0	--	--	42.0	288.0	67.5	--	--	295.0	112.0
PCM/Reseller	--	9.8	7.9	--	5.0	33.9	--	3.5	57.8	--	--	1.7	84.0	8.0	--	--	92.3	22.4
OEM/Integrator	24.7	229.1	33.0	--	136.4	205.0	--	77.8	484.5	--	--	35.0	507.0	33.6	--	--	406.9	154.8
TOTAL U.S. REVENUES	1,912.5	767.0	40.9	1,671.7	1,040.2	238.9	1,473.4	598.8	1,006.3	60.0	703.5	225.7	1,474.0	521.6	180.0	--	1,394.2	1,039.2
<b>NON-U.S. MANUFACTURERS</b>																		
Captive	211.5	309.8	--	275.0	347.9	3.6	231.0	380.0	104.0	--	180.0	266.0	189.0	--	120.0	144.0	210.0	60.0
PCM/Reseller	--	--	--	--	3.6	--	--	6.8	13.6	--	--	3.2	28.5	--	--	--	32.5	10.5
OEM/Integrator	69.6	227.3	.9	21.5	183.3	61.7	6.0	108.0	132.6	--	--	56.0	166.5	12.0	--	23.8	139.1	45.5
TOTAL NON-U.S. REVENUES	281.1	537.1	.9	296.5	534.8	65.3	237.0	494.8	250.2	--	180.0	325.2	384.0	12.0	120.0	167.8	381.6	116.0
<b>WORLDWIDE RECAP</b>																		
Captive	2,099.3 +49.3%	837.9 +91.3%	--	1,946.7 -7.3%	1,246.7 +48.8%	3.6 --	1,704.4 -12.4%	897.5 -28.0%	568.0 --	60.0 --	883.5 -48.2%	455.0 -49.3%	1,072.0 +88.7%	480.0 +700.0%	300.0 -66.0%	144.0 -68.4%	1,105.0 +3.1%	922.0 +92.1%
PCM/Reseller	--	9.8 --	7.9 --	--	8.6 -12.2%	33.9 +329.1%	--	10.3 +19.8%	71.4 +110.6%	--	--	4.9 -52.4%	112.5 +57.6%	8.0 --	--	--	124.8 +10.9%	32.9 +311.3%
OEM/Integrator	94.3 --	456.4 --	33.9 --	21.5 -77.2%	319.7 -30.0%	266.7 +686.7%	6.0 -72.1%	185.8 -41.9%	617.1 +131.4%	--	--	91.0 -51.0%	673.5 +9.1%	45.6 --	--	23.8 -73.8%	546.0 -18.9%	200.3 +339.3%
Total Revenues	2,193.6 +43.1%	1,304.1 +48.7%	41.8 +1,061.1%	1,968.2 -10.3%	1,575.0 +20.8%	304.2 +627.8%	1,710.4 -13.1%	1,093.6 -30.6%	1,256.5 +313.1%	60.0 --	883.5 -48.3%	550.9 -49.6%	1,858.0 +47.9%	533.6 +789.3%	300.0 -66.0%	167.8 -69.5%	1,775.8 -4.4%	1,155.2 +116.5%
ANNUAL SHARE, BY DIAMETER	62.0%	36.8%	1.2%	51.2%	40.9%	7.9%	41.5%	26.5%	30.5%	1.5%	23.1%	14.4%	48.6%	13.9%	8.8%	4.9%	52.3%	34.0%

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  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988			1989				1990				Forecast				1992			
	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	14"	8"	5.25"	3.5"	
<b>U.S. MANUFACTURERS</b>																			
IBM Captive	53.0	15.0	--	55.0	35.0	--	58.0	25.0	30.0	10.0	35.0	10.0	85.0	75.0	10.0	--	100.0	150.0	
Other U.S. Captive	44.1	20.4	--	28.5	23.8	--	12.0	10.0	32.0	--	--	3.5	48.0	15.0	--	--	59.0	28.0	
PCM/Reseller	--	1.9	3.2	--	1.3	17.8	--	1.0	34.0	--	--	.5	56.0	5.0	--	--	71.0	16.0	
OEM/Integrator	3.6	53.8	13.8	--	35.0	106.0	--	21.0	285.0	--	--	10.0	338.0	24.0	--	--	313.0	129.0	
TOTAL U.S. SHIPMENTS	100.7	91.1	17.0	83.5	95.1	123.8	70.0	57.0	381.0	10.0	35.0	24.0	527.0	119.0	10.0	--	543.0	323.0	
<b>NON-U.S. MANUFACTURERS</b>																			
Captive	9.5	15.3	--	12.5	17.0	.3	11.0	19.0	13.0	--	9.0	14.0	27.0	--	6.0	8.0	35.0	12.0	
PCM/Reseller	--	--	--	--	1.0	--	--	2.0	8.0	--	--	1.0	19.0	--	--	--	25.0	7.0	
OEM/Integrator	11.0	58.5	.4	3.1	48.8	33.6	1.0	30.0	78.0	--	--	16.0	111.0	8.0	--	7.0	107.0	35.0	
TOTAL NON-U.S. SHIPMENTS	20.5	73.8	.4	15.6	66.8	33.9	12.0	51.0	99.0	--	9.0	31.0	157.0	8.0	6.0	15.0	167.0	54.0	
<b>WORLDWIDE RECAP</b>																			
Captive	106.6 +66.8%	50.7 +95.8%	--	96.0 -9.9%	75.8 +49.5%	.3 --	81.0 -15.6%	54.0 -28.8%	75.0 --	10.0 --	44.0 -45.7%	27.5 -49.1%	160.0 +113.3%	90.0 +800.0%	16.0 -63.6%	8.0 -70.9%	194.0 +21.3%	190.0 +111.1%	
PCM/Reseller	--	1.9 --	3.2 --	--	2.3 +21.1%	17.8 +456.2%	--	3.0 +30.4%	42.0 +136.0%	--	--	1.5 -50.0%	75.0 +78.6%	5.0 --	--	--	96.0 +28.0%	23.0 +360.0%	
OEM/Integrator	14.6 --	112.3 --	14.2 --	3.1 -78.8%	83.8 -25.4%	139.6 +883.1%	1.0 -67.7%	51.0 -39.1%	363.0 +160.0%	--	--	26.0 -49.0%	449.0 +23.7%	32.0 --	--	7.0 -73.1%	420.0 -6.5%	164.0 +412.5%	
Total Shipments	121.2 +49.1%	164.9 +48.0%	17.4 +1,640.0%	99.1 -18.2%	161.9 -1.8%	157.7 +806.3%	82.0 -17.3%	108.0 -33.3%	480.0 +204.4%	10.0 --	44.0 -46.3%	55.0 -49.1%	684.0 +42.5%	127.0 +1,170.0%	16.0 -63.6%	15.0 -72.7%	710.0 +3.8%	377.0 +196.9%	
ANNUAL SHARE, BY DIAMETER	40.0%	54.3%	5.7%	23.7%	38.6%	37.7%	12.0%	15.9%	70.6%	1.5%	4.8%	6.0%	75.2%	14.0%	1.4%	1.3%	63.6%	33.7%	
TOTAL CAPACITY (Terabytes)	106.6	106.5	12.2	90.0	109.4	112.8	77.0	76.9	347.0	7.4	41.5	39.2	505.2	88.0	14.3	10.8	510.8	264.9	

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

TABLE 57  
FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE  
APPLICATIONS SUMMARY  
Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection		
	Units (000)	%	Units (000)	%	
MAINFRAME/SUPERMINI General purpose	202.8	66.8	35.66 626.1	56.0	21.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	71.5	23.6	36.31 377.9	33.8	59.0
PERSONAL COMPUTERS Business and professional, single user	1.6	.5	3.02 20.1	1.8	6.0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	6.6	2.2	4.37 4.5	.4	3.0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	21.0	6.9	20.64 89.4	8.0	11.0
CONSUMER AND HOBBY COMPUTERS	--	--	0 --	--	--
OTHER APPLICATIONS	--	--	0 --	--	--
Total	303.4	100.0	1,118.0	100.0	

TABLE 58  
 FIXED DISK DRIVES, 500 MEGABYTES TO 1 GIGABYTE  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments									
	To United States Destinations					Worldwide				
	Units (000)				%	Units (000)				%
	14"	8"	5.25"	Total		14"	8"	5.25"	Total	
IMPRIMIS	3.3	37.8	3.1	44.2	44.9	3.6	52.7	3.8	60.1	41.1
FUJITSU	.9	14.6	.1	15.6	15.9	8.1	26.7	.2	35.0	23.9
NEC	--	9.5	--	9.5	9.7	--	15.5	--	15.5	10.6
MAXTOR	--	--	11.0	11.0	11.2	--	--	13.0	13.0	8.9
TOSHIBA	--	8.0	--	8.0	8.1	--	9.0	--	9.0	6.2
HITACHI	.8	1.5	--	2.3	2.3	2.9	2.3	.2	5.4	3.7
NORTHERN TELECOM	--	5.0	--	5.0	5.1	--	5.0	--	5.0	3.4
Other U.S.	--	2.6	.2	2.8	2.8	--	3.0	.2	3.2	2.2
Other Non-U.S.	--	--	--	--	--	--	--	--	--	--
TOTAL	5.0	79.0	14.4	98.4	100.0	14.6	114.2	17.4	146.2	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

Comparex	8485
Hitachi	DKU-85I, DKU-98I
Ibis	1012, 2812
IBM	3380-AJ4, 3380-CJ2, 3380-BK4
Imprimis	9772-13G
Memorex Telex	3680, 3682
National Advanced Systems	7380-AE
NEC	N7765
Storage Technology	8380-BP4, 8380F
Unisys	9494-12, 9494-24

10.5" disk diameter

Amdahl	6380-BK4
Fujitsu	F6425M4, F6425H

9.5" disk diameter

Comparex	6480BK
Hitachi	DKU-86I
National Advanced Systems	7380-AJX, 7380-BK

9" disk diameter

Digital Equipment	RA90
Hitachi	DK815-10
NEC	D2367, D2377

8" disk diameter

Century Data	C21600
DDC Pertec	DX1246
Imprimis	9730-1230, 97200-25G
Fujitsu	M2392K
Memorex Telex	3835, 3890-00K4
Northern Telecom	8514, 9514, 9516

5.25" disk diameter

Hewlett-Packard	97560E
Imprimis	94601-12G, 97501-15G
Maxtor	P1-13, P2-17S
Micropolis	1518-14

IBM's 3380 series of high-end mainframe disk drives comprise the core of this product group. 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, 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 up to 2.5 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.

Northern Telecom has become the first manufacturer to offer rigid disk drives using perpendicular recording technology. The firm announced a family of 8" drives this year with up to 2.2 gigabytes, employing a head and disk combination developed by Censtor, operating at 2270 TPI.

Starting with last year's DISK/TREND Report, plug compatible drives sold by major PCM vendors such as Amdahl, National Advanced Systems, Comparex and Memorex Telex have been included in the product specification section and are mentioned in the list of examples shown above even though

not manufactured by these companies, in the interest of clarity. Currently, Fujitsu makes the drives sold by Amdahl, while Hitachi makes the drives sold by National Advanced Systems and Comparex. Drives currently offered in the plug compatible market by Memorex Telex are made by Unisys, Fujitsu and Northern Telecom.

### Market status

DISK/TREND estimate of total market size:

<u>Worldwide sales (\$M)</u>	<u>1988</u>	<u>1989</u>	<u>1990</u>	<u>1991</u>	<u>1992</u>
U.S. manufacturers	4,600.5	5,224.0	7,766.7	10,632.9	11,678.2
All manufacturers	6,141.1	7,210.2	10,036.8	12,556.1	13,535.0

1988 revenues for disk drives with more than 1 gigabyte capacity increased 21.5% in 1988, for a total of \$6.1 billion. However, the expected growth for 1989 is placed at a lower level, an estimated 17.4% increase to \$7.2 billion.

Although unit shipments for all drives in 1989 are forecasted to be up 45.4%, most of the increase will be derived from drives using disks smaller than the older 14" drives -- and sold for lower average prices. Expected overall 14" drive shipments of 129,300 for 1989 will be down 14.1%, while shipments of 8"-9.5" drives of 144,600 will be up 262.4%.

IBM's 3380 drive family provides about 30% of the revenue for this product group, but the company's 1989 growth is expected to be flat, with revenues slightly up due to improved mix, but unit shipments slightly down due to customer resistance to the aging product line. IBM damaged both its pride and its bank account with a last minute cancellation this July of the long delayed "Soquel", the performance drive in the 10" range intended to improve throughput in high activity installations.

## **1989 DISK/TREND REPORT**

If any of IBM's major customers were not already aware of an impending threat to the net present value of newly purchased 3380s, this episode put them on warning. Few will buy from IBM's existing disk product line unless absolutely necessary, pending appearance of the new generation.

PCM vendors increased both revenues and unit shipments slightly, as they offset lower average prices with a product mix continuing to move upscale with more 3380K equivalent drives. All of the non-U.S. PCM product lines are primary 8"-9.5" drives.

Shipments of drives in the 8"-9" group have also been boosted by fast growth in OEM shipments, from 4,600 units in 1987, to 28,300 in 1988, to an estimated 90,900 in 1989. Captive drives in this size range other than IBM have also been increasing, led by Digital Equipment's RA90 9" drive.

Hitachi maintained its leadership in worldwide non-captive shipments with 33.5%, representing 27,200 units, both 14" and 9"-9.5" models, and including both PCM and OEM distribution. Fujitsu held second with 23.4%, including 14", 10.5" and 8" models, also both PCM and OEM.

### Marketing trends

Although the growth rate is expected to taper off somewhat by 1992, the revenues for this product group are expected to have grown to \$13.5 billion by that year. Next year is expected to provide the largest revenue jump, as IBM will apparently start production of its long-awaited new drives for mainframe applications.

Previous DISK/TREND assumptions regarding production start-up have been upset by IBM's technical problems, but it now seems inevitable that these products will finally go into production in 1990. The current fore-

casts assume that the "Soquel" drive in the 10" range, designed for optimum performance, will be shipped starting in first quarter of 1990 and that the "Sutter" 5.25" drive, designed for improved cost per megabyte and footprint, will be shipped starting in second or third quarter of 1990.

As usual, the PCM suppliers which survive these changes will be those which are able to react quickly to compete with IBM's new drives. Most plug compatible drive vendors had to scramble to start production of 3380K equivalent models during the last two years.

However, IBM's 10.25" drive is expected to be a tougher target, with new heads, motors and head positioning systems which the independents will probably take 18-24 months to match, and may not choose to do so, considering the specialized nature of the market opportunity. PCM vendors may choose to match the Soquel's performance features with special versions of their 3380-equivalent subsystems, and pass up the high cost of reverse engineering a close imitation. The IBM 5.25" drive will be the future mainstream disk drive for mainframes, and all companies staying in the PCM market will need to have an equivalent product, the first of which is expected in 1991.

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 until 1991, at an impressive 153,000 drives. But the 5.25" drives introduced this year are destined to overtake all other drive form factors in this group, and are expected to provide 65% of 1992's unit shipments of OEM drives.

Other captive drive manufacturers are also expected to sustain continuing shipment growth through 1992, with the established pattern of increases for 8"-9" drives supplemented with 5.25" models not yet introduced starting in 1990.

### Technical trends

IBM's new drives expected next year will introduce new technical challenges for other manufacturers. Both the Soquel 10.25" and Sutter 5.25" drives are expected to use rotational speeds higher than currently normal -- about 4,300 RPM with the Soquel and 5,400 RPM with the Sutter. Higher rotational speeds will intensify problems with heat and power, but drive designs can be modified to solve these situations.

Head positioning speeds are also expected to improve, embodying new actuator designs and advanced magnetic materials. Competitive drive manufacturers will also be able to meet these challenges, and some may already be close to doing it. Some of the new 5.25" OEM drives in this product group already have average head positioning times better than IBM's fastest 3380 models.

The potential development that IBM's PCM competitors would find most difficult to match rapidly would be usage of multiple head sliders. Many in the industry have been waiting for some time for the appearance of multiple head sliders, which would make possible larger logical cylinders and allow fewer head movements, but introduce new considerations in head design, flying characteristics and controller logic. If multiple head sliders should appear on Soquel or Sutter, an extensive effort would be required to establish production of competitive equivalents.

Forecasting assumptions

1. IBM will ship the Soquel 10.25" high performance drive in the first quarter of 1990 and will ship the Sutter high capacity 5.25" drive in second or third quarter of 1990
2. PCM vendors will match IBM's new drives starting in 1991.
3. Most of the existing leading manufacturers of high capacity 5.25" OEM drives will ship drives in this group in the first half of 1990.



TABLE 59  
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE  
 REVENUE SUMMARY

	-----DISK DRIVE REVENUES, BY SHIPMENT DESTINATION (\$M)-----									
	1988		Forecast							
	Revenues		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
<u>U.S. Manufacturers</u>										
IBM Captive	2,440.7	3,854.1	2,511.9	4,014.7	3,856.7	5,869.2	5,635.6	8,378.8	5,732.0	9,150.0
Other U.S. Captive	171.0	269.1	438.6	701.3	813.0	1,309.8	965.0	1,558.0	1,025.8	1,674.6
TOTAL U.S. CAPTIVE	2,611.7	4,123.2	2,950.5	4,716.0	4,669.7	7,179.0	6,600.6	9,936.8	6,757.8	10,824.6
PCM/Reseller	157.7	258.2	151.8	244.2	119.8	165.7	106.4	147.6	81.2	114.0
OEM/Integrator	127.7	219.1	176.8	263.8	301.2	422.0	394.0	548.5	522.4	739.6
TOTAL U.S. NON-CAPTIVE	285.4	477.3	328.6	508.0	421.0	587.7	500.4	696.1	603.6	853.6
TOTAL U.S. REVENUES	2,897.1	4,600.5	3,279.1	5,224.0	5,090.7	7,766.7	7,101.0	10,632.9	7,361.4	11,678.2
<u>Non-U.S. Manufacturers</u>										
Captive	--	605.6	26.4	712.4	72.0	896.0	115.0	880.0	110.0	802.0
PCM/Reseller	237.9	595.5	363.6	741.1	446.6	853.6	303.2	560.0	357.6	626.0
OEM/Integrator	115.0	339.5	271.2	532.7	316.5	520.5	324.4	483.2	313.6	428.8
TOTAL NON-U.S. REVENUES	352.9	1,540.6	661.2	1,986.2	835.1	2,270.1	742.6	1,923.2	781.2	1,856.8
<u>Worldwide Recap</u>										
TOTAL WORLDWIDE REVENUES	3,250.0	6,141.1	3,940.3	7,210.2	5,925.8	10,036.8	7,843.6	12,556.1	8,142.6	13,535.0
	With 9335: 7323.6									
OEM Average Price (\$000)	9.3	12.8	5.7	7.5	4.3	5.0	3.5	3.8	3.0	3.0

TABLE 60  
FIXED DISK DRIVES, MORE THAN 1 GIGABYTE  
UNIT SHIPMENT SUMMARY

	-----DISK DRIVE UNIT SHIPMENTS, BY SHIPMENT DESTINATION (000)-----									
	1988		1989		1990		1991		1992	
	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW	U.S.	WW
U.S. Manufacturers	-----									
IBM Captive	50.0	79.4	48.6	78.0	86.4	133.4	191.4	300.7	271.0	450.0
Other U.S. Captive	5.8	9.0	16.2	25.8	33.4	53.2	47.8	76.0	57.2	92.0
TOTAL U.S. CAPTIVE	55.8	88.4	64.8	103.8	119.8	186.6	239.2	376.7	328.2	542.0
PCM/Reseller	6.5	10.7	9.8	13.5	11.9	13.8	19.3	24.5	25.3	34.0
OEM/Integrator	8.2	12.9	23.5	28.0	71.5	87.2	119.7	154.8	191.0	266.0
TOTAL U.S. NON-CAPTIVE	14.7	23.6	33.3	41.5	83.4	101.0	139.0	179.3	216.3	300.0
TOTAL U.S. SHIPMENTS	70.5	112.0	98.1	145.3	203.2	287.6	378.2	556.0	544.5	842.0
Non-U.S. Manufacturers	-----									
Captive	--	20.7	1.2	26.1	3.0	36.0	5.0	40.0	5.0	47.0
PCM/Reseller	10.9	27.1	13.2	27.1	17.8	33.8	17.6	32.0	27.4	47.0
OEM/Integrator	17.8	30.6	55.0	78.3	72.0	101.0	85.0	117.0	90.0	124.0
TOTAL NON-U.S. SHIPMENTS	28.7	78.4	69.4	131.5	92.8	170.8	107.6	189.0	122.4	218.0
Worldwide Recap	-----									
TOTAL WORLDWIDE SHIPMENTS	99.2	190.4	167.5	276.8	296.0	458.4	485.8	745.0	666.9	1,060.0
Total Capacity (Terabytes)	280.9	511.0	387.8	662.7	626.1	982.9	952.5	1,438.3	1,228.8	1,917.1
Cumulative Shipments	-----									
IBM	294.0	498.3	342.6	576.3	429.0	709.7	620.4	1,010.4	891.4	1,460.4
Non-IBM	112.8	274.5	231.7	473.3	441.3	798.3	735.7	1,242.6	1,131.6	1,852.6
WORLDWIDE TOTAL	406.8	772.8	574.3	1,049.6	870.3	1,508.0	1,356.1	2,253.0	2,023.0	3,313.0

TABLE 61  
FIXED DISK DRIVES, MORE THAN 1 GIGABYTE  
WORLDWIDE REVENUES (\$M)  
BREAKDOWN BY DISK DIAMETER

	1988			Forecast										
	Revenues		1989			1990			1991			1992		
	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
<b>U.S. MANUFACTURERS</b>														
IBM Captive	3,854.1	--	4,014.7	--	--	5,449.2	--	420.0	5,578.8	--	2,800.0	3,900.0	--	5,250.0
Other U.S. Captive	162.7	106.4	147.8	553.5	--	147.8	1,092.0	70.0	105.0	1,225.0	228.0	69.6	1,272.0	333.0
PCM/Reseller	256.0	2.2	219.9	23.7	.6	129.0	27.5	9.2	94.5	13.5	39.6	48.0	4.0	62.0
OEM/Integrator	191.7	27.4	161.6	93.6	8.6	156.0	167.2	98.8	114.0	199.5	235.0	70.0	182.0	487.6
TOTAL U.S. REVENUES	4,464.5	136.0	4,544.0	670.8	9.2	5,882.0	1,286.7	598.0	5,892.3	1,438.0	3,302.6	4,087.6	1,458.0	6,132.6
<b>NON-U.S. MANUFACTURERS</b>														
Captive	575.0	30.6	499.0	213.4	--	476.0	384.0	36.0	378.0	414.0	88.0	208.0	374.0	220.0
PCM/Reseller	450.2	145.3	225.1	516.0	--	259.6	594.0	--	132.0	288.0	140.0	96.0	200.0	330.0
OEM/Integrator	191.7	147.8	172.0	360.7	--	96.0	400.5	24.0	46.0	384.0	53.2	--	328.0	100.8
TOTAL NON-U.S. REVENUES	1,216.9	323.7	896.1	1,090.1	--	831.6	1,378.5	60.0	556.0	1,086.0	281.2	304.0	902.0	650.8
<b>WORLDWIDE RECAP</b>														
Captive	4,591.8	137.0	4,661.5	766.9	--	6,073.0	1,476.0	526.0	6,061.8	1,639.0	3,116.0	4,177.6	1,646.0	5,803.0
	+12.7%	+6,127.3%	+1.5%	+459.8%	--	+30.3%	+92.5%	--	-2%	+11.0%	+492.4%	-31.1%	+4%	+86.2%
PCM/Reseller	706.2	147.5	445.0	539.7	.6	388.6	621.5	9.2	226.5	301.5	179.6	144.0	204.0	392.0
	--	--	-37.0%	+265.9%	--	-12.7%	+15.2%	+1,433.3%	-41.7%	-51.5%	+1,852.2%	-36.4%	-32.3%	+118.3%
OEM/Integrator	383.4	175.2	333.6	454.3	8.6	252.0	567.7	122.8	160.0	583.5	288.2	70.0	510.0	588.4
	--	--	-13.0%	+159.3%	--	-24.5%	+25.0%	+1,327.9%	-36.5%	+2.8%	+134.7%	-66.0%	-12.6%	+104.2%
Total Revenues	5,681.4	459.7	5,440.1	1,760.9	9.2	6,713.6	2,665.2	658.0	6,448.3	2,524.0	3,583.8	4,391.6	2,360.0	6,783.4
	+13.1%	+1,341.1%	-4.2%	+283.1%	--	+23.4%	+51.4%	+7,052.2%	-4.0%	-5.3%	+444.7%	-31.9%	-6.5%	+89.3%
ANNUAL SHARE, BY DIAMETER	92.5%	7.5%	75.5%	24.4%	.1%	66.9%	26.6%	6.5%	51.4%	20.1%	28.5%	32.5%	17.4%	50.1%

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

TABLE 62  
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE  
 WORLDWIDE SHIPMENTS (000)  
 BREAKDOWN BY DISK DIAMETER

	1988			Forecast										
	Shipments		1989			1990			1991			1992		
	14"	8"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"	14"	8"	5.25"
<b>U.S. MANUFACTURERS</b>														
IBM Captive	79.4	--	78.0	--	--	103.4	--	30.0	100.7	--	200.0	75.0	--	375.0
Other U.S. Captive	4.9	4.1	4.5	21.3	--	4.2	42.0	7.0	3.0	49.0	24.0	2.0	53.0	37.0
PCM/Reseller	10.3	.4	8.6	4.7	.2	4.3	5.5	4.0	3.5	3.0	18.0	2.0	1.0	31.0
OEM/Integrator	8.0	4.9	5.8	19.5	2.7	5.2	44.0	38.0	3.8	57.0	94.0	2.0	52.0	212.0
TOTAL U.S. SHIPMENTS	102.6	9.4	96.9	45.5	2.9	117.1	91.5	79.0	111.0	109.0	336.0	81.0	106.0	655.0
<b>NON-U.S. MANUFACTURERS</b>														
Captive	19.5	1.2	17.4	8.7	--	17.0	16.0	3.0	14.0	18.0	8.0	8.0	17.0	22.0
PCM/Reseller	21.2	5.9	8.1	19.0	--	11.8	22.0	--	6.0	12.0	14.0	4.0	10.0	33.0
OEM/Integrator	7.2	23.4	6.9	71.4	--	4.0	89.0	8.0	2.0	96.0	19.0	--	82.0	42.0
TOTAL NON-U.S. SHIPMENTS	47.9	30.5	32.4	99.1	--	32.8	127.0	11.0	22.0	126.0	41.0	12.0	109.0	97.0
<b>WORLDWIDE RECAP</b>														
Captive	103.8	5.3	99.9	30.0	--	124.6	58.0	40.0	117.7	67.0	232.0	85.0	70.0	434.0
	+3.9%	+5,200.0%	-3.8%	+466.0%	--	+24.7%	+93.3%	--	-5.5%	+15.5%	+480.0%	-27.8%	+4.5%	+87.1%
PCM/Reseller	31.5	6.3	16.7	23.7	.2	16.1	27.5	4.0	9.5	15.0	32.0	6.0	11.0	64.0
	--	--	-47.0%	+276.2%	--	-3.6%	+16.0%	+1,900.0%	-41.0%	-45.5%	+700.0%	-36.8%	-26.7%	+100.0%
OEM/Integrator	15.2	28.3	12.7	90.9	2.7	9.2	133.0	46.0	5.8	153.0	113.0	2.0	134.0	254.0
	--	--	-16.4%	+221.2%	--	-27.6%	+46.3%	+1,603.7%	-37.0%	+15.0%	+145.7%	-74.4%	-12.4%	+124.8%
Total Shipments	150.5	39.9	129.3	144.6	2.9	149.9	218.5	90.0	133.0	235.0	377.0	93.0	215.0	752.0
	+8.3%	+748.9%	-14.1%	+262.4%	--	+15.9%	+51.1%	+3,003.4%	-11.3%	+7.6%	+318.9%	-30.1%	-8.5%	+99.5%
ANNUAL SHARE, BY DIAMETER	79.0%	21.0%	46.8%	52.2%	1.0%	32.7%	47.7%	19.6%	17.9%	31.5%	50.6%	8.8%	20.3%	70.9%
TOTAL CAPACITY (Terabytes)	454.7	56.2	441.6	217.6	3.4	513.2	344.5	125.2	450.0	451.0	537.3	317.1	496.4	1,103.6

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

TABLE 63  
 WORLDWIDE SHIPMENTS OF IBM AND PCM FIXED DISK DRIVES FOR MAINFRAMES  
 PRODUCT MIX ANALYSIS

	-----DISK DRIVE SHIPMENTS, BY SHIPMENT DESTINATION (000 SPINDLES)-----									
	1988		-----FORECAST-----							
	---Shipments---		-----1989-----		-----1990-----		-----1991-----		-----1992-----	
	US	WW	US	WW	US	WW	US	WW	US	WW
<u>IBM 3370 (729 MB)</u>	2.0	5.0	--	--	--	--	--	--	--	--
<u>IBM 9335 (856 MB)</u>	25.0	48.0	28.0	55.0	28.0	58.0	16.0	35.0	4.0	10.0
<u>3380D/J Type (1260 MB)</u>										
IBM	9.3	15.7	6.4	11.0	4.8	8.4	2.1	3.7	--	--
PCM*	4.9	12.4	3.9	8.7	4.1	7.9	1.6	3.0	--	--
TOTAL	14.2	28.1	10.3	19.7	8.9	16.3	3.7	6.7	--	--
<u>3380E Type (2520 MB)</u>										
IBM	1.5	2.5	--	--	--	--	--	--	--	--
PCM*	11.3	22.6	4.5	7.5	.5	.7	--	--	--	--
TOTAL	12.8	25.1	4.5	7.5	.5	.7	--	--	--	--
<u>3380K Type (3780 MB)</u>										
IBM	39.2	61.2	42.2	67.0	18.6	30.0	4.3	7.0	--	--
PCM*	.8	2.4	9.8	17.5	15.4	28.0	5.0	9.0	--	--
TOTAL	40.0	63.6	52.0	84.5	34.0	58.0	9.3	16.0	--	--
<u>Not yet announced</u>										
IBM 10.25 INCH (3000 MB)	--	--	--	--	45.0	65.0	65.0	90.0	51.0	75.0
PCM 10.25 INCH (3000 MB)	--	--	--	--	--	--	6.3	9.0	9.6	16.0
TOTAL 10.25 INCH	--	--	--	--	45.0	65.0	71.3	99.0	60.6	91.0
IBM 5.25 INCH (1200 MB)	--	--	--	--	18.0	30.0	120.0	200.0	220.0	375.0
PCM 5.25 INCH (1200 MB)	--	--	--	--	--	--	14.4	24.0	30.0	55.0
TOTAL 5.25 INCH	--	--	--	--	18.0	30.0	134.4	224.0	250.0	430.0
<b>TOTAL SPINDLES</b>	<b>94.0</b>	<b>169.8</b>	<b>94.8</b>	<b>166.7</b>	<b>134.4</b>	<b>228.0</b>	<b>234.7</b>	<b>380.7</b>	<b>314.6</b>	<b>531.0</b>
<b>TOTAL FORMATTED CAPACITY (Terabytes)</b>		<b>383.8</b>		<b>410.5</b>		<b>522.2</b>		<b>664.7</b>		<b>797.6</b>
		+39%		+7%		+27%		+27%		+20%

NOTE: 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 physical spindles in order to equal the capacity of a specific IBM spindle.

TABLE 64  
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE  
 APPLICATIONS SUMMARY  
 Percentage of Worldwide Shipments

APPLICATION	1988 Estimate		1992 Projection			
	Units (000)	%	Units (000)	%		
MAINFRAME/SUPERMINI General purpose	178.6	93.8	76.8%	890.4	84.0	68.0
MINICOMPUTERS AND MULTI-USER MICROS Business and professional, including networks	8.7	4.6	21.5%	84.8	8.0	28.0
PERSONAL COMPUTERS Business and professional, single user	--	--	--	--	--	0
OFFICE SYSTEMS AND WORKSTATIONS Dedicated application	.4	.2	.02	5.3	.5	0
NON-OFFICE SYSTEMS AND WORKSTATIONS Technical, distribution, medical, other specialized	2.7	1.4	1.58	79.5	7.5	6.0
CONSUMER AND HOBBY COMPUTERS	--	--	0	--	--	0
OTHER APPLICATIONS	--	--	0	--	--	0
Total	190.3	100.0		1,060.0	100.0	

TABLE 65  
 FIXED DISK DRIVES, MORE THAN 1 GIGABYTE  
 MARKET SHARE SUMMARY  
 Worldwide Shipments of Non-Captive Disk Drives

Drive Manufacturers	1988 Net Shipments							
	To United States Destinations				Worldwide			
	Units (000)			%	Units (000)			%
	14"	8"	Total		14"	8"	Total	
HITACHI	3.5	7.8	11.3	26.0	14.1	13.1	27.2	33.5
FUJITSU	5.9	3.0	8.9	20.5	14.3	4.7	19.0	23.4
NEC	--	6.5	6.5	15.0	--	9.5	9.5	11.7
IMPRIMIS	2.5	3.3	5.8	13.4	2.5	5.3	7.8	9.6
STORAGE TECHNOLOGY	4.4	--	4.4	10.1	6.4	--	6.4	7.9
Other U.S.	4.5	--	4.5	10.4	9.4	--	9.4	11.6
Other Non-U.S.	--	2.0	2.0	4.6	--	2.0	2.0	2.3
TOTAL	20.8	22.6	43.4	100.0	46.7	34.6	81.3	100.0

Note: 14 inch totals include 10.5 inch drives.

Note: 8 inch totals include 9 inch drives.







## RIGID MAGNETIC DISK DRIVE SPECIFICATIONS

### Coverage

This section includes most 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 models made by the same manufacturer. For most PCM 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 OEM 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

For the majority of OEM drives sold in the United States, OEM prices at the 100 unit level are provided. When prices for higher quantities have been used, the applicable quantity is shown in parentheses. Since prices may be changed by manufacturers without notice, please use them with the appropriate caution.

Capacities

Capacities are listed as "U" for unformatted or "F" for formatted. In general, unformatted capacities are shown for OEM drives, and formatted capacities are given for captive drives, PCM drives, and OEM drives with embedded controllers, such as SCSI. 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.

1989 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	Ferrite*	Ferrite*	Ferrite*	Ferrite*
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
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
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
U.S. OEM PRICE FOR 100 UNITS	\$7,495	--	--	--	--
COMMENTS	8 Parallel channel version available	25.4 mm high *Metal in Gap **2,7 RLL Code	30 mm high *Metal in Gap **2,7 RLL Code	25.4 mm high *Metal in Gap **2,7 RLL Code	30 mm high *Metal in Gap **2,7 RLL Code

MANUFACTURER	ALPS ELECTRIC	ALPS ELECTRIC	AMDAHL	AMDAHL	AREAL TECHNOLOGY
DRIVE	DRQ040A	DRQ040D	6380-AJ4 6380-BJ4	6380-AK4 6380-BK4	BP 50
DISK/TREND GROUP	4	4	8	9	4
MARKET	OEM	OEM	PCM	PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Sputtered	Thin Film
DRIVE: Heads	Ferrite*	Ferrite*	Ferrite	Ferrite	Thin Film
Interface	Alps	SCSI	IBM	IBM	SCSI, PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2	F: 42.8	F: 630.2	F: 1,890	F: 50
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 17,408	F: 47,476	F: 47,476	F: 30,720
Data surfaces per spindle	4	4	8	16	1
Heads per data surface	1	1	2	2	1
Tracks per surface	615	615	1770	2656	1720
Track density (TPI)	880	880	*	*	1720
Maximum linear density (BPI)	27022 BPI** 18015 FCI	27022 BPI** 18015 FCI	*	*	57000 BPI* 38000 FCI
Rotational speed (RPM)	2640	2640	3620	3620	1600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	45 (including settling)	45 (including settling)	12	16	29
Average rotational delay (msec)	11.4	11.4	8.3	8.3	18.75
Average access time (msec)	56.4	56.4	20.3	24.3	47.75
Data transfer rate (KBytes/sec)	937.5	1667	3000	3000	937.5
FIRST CUSTOMER SHIPMENT	1988	1988	1Q89	1Q89	4Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	25.4 mm high *Metal in Gap **2,7 RLL Code	30 mm high *Metal in Gap **2,7 RLL Code	PCM 3380J Drive has 4 spindles *Not announced	PCM 3380K Drive has 4 spindles *Not announced	25.4 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	AREAL TECHNOLOGY	AREAL TECHNOLOGY	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS
DRIVE	MD-2050	BP 100	F3116-E	F3116-S,A	F3193-E
DISK/TREND GROUP	4	6	6	6	6
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	Thin Film	Thin Film	MIG	MIG	MIG
Interface	SCSI, PC AT	SCSI, PC AT	ESDI	SCSI, PC AT	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 49.2	F: 100	U: 115.8	F: 102.0	U: 193.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 30,720	F: 30,720	U: 25,000	F: 22,016	U: 25,000
Data surfaces per spindle	2	2	3	3	5
Heads per data surface	1	1	1	1	1
Tracks per surface	819	1720	1544	1544	1544
Track density (TPI)	1931	1720	1736	1736	1736
Maximum linear density (BPI)	57000 BPI*	57000 BPI*	35796 BPI*	35796 BPI*	35796 BPI*
Rotational speed (RPM)	38000 FCI 1600	38000 FCI 1600	23864 FCI 3600	23864 FCI 3600	23864 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	29	29	15	15	15
Average rotational delay (msec)	18.75	18.75	8.3	8.3	8.3
Average access time (msec)	47.75	47.75	23.3	23.3	23.3
Data transfer rate (KBytes/sec)	937.5	937.5	1500	Up to 5000	1500
FIRST CUSTOMER SHIPMENT	2Q90	4Q89	--	--	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	17 mm high *2,7 RLL Code Embedded Servo	25.4 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CARDIFF PERIPHERALS	CENTURY DATA	CENTURY DATA
DRIVE	F3193-S,A	F3347-E	F3347-S,A	7110	7130
DISK/TREND GROUP	6	7	7	1	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	8" Cartridge	8" Cartridge
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	200 mm OD	200 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated
DRIVE: Heads	MIG	MIG	MIG	Ferrite	Ferrite
Interface	SCSI, PC AT	ESDI	SCSI, PC AT	SMD, SCSI	SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 170.0	U: 347.4	F: 305.9	U: 26.9	U: 80.9
REMOVABLE	--	--	--	U: 26.9	U: 26.9
Capacity per track (Bytes)	F: 22,016	U: 25,000	F: 22,016	U: 20,928	U: 20,928
Data surfaces per spindle	5	9	9	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1544	1544	1544	644	644
Track density (TPI)	1736	1736	1736	555	555
Maximum linear density (BPI)	35796 BPI*	35796 BPI*	35796 BPI*	10986 BPI*	10986 BPI*
Rotational speed (RPM)	23864 FCI 3600	23864 FCI 3600	23864 FCI 3600	7324 FCI 3600	7324 FCI 3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	15	15	25	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	23.3	33.3	33.3
Data transfer rate (KBytes/sec)	Up to 5000	1500	Up to 1500	1229	1229
FIRST CUSTOMER SHIPMENT	--	--	--	1Q83	1/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$4,285	\$3,845
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	PhD	T306 Trident	AMS 315	C2400	C2476
DISK/TREND GROUP	1	2	7	7	7
MARKET	PCM	OEM	OEM	OEM	OEM
MEDIA: Generic type	8" Cartridge	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD	14"	14"	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Oxide Coated	Oxide Coated	Oxide Coated	63.5 mm ID Thin Film	63.5 mm ID High Dens Oxide
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI, PC	SMD	SMD	SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 80.9	--	U: 315.2	U: 344	U: 475.9
REMOVABLE	U: 26.9	U: 315.2	--	--	--
Capacity per track (Bytes)	U: 20,928	U: 20,160	U: 20,160	U: 20,160	U: 28,160
Data surfaces per spindle	8	19	9.5	24	10
Heads per data surface	1	1	2	1	2
Tracks per surface	644	823	1646	711	1690
Track density (TPI)	555	384	712	1143	1143
Maximum linear density (BPI)	10986 BPI* 7324 FCI	6060	6363	12783 BPI* 8522 FCI	17900 BPI* 11933 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3961
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	30	25	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.57
Average access time (msec)	33.3	38.3	33.3	23.3	22.57
Data transfer rate (KBytes/sec)	1229	1209	1209	1209	1859
FIRST CUSTOMER SHIPMENT	1/86	8/76	11/82	3Q85	3/85
U.S. OEM PRICE FOR 100 UNITS	\$3,890	\$12,320	\$7,065	\$5,835	\$6,200
COMMENTS	*2,7 RLL Code Embedded Servo		T306 Trident compatibility	*2,7 RLL Code	*2,7 RLL Code Eagle I compatibility



MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	C2600	C2800	DS21200	DS21600	DS2800
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM	OEM	PCM	PCM	PCM
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 Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Modified SMD	Modified SMD	SDI (DEC)	SDI (DEC)	SDI (DEC)
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 613	U: 830	F: 900	F: 1,200	F: 625
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 40,960	F: 30,720	F: 33,600	F: 31,990
Data surfaces per spindle	12	16	16	16	16
Heads per data surface	1	1	1	1	1
Tracks per surface	1690	1221	1831	2230	1221
Track density (TPI)	1143	1087	1087	1358	1087
Maximum linear density (BPI)	19200 BPI*	19739 BPI*	24846 BPI*	27624 BPI*	19739 BPI*
Rotational speed (RPM)	12800 FCI 3600	13159 FCI 3600	16564 FCI 3600	18416 FCI 3600	13159 FCI 3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	15	18	16	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	26.3	24.3	23.3
Data transfer rate (KBytes/sec)	1813	2400	2400	2700	2400
FIRST CUSTOMER SHIPMENT	3Q85	8/86	2Q88	1Q90	1Q88
U.S. OEM PRICE FOR 100 UNITS	\$6,905	\$8,005	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code RA82/90 compatible DEC market	*2,7 RLL Code RA90 compatible DEC market	*2,7 RLL Code RA82 compatible DEC market

MANUFACTURER	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA	CENTURY DATA
DRIVE	T21600	T2801	T2802	C21200	C21600
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	200 mm OD	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	Modified SMD	Modified SMD	DIMS-500X	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,600	U: 830	U: 830	U: 1,200	U: 1,500
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 45,000	U: 40,960	U: 40,960	U: 40,960	U: 45,000
Data surfaces per spindle	16	12	12	16	16
Heads per data surface	1	2	2	1	1
Tracks per surface	2230	845	845	1831	2230
Track density (TPI)	1358	1115	1115	1087	1358
Maximum linear density (BPI)	27624 BPI*	24787 BPI*	24787 BPI*	24846 BPI*	27624 BPI*
Rotational speed (RPM)	18416 FCI 3600	16525 FCI 3600	16525 FCI 3600	16564 FCI 3600	18416 FCI 3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	16	15	15	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	23.3	23.3	26.3	24.3
Data transfer rate (KBytes/sec)	21600	2458/9830/12288	11760	2400	2400
FIRST CUSTOMER SHIPMENT	1Q90	1Q88	2Q88	1Q88	1Q89
U.S. OEM PRICE FOR 100 UNITS	--	\$10,390	--	--	--
COMMENTS	*2,7 RLL Code Parallel data transfer 1,5,6 or 8 channels	*2,7 RLL Code Parallel data transfer, 1 or 5 channels	*2,7 RLL Code 2 HDA'S parallel data transfer	*2,7 RLL Code	*2,7 RLL Code

## 1989 DISK/TREND REPORT

RSPEC-11

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)	*	*	*	*	*
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
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
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
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

1989 DISK/TREND REPORT

MANUFACTURER	COMPORT	COMPORT	COMPORT	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE	2040	2041	2082	CP-3020	CP-3024
DISK/TREND GROUP	4	4	5	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	PC AT	SCSI	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.3	F: 43.7	F: 85.7	F: 21.4	F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624	F: 13,312	F: 17,408	F: 16,896	F: 16,896
Data surfaces per spindle	4	4	6	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	820	636	636
Track density (TPI)	1065	1065	1065	1150	1150
Maximum linear density (BPI)	20196 BPI*	20196 BPI*	26928 BPI*	21379 BPI*	21379 BPI*
Rotational speed (RPM)	13464 FCI 3600	13464 FCI 3600	17952 FCI 3600	14253 FCI 3575	14253 FCI 3575
PERFORMANCE					
Actuator type	Linear, Stepping Motor	Linear, Stepping Motor	Linear, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	35 (including settling)	29 (including settling)	29 (including settling)	27	27
Average rotational delay (msec)	8.3	8.3	8.3	8.4	8.4
Average access time (msec)	43.3	37.3	37.3	35.4	35.4
Data transfer rate (KBytes/sec)	937.5	937.5	1250	1250	1250
FIRST CUSTOMER SHIPMENT	3Q88	4Q88	1Q90	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	25.4 mm high *2,7 RLL Code Embedded Servo	25.4 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS
DRIVE					
	CP-3040	CP-3044	CP-340	CP-344	CP-3100
DISK/TREND GROUP	4	4	4	4	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.65	F: 42.65	F: 40.4	F: 42.6	F: 104.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 20,480	F: 20,480	F: 13,312	F: 13,312	F: 16,896
Data surfaces per spindle	2	2	4	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1047	1047	788	805	776
Track density (TPI)	1400	1400	1000	1000	1150
Maximum linear density (BPI)	30871 BPI* 20581 FCI	30871 BPI* 20581 FCI	21379 BPI* 14253 FCI	21379 BPI* 14253 FCI	23441 BPI* 15627 FCI
Rotational speed (RPM)	3557	3557	3600	3600	3575
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	25	29	29	25
Average rotational delay (msec)	8.4	8.4	8.3	8.3	8.4
Average access time (msec)	33.4	33.4	37.3	37.3	33.4
Data transfer rate (KBytes/sec)	1500	1500	1000	1000	1250
FIRST CUSTOMER SHIPMENT	4Q88	4Q88	1Q87	1Q87	4Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	25.4 mm high *2,7 RLL Code Embedded Servo	25.4 mm high *2,7 RLL Code Embedded Servo	38 mm high *2,7 RLL Code Embedded Servo	38 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	CONNER PERIPHERALS	DATA GENERAL
DRIVE	CP-3104	CP-3114	CP-3200	CP-3204	6236 6237
DISK/TREND GROUP	6	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	14"
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Ferrite
Interface	PC AT	PC AT	SCSI	PC AT	Data General
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 104.9	F: 112	F: 209.7	F: 209.7	F: 354.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 16,896	F: 19,456	F: 19,456	F: 28,672
Data surfaces per spindle	8	8	8	8	8
Heads per data surface	1	1	1	1	2
Tracks per surface	776	833	1348	1348	1572
Track density (TPI)	1150	1150	1700	1700	714
Maximum linear density (BPI)	23441 BPI* 15627 FCI	*	31800 BPI* 21200 FCI	31800 BPI* 21200 FCI	10438 BPI* 6958 FCI
Rotational speed (RPM)	3575	3575	3600	3600	3000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	25	25	19	19	20
Average rotational delay (msec)	8.4	8.4	8.3	8.3	10
Average access time (msec)	33.4	33.4	27.3	27.3	30
Data transfer rate (KBytes/sec)	1250	1250	1500	1500	1680
FIRST CUSTOMER SHIPMENT	4Q87	1988	2Q89	2Q89	9/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo	*2,7 RLL Code 6237-3 spindles

## 1989 DISK/TREND REPORT

MANUFACTURER	DATA GENERAL	DATA GENERAL	DATA GENERAL	DDC PERTEC	DDC PERTEC
DRIVE	6239 6290 6240	6357 6398 6399 6400	6581	DX199	DX265
DISK/TREND GROUP	8	8	8	6	6
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Ferrite	Ferrite
Interface	Data General	Data General	Data General	SMD,SCSI,ANSI	SMD,SCSI,ANSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 592.2	F: 862	F: 500	U: 199	U: 265
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 38,400	F: 35,840	F: 27,648	U: 20,160	U: 20,160
Data surfaces per spindle	8	8	12	6	8
Heads per data surface	2	2	1	1	1
Tracks per surface	1956	3058	1545	1649	1649
Track density (TPI)	800	1250	1279	1083	1083
Maximum linear density (BPI)	14154 BPI* 9436 FCI	14614 BPI* 9742 FCI	12223 BPI* 8149 FCI	12022 BPI* 8014 FCI	12022 BPI* 8014 FCI
Rotational speed (RPM)	2940	3000	4630	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	21	22	16	22	22
Average rotational delay (msec)	10.2	10	6.5	8.3	8.3
Average access time (msec)	31.2	32	22.5	30.3	30.3
Data transfer rate (KBytes/sec)	2200	2310	2670	1208	1208
FIRST CUSTOMER SHIPMENT	2/85	1/88	7/88	4/85	4/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code  6239-1 spindle 6290-2 spindles 6240-3 spindles	*2,7 RLL Code  6357-1 spindle 6398-2 spindles 6399-3 spindles 6400-6 spindles	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	DDC PERTEC	DDC PERTEC	DDC PERTEC	DDC PERTEC	DDC PERTEC
DRIVE					
	DX332	DX368	DX375	DX548	DX731
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	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 Oxide Coated	63.5 mm ID Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD,SCSI,ANSI	SMD, Mod. SMD	SMD, Mod. SMD	SMD, Mod. SMD	SMD, Mod. SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 332	U: 368	U: 374.8	U: 548.5	U: 731.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 30,240	U: 40,320	U: 30,240	U: 40,320
Data surfaces per spindle	10	10	11	11	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1649	1217	845	1649	1649
Track density (TPI)	1083	1083	1083	1083	1083
Maximum linear density (BPI)	12022 BPI*	15176 BPI*	17785 BPI*	18046 BPI*	24061 BPI*
Rotational speed (RPM)	8014 FCI 3600	10117 FCI 3600	11856 FCI 3600	12030 FCI 3600	16040 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	22	18	13	20	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	30.3	26.3	21.3	28.3	26.3
Data transfer rate (KBytes/sec)	1208	1815	2418	1815	2418
FIRST CUSTOMER SHIPMENT	4/85	1Q86	4Q87	2Q86	4Q87
U.S. OEM PRICE FOR 100 UNITS	\$3,180	\$3,625	\$3,775	\$3,830	\$5,050
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

## 1989 DISK/TREND REPORT



MANUFACTURER	DDC PERTEC	DDC PERTEC	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION
DRIVE					
	DX914	DX1246	RA60	RF30	RA70
DISK/TREND GROUP	8	9	2	6	7
MARKET	OEM	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Special Disk Pack	Fixed	Fixed
Nominal disk diameter	200 mm OD	200 mm OD	14"	130 mm OD	130 mm OD
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	Oxide Coated	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	SMD, Mod. SMD	SCSI, SMD	DEC	DEC	DEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 914.2	U: 1,246	--	U: 200 F: 150	U: 350 F: 280
REMOVABLE	--	--	F: 205.0	--	--
Capacity per track (Bytes)	U: 50,400	U: 50,400	F: 21,504	F: 25,000	F: 17,408
Data surfaces per spindle	11	15	6	6	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1649	1649	1600	1331	1507
Track density (TPI)	1083	1083	779	1355	1355
Maximum linear density (BPI)	30075 BPI*	30075 BPI*	9668 BPI*	22784 BPI*	22437 BPI*
Rotational speed (RPM)	20050 FCI 3600	20050 FCI 3600	6445 FCI 3600	15189 FCI 3600	14958 FCI 4000
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	16	16	41.7	21.0	19.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	7.5
Average access time (msec)	24.3	24.3	50.0	29.3	27.0
Data transfer rate (KBytes/sec)	3024	3024	1980	1500	1450
FIRST CUSTOMER SHIPMENT	1988	1988	3Q83	10/88	4/88
U.S. OEM PRICE FOR 100 UNITS	\$5,230	\$6,110	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code	*2,7 RLL Code Embedded Servo

MANUFACTURER	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DIGITAL EQUIPMENT CORPORATION	DMA TECHNOLOGIES
DRIVE	RA81	RF71	RA82	RA90	360
DISK/TREND GROUP	7	7	8	9	1
MARKET	Captive	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	--
Nominal disk diameter	14"	130 mm OD 40 mm ID	14"	9"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	DEC	DEC	DEC	DEC	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 456	U: 532 F: 400	U: 855 F: 622	U: 1,607 F: 1,216	--
REMOVABLE	--	--	--	--	U: 12.75
Capacity per track (Bytes)	F: 26,112	F: 25,000	F: 29,184	F: 35,328	U: 10,416
Data surfaces per spindle	7	8	8	13	2
Heads per data surface	2	1	2	1	1
Tracks per surface	2496	1331	2846	2649	612
Track density (TPI)	960	1355	1063	1750	612
Maximum linear density (BPI)	11400 BPI* 7600 FCI	22784 BPI* 15189 FCI	12545 BPI* 8363 FCI	22839 BPI* 15226 FCI	10894
Rotational speed (RPM)	3600	3600	3600	3600	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Average positioning time (msec)	28	21.0	20	17.5	98 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.6
Average access time (msec)	36.3	29.3	28.3	27	106.6
Data transfer rate (KBytes/sec)	2200	1500	2400	2800	625
FIRST CUSTOMER SHIPMENT	9/82	--	4Q87	8/88	5/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code	*2,7 RLL Code Embedded Servo SA482 consists of 4 spindles Total 2,448 MB	*2,7 RLL Code SA600 consists of 4 or 8 spindles, up to 9,728 MB	41.3 mm high Embedded Servo

MANUFACTURER	DMA TECHNOLOGIES	DMA TECHNOLOGIES	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE					
	370	371	FK309-26	FK311-26	FK311A-26
DISK/TREND GROUP	1	1	3	3	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	--	--	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	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	U: 25.6	U: 25.6	F: 20
REMOVABLE	U: 25.0	F: 21.2	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 8,704	U: 10,416	U: 10,416	F: 8,704
Data surfaces per spindle	2	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	615	615	615
Track density (TPI)	1222	1222	753	910	910
Maximum linear density (BPI)	10894	10894	15600	15200	15200
Rotational speed (RPM)	3473	3473	3350	3050	3050
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	85 (including settling)	85 (including settling)	65 (including settling)	60 (including settling)	60 (including settling)
Average rotational delay (msec)	8.6	8.6	8.96	9.84	9.84
Average access time (msec)	93.6	93.6	73.96	69.84	69.84
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	5/88	5/88	4/87	1/89	2/89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high Embedded Servo	41.3 mm high Embedded Servo	41.3 mm high	25.4 mm high	30 mm high

MANUFACTURER	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC	FUJI ELECTRIC
DRIVE	FK303-52	FK309-39R	FK309S-50R	FK312A-50R	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	ST412	ST412	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2	U: 38.4*	F: 41.5	F: 40	F: 45
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624*	F: 16,896	F: 17,408	F: 17,408
Data surfaces per spindle	8	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	652
Track density (TPI)	753	753	753	1050	1050
Maximum linear density (BPI)	15600	23400 BPI* 15600 FCI	29000 BPI* 19333 FCI	23400 BPI* 15600 FCI	23400 BPI* 15600 FCI
Rotational speed (RPM)	3350	3350	3150	3050	3050
PERFORMANCE					
Actuator type	Band, Stepping Motor	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40 (including settling)	65 (including settling)	47 (including settling)	28	28
Average rotational delay (msec)	8.96	8.96	9.5	9.84	9.84
Average access time (msec)	48.96	73.96	56.5	37.84	37.84
Data transfer rate (KBytes/sec)	625	937.5*	937.5	1000	1000
FIRST CUSTOMER SHIPMENT	8/87	4/87	--	4/89	2/89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *2,7 RLL Code	25.4 mm high *2,7 RLL Code	25.4 mm high *2,7 RLL Code

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
DISK/TREND GROUP	M2225AD	M2225D2	M2226D2	M2227D2	M2241AS2 M2241B
MARKET	3	3	4	4	4
MEDIA: Generic type	OEM	OEM	OEM	OEM	Captive, OEM
Nominal disk diameter	Fixed	Fixed	Fixed	Fixed	Fixed
Recording medium	95 mm OD 25 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 Oxide Coated	130 mm OD 40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST412	ST412, SA4000
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.62	U: 25.62	U: 38.43	U: 51.24	U: 31.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	6	8	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	615	754
Track density (TPI)	846	834	834	834	760
Maximum linear density (BPI)	13330	14845	14845	14845	10200
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Encoder Motor	Rotary, Encoder Motor	Rotary, Encoder Motor	Rotary, Voice Coil
Average positioning time (msec)	85 (including settling)	35	35	35	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	43.3	43.3	43.3	38.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	4Q86	2Q87	1Q87	1Q87	5/84
U.S. OEM PRICE FOR 100 UNITS	--	--	\$525	\$595	--
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high	

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	M2242AS2 M2242B	M2611S/SA/SB	M2611T	M2243AS2 M2243B	M2243T
DISK/TREND GROUP	4	4	4	5	5
MARKET	Captive, OEM	OEM	OEM	Captive, 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	Oxide Coated	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412, SA4000	SCSI	PC AT	ST412, SA4000	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 54.9	F: 45.07	F: 45.07	U: 86.3	U: 86.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 17,408	F: 16,896	U: 10,416	U: 10,416
Data surfaces per spindle	7	2	2	11	7
Heads per data surface	1	1	1	1	1
Tracks per surface	754	1334	1334	754	1185
Track density (TPI)	760	1681	1681	760	1226
Maximum linear density (BPI)	10200	29571 BPI* 22178 FCI	29571 BPI* 22178 FCI	10200	10200
Rotational speed (RPM)	3600	3490	3490	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	25	25	30	25
Average rotational delay (msec)	8.3	8.6	8.6	8.3	8.3
Average access time (msec)	38.3	33.6	33.6	38.3	33.3
Data transfer rate (KBytes/sec)	625	1250	7400	625	625
FIRST CUSTOMER SHIPMENT	5/84	4Q88	3Q89	5/84	3Q87
U.S. OEM PRICE FOR 100 UNITS	\$1,210	--	--	\$1,350	\$1,000
COMMENTS		25.4 mm high *1,7 RLL Code Embedded Servo	25.4 mm high *1,7 RLL Code		41.3 mm high

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2244C/E	M2244S/SA/SB	M2312K/S	M2321K/S	M2243R
DISK/TREND GROUP	5	5	5	5	6
MARKET	Captive, OEM	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	200 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	SMD, SCSI	SMD, SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.8	F: 63	U: 84.44	U: 84.2	U: 129.6*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	U: 20,480	U: 20,480	U: 15,624*
Data surfaces per spindle	5	5	7	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	589	823	1185
Track density (TPI)	850	850	720	683	1226
Maximum linear density (BPI)	20400 BPI* 13600 FCI	20400 BPI* 13600 FCI	9550	9867	15300 BPI* 10200 FCI
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
Average positioning time (msec)	25	25	20	20	25
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	33.3	33.3	28.3	28.3	33.3
Data transfer rate (KBytes/sec)	1250	1500/2500	1229	1229	937.5*
FIRST CUSTOMER SHIPMENT	3Q85	2Q87	4/81	11/83	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$1,150
COMMENTS	*2,7 RLL Code	*2,7 RLL Code			41.3 mm high *With RLL controller

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2245C/E	M2245S/SA/SB	M2246C/E	M2246S/SA/SB	M2247E
DISK/TREND GROUP	6	6	6	6	6
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, 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 Oxide Coated	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	ESDI	SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 120.2	F: 89.7	U: 171.7	F: 130.3	U: 181.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,864	F: 16,640	U: 20,864	F: 16,640	U: 20,864
Data surfaces per spindle	7	7	10	10	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	823	823	1243
Track density (TPI)	850	850	850	850	1267
Maximum linear density (BPI)	20400 BPI* 13600 FCI	20400 BPI* 13600 FCI	20400 BPI* 13600 FCI	20400 BPI* 13600 FCI	19295 BPI* 14471 FCI
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
Average positioning time (msec)	25	25	25	25	18
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	26.3
Data transfer rate (KBytes/sec)	1250	1500/2500	1250	1500/2500	1250
FIRST CUSTOMER SHIPMENT	3Q85	2Q87	3Q85	2Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	\$970	\$995	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code



MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2247S/SA/SB	M2248E	M2248S/SA/SB	M2322K	M2612S/SA/SB
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	210 mm OD	95 mm OD
Recording medium	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	100 mm ID Oxide Coated	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI	SMD	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 137.9	U: 285.3	F: 220.5	U: 168.5	F: 90.84
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,640	U: 20,864	F: 16,640	U: 20,480	F: 17,408
Data surfaces per spindle	7	11	11	10	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1243	1243	1243	823	1334
Track density (TPI)	1267	1267	1267	683	1681
Maximum linear density (BPI)	19295 BPI*	19295 BPI*	19295 BPI*	9867	29571 BPI*
Rotational speed (RPM)	14471 FCI 3600	14471 FCI 3600	14471 FCI 3600	3600	22178 FCI 3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	18	20	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.6
Average access time (msec)	26.3	26.3	26.3	28.3	28.6
Data transfer rate (KBytes/sec)	1500/2500	1250	1500/2500	1229	1500/2500
FIRST CUSTOMER SHIPMENT	1Q88	3Q87	1Q88	11/83	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$3,450	--
COMMENTS	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code		41.3 mm high *1,7 RLL Code Embedded Servo

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2612T	M2613S/SA/SB	M2613T	M2614S/SA/SB	M2614T
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	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 90.15	F: 136.6	F: 135.23	F: 182.36	F: 180.31
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,896	F: 17,408	F: 16,896	F: 17,408	F: 16,896
Data surfaces per spindle	4	6	6	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1334	1334	1334	1334	1334
Track density (TPI)	1681	1681	1681	1681	1681
Maximum linear density (BPI)	29571 BPI* 22178 FCI	29571 BPI* 22178 FCI	29571 BPI* 22178 FCI	29571 BPI* 22178 FCI	29571 BPI* 22178 FCI
Rotational speed (RPM)	3490	3490	3490	3490	3490
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	20	20	20	20
Average rotational delay (msec)	8.6	8.6	8.6	8.6	8.6
Average access time (msec)	28.6	28.6	28.6	28.6	28.6
Data transfer rate (KBytes/sec)	7400	1500/2500	7400	1500/2500	7400
FIRST CUSTOMER SHIPMENT	3Q89	4Q88	3Q89	4Q88	3Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *1,7 RLL Code	41.3 mm high *1,7 RLL Code Embedded Servo	41.3 mm high *1,7 RLL Code	41.3 mm high *1,7 RLL Code Embedded Servo	41.3 mm high *1,7 RLL Code

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6421	M2249E	M2249S/SA/SB	M2261E	M2261H/HA/HB M2261S/SA/SB
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" 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	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Fujitsu	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY	1.607 or 1.144 MB Fixed Head Option				
Total capacity (Mbytes) FIXED	F: 446/317.5	U: 389	F: 303.1	U: 415.1	F: 321.1**
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,793/ 19,069	U: 20,864	F: 16,640	U: 31,296	F: 27,136
Data surfaces per spindle	10	15	15	8	8
Heads per data surface	2	1	1	1	1
Tracks per surface	1680	1243	1243	1658	1658
Track density (TPI)	880	1267	1267	1712	1712
Maximum linear density (BPI)	12790	19295 BPI* 14471 FCI	19295 BPI* 14471 FCI	28816 BPI* 21612 FCI	28816 BPI* 21612 FCI
Rotational speed (RPM)	3961	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	18	16	16
Average rotational delay (msec)	7.5	8.3	8.3	8.3	8.3
Average access time (msec)	25.5	26.3	26.3	24.3	24.3
Data transfer rate (KBytes/sec)	1859	1250	1500/2500	1875	1750/4000
FIRST CUSTOMER SHIPMENT	3Q81	3Q87	1Q88	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	\$1,585	\$1,740	--	--
COMMENTS	Drive has 4 spindles	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code **256 byte sector

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2294K/N	M2333K/KS	M2350A	M2351A	F6425G
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	210 mm OD 100 mm ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID	10.5" OD 4.0" ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	Modified SMD	Modified SMD	Modified SMD	Fujitsu
CAPACITY/RECORDING DENSITY				1.69 MB Fixed Head Option	
Total capacity (Mbytes) FIXED	U: 335.5	U: 337.1	U: 474.2	U: 474.2	F: 630.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	U: 40,960	U: 28,160	U: 28,160	F: 47,476
Data surfaces per spindle	8	10	10	10	8
Heads per data surface	2	1	2	2	2
Tracks per surface	2048	823	1684	1684	1770
Track density (TPI)	858	683	880	880	1350
Maximum linear density (BPI)	6500	19734 BPI* 13156 FCI	12790	12790	21300 BPI* 15975 FCI
Rotational speed (RPM)	2964	3600	3961	3961	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	27	20	18	18	12
Average rotational delay (msec)	10.12	8.3	7.5	7.5	8.3
Average access time (msec)	37.12	28.3	25.5	25.5	20.3
Data transfer rate (KBytes/sec)	1012	2458	1859/7436/9295	1859	3000
FIRST CUSTOMER SHIPMENT	5/83	11/84	2/84	3/82	12/88
U.S. OEM PRICE FOR 100 UNITS	--	\$4,425	--	--	--
COMMENTS		*2,7 RLL Code	Parallel data transfer, 4 or 5 channels		*1,7 RLL Code Drive has 4 spindles

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE	F6425K4/L4	M2262E	M2262H/HA/HB M2262S/SA/SB	M2263E	M2263H/HA/HB M2263S/SA/SB
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" 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	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Fujitsu	ESDI	SCSI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 630.0	U: 570.8	F: 442.0**	U: 778.3	F: 603.2**
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	U: 31,296	F: 27,136	U: 31,296	F: 27,136
Data surfaces per spindle	8	11	11	15	15
Heads per data surface	2	1	1	1	1
Tracks per surface	1770	1658	1658	1658	1658
Track density (TPI)	905	1712	1712	1712	1712
Maximum linear density (BPI)	24420 BPI* 16280 FCI	28816 BPI* 21612 FCI	28816 BPI* 21612 FCI	28816 BPI* 21612 FCI	28816 BPI* 21612 FCI
Rotational speed (RPM)	3620	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	15	16	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	24.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	3000	1875	1750/4000	1875	1750/4000
FIRST CUSTOMER SHIPMENT	3Q86	2Q88	2Q88	2Q88	4Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$2,200	\$2,340
COMMENTS	*2,7 RLL Code Drive has 4 spindles	*1,7 RLL Code	*1,7 RLL Code **256 byte sector	*1,7 RLL Code	*1,7 RLL Code **256 byte sector

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	FUJITSU
DRIVE					
	M2344K/KS	M2360A	M2361A	M2372K/KS	F6425H
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	10.5" OD	10.5" OD	210 mm OD	10.5" OD
Recording medium	100 mm ID Oxide Coated	4.0" ID Oxide Coated	4.0" ID Oxide Coated	100 mm ID Oxide Coated	4.0" ID Oxide Sputtered
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Mod. SMD, SCSI	Modified SMD	Modified SMD	Mod. SMD, SCSI	Fujitsu
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 690.1	U: 689.8	U: 689.8	U: 823.9	F: 1,890
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 40,960	U: 40,960	U: 40,960	F: 47,476
Data surfaces per spindle	13.5	10	10	13.5	16
Heads per data surface	2/1	2	2	2/1	2
Tracks per surface	1248	1684	1684	1490	2654
Track density (TPI)	846	880	880	1193	1350
Maximum linear density (BPI)	20767 BPI* 13844 FCI	18620 BPI* 12413 FCI	18620 BPI* 12413 FCI	20766 BPI* 13844 FCI	24440 BPI* 18330 FCI
Rotational speed (RPM)	3600	3673	3600	3600	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	18	18	16	16
Average rotational delay (msec)	8.3	8.17	8.3	8.3	8.3
Average access time (msec)	24.3	26.17	26.3	24.3	24.3
Data transfer rate (KBytes/sec)	2458	2507-12537	2458	2458	3000
FIRST CUSTOMER SHIPMENT	2Q87	3Q86	2Q85	9/87	12/88
U.S. OEM PRICE FOR 100 UNITS	\$8,400	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code Parallel data transfer, 4 or 5 channels	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code Drive has 4 spindles

MANUFACTURER	FUJITSU	FUJITSU	FUJITSU	FUJITSU	GOLDSTAR TELE- COMMUNICATION
DRIVE	F6425M4/N4	M2380A	M2382K/P	M2392K	GSH-3026
DISK/TREND GROUP	9	9	9	9	3
MARKET	Captive	OEM	OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	10.5" OD 4.0" ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Sputtered	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	Fujitsu	Modified SMD	Mod. SMD, IPI-2	Modified SMD	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	U: 889.1	U: 1,000.2	U: 2,020	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	U: 49,728	U: 49,728	U: 50,400	U: 10,416
Data surfaces per spindle	12	13.5	13.5	21	4
Heads per data surface	2	2/1	2/1	1	1
Tracks per surface	2360	1490	1490	1916	615
Track density (TPI)	1160	1193	1193	1456	753
Maximum linear density (BPI)	24989 BPI* 16659 FCI	25211 BPI* 18908 FCI	25211 BPI* 18908 FCI	25076 BPI* 18807 FCI	15600
Rotational speed (RPM)	3620	3709	3620	3600	3350
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Stepping Motor
Average positioning time (msec)	17	16	16	12	65 (including settling)
Average rotational delay (msec)	8.3	8.1	8.3	8.3	8.9
Average access time (msec)	25.3	24.1	24.3	20.3	73.9
Data transfer rate (KBytes/sec)	3000	3074-1844	3000	3000	625
FIRST CUSTOMER SHIPMENT	3Q86	1Q89	1Q88	3Q89	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$6,995	--
COMMENTS	*2,7 RLL Code Drive has 4 spindles	*1,7 RLL Code Parallel data transfer, 4, 5 or 6 channels	*1,7 RLL Code	*1,7 RLL Code	41.3 mm high

MANUFACTURER	GOLDSTAR TELE- COMMUNICATION	GOLDSTAR TELE- COMMUNICATION	GOLDSTAR TELE- COMMUNICATION	GOLDSTAR TELE- COMMUNICATION	HEWLETT- PACKARD
DRIVE	GSH-520	GSH-3040	GSH-3046S	GSH-540	9153 9154 97501B 97515B
DISK/TREND GROUP	3	4	4	4	3
MARKET	Captive, OEM	OEM	OEM	Captive, OEM	Captive, 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	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SASI, SCSI	ST412	SCSI	SASI, SCSI	HP
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20.7	U: 51.2	F: 41.5	F: 41.5	F: 20
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 10,752	U: 10,416	F: 8,448	F: 10,752	F: 7,168
Data surfaces per spindle	2	8	8	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	966	615	615	966	1400
Track density (TPI)	880	910	880	800	1850
Maximum linear density (BPI)	13160	12500	25600 BPI* 17066 FCI	13160	12700
Rotational speed (RPM)	3600	3600	3150	3600	3000
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Linear, Stepping Motor	Rotary, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	60 (including settling)	40 (including settling)	40 (including settling)	60 (including settling)	75 (including settling)
Average rotational delay (msec)	8.3	8.3	9.5	8.3	10
Average access time (msec)	68.3	48.3	49.5	68.3	85
Data transfer rate (KBytes/sec)	625	625	1100	625	500
FIRST CUSTOMER SHIPMENT	1988	1989	1989	1988	12/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$950
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high	51 mm high Embedded Servo

## 1989 DISK/TREND REPORT



MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	7957B 97961	7957S	7958B 7962B	7958S	9262B
DISK/TREND GROUP	5	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	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	SCSI	SCSI	HPIB	SCSI	HPIB
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 81	F: 107	F: 152	F: 161	F: 152
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,128	F: 17,152	F: 16,128	F: 17,152	F: 16,128
Data surfaces per spindle	4	4	6	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1269	1572	1552	1572	1552
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
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
Average positioning time (msec)	17	17	17	17	17
Average rotational delay (msec)	8.95	8.95	8.95	8.95	8.95
Average access time (msec)	25.95	25.95	25.95	25.95	25.95
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	3Q88	2Q88	4Q88	2Q88	1Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code HP 3000, 9000, 1000, 260	*2,7 RLL Code HP 9000	*2,7 RLL Code Embedded Servo HP 3000, 9000, 1000, 260	*2,7 RLL Code Embedded Servo HP 9000	*2,7 RLL Code Removable drive unit

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97532E	97532D 97532S 97532T	97533D 97533S 97533T	97533E	7936FL 7936H 7936XP
DISK/TREND GROUP	6	6	6	6	7
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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	Ferrite
Interface	ESDI	SCSI	SCSI	ESDI	HPIB,Fiber Link
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 129.68	F: 108	F: 162	U: 195	F: 308
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,480	F: 16,384	F: 16,384	U: 20,480	F: 31,488
Data surfaces per spindle	4	4	6	6	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1583	1643	1643	1583	1396
Track density (TPI)	1590	1590	1590	1590	1121
Maximum linear density (BPI)	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	20500 BPI* 13666 FCI	18800 BPI* 14101 FCI
Rotational speed (RPM)	3350	3350	3350	3350	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	17	17.5	17.5	17	20.5
Average rotational delay (msec)	8.95	8.95	8.95	8.95	8.3
Average access time (msec)	25.95	26.45	26.45	25.95	28.8
Data transfer rate (KBytes/sec)	1250	**	**	1250	2351
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	3Q87	3Q87	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$1,090	\$1,190(S model)	\$1,250(S model)	\$1,070	--
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code. Embedded Servo. **Transfer rate maximum: S- 2000 KB/sec. D- 4000 KB/sec. T- 4000 KB/sec.	*2,7 RLL Code. Embedded Servo. **Transfer rate maximum: S- 2000 KB/sec. D- 4000 KB/sec. T- 4000 KB/sec.	*2,7 RLL Code Embedded Servo	*Variable Length Frequency Modulation  Embedded Servo

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	7959B 7963B	7959S	9263B	97536D 97536S 97536T	97536E
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	Captive	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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	HPIB	SCSI	HPIB	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 304	F: 323	F: 304	F: 323.03	U: 389.04
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,128	F: 17,152	F: 16,128	F: 16,384	U: 20,480
Data surfaces per spindle	12	12	12	12	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1572	1572	1572	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
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
Average positioning time (msec)	17	17	17	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	25.95	26.45	25.95
Data transfer rate (KBytes/sec)	1250	1250	1250	**	1250
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	1Q88	3Q87	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$1,440(S Model)	\$1,440
COMMENTS	*2,7 RLL Code Embedded Servo HP 9000, 3000, 1000	*2,7 RLL Code Embedded Servo HP 9000	*2,7 RLL Code Embedded Servo Removable drive unit	*2,7 RLL Code. Embedded Servo. **Transfer rate maximum: S- 2000 KB/sec. D- 4000 KB/sec. T- 4000 KB/sec.	*2,7 RLL Code Embedded Servo

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97544D 97544S	97544E	97544P 97544T	7937FL 7937H 7937XP	7937S
DISK/TREND GROUP	7	7	7	8	8
MARKET	OEM	OEM	OEM	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	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	Ferrite	Ferrite
Interface	SCSI	ESDI	SCSI-2	HPIB,Fiber Link	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 331	U: 396	F: 331	F: 571	F: 571
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,672	U: 34,029	F: 28,672	F: 31,488	F: 31,488
Data surfaces per spindle	8	8	8	13	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1447	1457	1447	1396	1396
Track density (TPI)	1666	1666	1666	1121	1121
Maximum linear density (BPI)	30552 BPI* 20368 FCI	30552 BPI* 20368 FCI	30552 BPI* 20368 FCI	18800 BPI* 14101 FCI	18800 BPI* 14101 FCI
Rotational speed (RPM)	4002	4002	4002	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16.5	17	16.5	20.5	20.5
Average rotational delay (msec)	7.49	7.49	7.49	8.3	8.3
Average access time (msec)	23.99	24.49	23.99	28.8	28.8
Data transfer rate (KBytes/sec)	4000 max.	2500	4000 max.	2351	2351
FIRST CUSTOMER SHIPMENT	2Q89	2Q89	9/89	4Q86	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$1,470	\$1,470	\$1,470	--	\$8,240
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*Variable Length Frequency Modulation  Embedded Servo	*Variable Length Frequency Modulation  Embedded Servo

## 1989 DISK/TREND REPORT

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD
DRIVE	97548D 97548S	97548E	97548P 97548T	97549P 97549T	97558E
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	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	SCSI-2	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 663	U: 793	F: 663	F: 1,000	U: 1,262
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,672	U: 34,029	F: 28,672	F: 32,768	U: 40,672
Data surfaces per spindle	16	16	16	16	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1447	1457	1447	1918	2069
Track density (TPI)	1666	1666	1666	1850	1960
Maximum linear density (BPI)	30552 BPI* 20368 FCI	30552 BPI* 20368 FCI	30552 BPI* 20368 FCI	40500 BPI* 27000 FCI	38100 BPI* 25400 FCI
Rotational speed (RPM)	4002	4002	4002	4002	4033
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16.5	17	16.5	17.5	15
Average rotational delay (msec)	7.49	7.49	7.49	7.4	7.4
Average access time (msec)	23.99	24.49	23.99	24.9	22.4
Data transfer rate (KBytes/sec)	4000 max.	2500	4000 max.	5000 max.	2750
FIRST CUSTOMER SHIPMENT	4Q88	4Q88	9/89	1Q90	12/89
U.S. OEM PRICE FOR 100 UNITS	\$1,930(S model)	\$1,930	\$1,930	--	--
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	HEWLETT-PACKARD	HEWLETT-PACKARD	HEWLETT-PACKARD	HITACHI	HITACHI
DRIVE	97558P 97558T	97560E	97560P 97560T	DK302-2	DK505-2
DISK/TREND GROUP	9	9	9	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	130 mm OD 40 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	SCSI-2	ESDI	SCSI-2	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,071	U: 1,599	F: 1,358	U: 25.5	U: 25.62
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 34,816	U: 40,672	F: 34,816	U: 10,416	U: 10,416
Data surfaces per spindle	15	19	19	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	2059	2069	2059	615	615
Track density (TPI)	1960	1960	1960	822	650
Maximum linear density (BPI)	38100 BPI* 25400 FCI	38100 BPI* 25400 FCI	38100 BPI* 25300 FCI	13700	9490
Rotational speed (RPM)	4033	4033	4033	3550	3550
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor
Average positioning time (msec)	15	15	15	85 (including settling)	85 (including settling)
Average rotational delay (msec)	7.4	7.4	7.4	8.45	8.45
Average access time (msec)	22.4	22.4	22.4	93.45	93.45
Data transfer rate (KBytes/sec)	5000 max.	2750	5000 max.	625	625
FIRST CUSTOMER SHIPMENT	12/89	12/89	12/89	9/86	3/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	41.3 mm high	41.3 mm high Mfg. by Tokico

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK302-3	DK511-3	DK511-5	DK521-5	DK812S-5
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	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
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
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
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high			41.3 mm high	*2,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK511-8	DK512-8	DK512C-8	DK812S-8	DK312C-20
DISK/TREND GROUP	5	5	5	5	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	130 mm OD	210 mm OD	95 mm OD
	40 mm ID	40 mm ID	40 mm ID	100 mm ID	25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite**
Interface	ST412, SCSI	ESDI, SMD	SCSI	SMD	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.7	U: 86.1	F: 73.3	U: 85	F: 209
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,944	F: 17,920	U: 20,672	F: 19,456
Data surfaces per spindle	10	5	5	5	10
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	819	823	1076
Track density (TPI)	925	925	925	760	1660
Maximum linear density (BPI)	9250	18500 BPI* 12333 FCI	18500 BPI* 12333 FCI	9650 BPI* 6433 FCI	38800 BPI* 25866 FCI
Rotational speed (RPM)	3600	3482	3482	3510	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	23	23	23	25	20
Average rotational delay (msec)	8.3	8.6	8.6	8.5	8.3
Average access time (msec)	31.3	31.6	31.6	33.5	28.3
Data transfer rate (KBytes/sec)	625	1209	1500 max.	1209	1500/4000
FIRST CUSTOMER SHIPMENT	2Q84	3/85	1/87	7/83	3Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	41.3 mm high *2,7 RLL Code **Metal in Gap



MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
DISK/TREND GROUP	DK312C-25	DK512-12	DK512-17	DK512C-12	DK512C-17
MARKET	6	6	6	6	6
MEDIA: Generic type	OEM	OEM	OEM	OEM	OEM
Nominal disk diameter	Fixed	Fixed	Fixed	Fixed	Fixed
Recording medium	95 mm OD 25 mm ID Thin Film	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
DRIVE: Heads	Ferrite**	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 3600	18500 BPI* 12333 FCI 3482	18500 BPI* 12333 FCI 3482	18500 BPI* 12333 FCI 3482	18500 BPI* 12333 FCI 3482
Rotational speed (RPM)					
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	23	23	23	23
Average rotational delay (msec)	8.3	8.6	8.6	8.6	8.6
Average access time (msec)	28.3	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
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code **Metal in Gap	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

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		
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
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
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
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

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)

Rotational speed (RPM)

PERFORMANCE

Actuator type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

U.S. OEM PRICE FOR 100 UNITS

COMMENTS

HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DK812S-12	DK812S-17	DK814S-17	DK814S-24	DK514-38
6	6	6	6	7
OEM	OEM	OEM	OEM	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 Oxide Coated	130 mm OD 40 mm ID Oxide Coated
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
SMD	SMD	Modified SMD	Modified SMD	ESDI
U: 119	U: 170.1	U: 170	U: 238	U: 382.3
--	--	--	--	--
U: 20,672	U: 20,672	U: 32,768	U: 32,768	U: 30,240
7	10	5	7	14
1	1	1	1	1
823	823	823	823	903
760	760	800	800	1033
9650 BPI* 6433 FCI 3510	9650 BPI* 6433 FCI 3510	18500 BPI* 12333 FCI 2632	18500 BPI* 12333 FCI 2632	26000 BPI* 17333 FCI 3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
25	25	20	20	16
8.5	8.5	11.4	11.4	8.3
33.5	33.5	31.4	31.4	24.3
1209	1209	1815	1815	1815
6/83	6/83	12/84	12/84	3Q87
--	--	--	--	--
*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE					
	DK514C-38	DK514S-38	DK814S-34	DK515-78	DK515C-78
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	Ferrite**	Ferrite**
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
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
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
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code **Metal in Gap	*2,7 RLL Code **Metal in Gap

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DK711S-60D DK711S-60S	DK815-5	DKU-85I-D14 DKU-85I-D24	DKU-97I	DKU-97S
DISK/TREND GROUP	8	8	8	8	8
MARKET	OEM, Captive	OEM	Captive	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	224 mm OD 100 mm ID	14"	14"	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Modified SMD	Modified SMD	IBM	IBM	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 600	U: 525.38	F: 630	F: 635	U: 697.059
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 30,240	U: 30,240	F: 47,476	F: 19,069	U: 20,672
Data surfaces per spindle	22	14	*	20	20
Heads per data surface	1	1	2	2	2
Tracks per surface	903	1241	*	1666	1682
Track density (TPI)	1033	860	*	720	720
Maximum linear density (BPI)	26000 BPI* 17333 FCI 4876	14585 BPI* 9723 FCI 3600	*	6425	6425
Rotational speed (RPM)			3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Rotary, Voice Coil	Dual, Rotary, Voice Coil
Average positioning time (msec)	12	18	15	20/18	20
Average rotational delay (msec)	6.15	8.3	8.3	8.3	8.3
Average access time (msec)	18.15	26.3	23.3	28.3/26.3	28.3
Data transfer rate (KBytes/sec)	2458	1815	3000	1198	1240
FIRST CUSTOMER SHIPMENT	4Q87	11/84	4/86	1/81	9/83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Oversized packaging	*2,7 RLL Code	Drive has 4 spindles *Not announced	Drive has 2 spindles	

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	H-6555	H-8576-12 H-8576-22	DK815-10	DK815-10A	DK816-20
DISK/TREND GROUP	8	8	9	9	9
MARKET	Captive	Captive	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	224 mm OD 100 mm ID	14"	224 mm OD 100 mm ID	224 mm OD 100 mm ID	224 mm OD 100 mm ID
Recording medium	High Dens Oxide	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Thin Film	Thin Film	Thin Film
Interface	Hitachi	Hitachi	Mod SMD, IPI-2	Modified SMD	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 500	F: 635	U: 1,067	U: 1,067	U: 2,000
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 28,884	F: 19,069	U: 40,960	U: 40,960	U: 74,600
Data surfaces per spindle	14	20	15	15	15
Heads per data surface	1	2	1	1	1
Tracks per surface	1237	1666	1737	1737	1790
Track density (TPI)	860	720	1160	1220	1256
Maximum linear density (BPI)	14585 BPI* 9723 FCI	6425	20000 BPI* 15000 FCI	19560 BPI* 14670 FCI	35470 BPI* 26602 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Dual, Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	20	15	13	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	28.3	23.3	21.3	22.3
Data transfer rate (KBytes/sec)	1815	1198	2460	2460	4500
FIRST CUSTOMER SHIPMENT	1Q85	4Q80	1Q87	4Q87	3Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$9,600
COMMENTS	*2,7 RLL Code Drive has 1 to 4 spindles	Drive has 2 spindles	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code

MANUFACTURER	HITACHI	HITACHI	HITACHI	HITACHI	HITACHI
DRIVE	DKU-85I-E14 DKU-85I-E24 H-6585-14 H-6585-24	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
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM	Captive,OEM,PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	9.5"	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, Hitachi	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi	IBM, Hitachi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	F: 1,260	F: 630	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	*	15	15	15	20
Heads per data surface	2	1	1	2	2
Tracks per surface	*	1770 (Physical)	885	2655	1328 (Physical)
Track density (TPI)	*	*	*	*	600
Maximum linear density (BPI)	*	*	*	*	15240 BPI* 10160 FCI 3600
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Dual, Rotary, Voice Coil
Average positioning time (msec)	17	13	11	12.5	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	25.3	21.3	19.3	20.8	24.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	12/85	3Q88	3Q88	3Q88	4Q82
U.S. OEM PRICE FOR 100 UNITS	--	--	--		--
COMMENTS	Drive has 4 spindles  *Not announced	Drive has 8 spindles  *Not announced	Drive has 8 spindles  *Not announced	Drive has 8 spindles  *Not announced	*2,7 RLL Code Drive has 2 spindles  2 actuators per spindle

MANUFACTURER	HITACHI	HYOSUNG COMPUTER	HYOSUNG COMPUTER	HYOSUNG COMPUTER	IBIS
DRIVE					
	H-6556-1	HC8085	HC8128	HC8170E	1012
DISK/TREND GROUP	9	5	6	6	9
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	Hitachi	ST412	ST412	ESDI	Custom, VME
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,260	U: 85.3	U: 127.9	U: 171.5	U: 1,010
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	U: 10,416	U: 15,624	U: 20,934	U: 99,840
Data surfaces per spindle	15	8	8	8	5
Heads per data surface	1	1	1	1	2
Tracks per surface	1770 (Physical)	1024	1024	1024	2024
Track density (TPI)	*	1053	1053	1053	818
Maximum linear density (BPI)	*	9290	13935 BPI* 9250 FCI	19222 BPI* 12815 FCI	32000
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, DC Motor	Rotary, DC Motor	Rotary, DC Motor	Linear, Voice Coil
Average positioning time (msec)	15	25	25	25	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	33.3	33.3	33.3	26.3
Data transfer rate (KBytes/sec)	3000	625	937.5	1250	12000
FIRST CUSTOMER SHIPMENT	3/88	1989	1989	1989	4/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Drive has 4 spindles  *Not announced		*2,7 RLL Code	*2,7 RLL Code	2 track parallel data transfer



MANUFACTURER	IBIS	IBIS	IBM	IBM	IBM
DRIVE	2012	2812	8525-001,004 8525-G01,G04 8525-L01,L04 8530-E01,E21	8530-021,R21	WD-325
DISK/TREND GROUP	9	9	3	3	3
MARKET	OEM	OEM	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	Custom, VME	Custom, ISI		ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,020	U: 2,830.0	F: 20	F: 20.8	U: 25.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 99,840	U: 99,840	F: 8,704	F: 8,704	U: 10,416
Data surfaces per spindle	5	16	4	4	4
Heads per data surface	2	2	1	1	1
Tracks per surface	4048	1776	610	598	612
Track density (TPI)	1636	769	850	850	850
Maximum linear density (BPI)	32000	32000	13400	13400	13400
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	16	16	80 (including settling)	80 (including settling)	80 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	88.3	88.3	88.3
Data transfer rate (KBytes/sec)	12000	12000	625	625	625
FIRST CUSTOMER SHIPMENT	4Q89	4Q87	4Q88	4/87	5/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	2 track parallel data transfer  "8000 series" is 4 spindles with 8 GB capac	2 track parallel data transfer  Drive has 1 spindle with 2 actuators	41.3 mm high. PS/2 Model 25, Model 30 286. Optional drive w/38 ms average position. time made by Seagate	41.3 mm high PS/2 Model 30	41.3 mm high

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	WDI-325	4956-G10(40 MB) 4956-H10(40 MB)	5364-001	6150-4735	7541 7542
DISK/TREND GROUP	3	4	4	4	4
MARKET	Captive	Captive	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	130 mm OD	130 mm OD	130 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412	IBM, ST412	ST412	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.3	F: 40	F: 41.92	F: 44.6	F: 31.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 8,704	F: 8,192	F: 8,704	F: 12,800
Data surfaces per spindle	4	7	7	7	4
Heads per data surface	1	1	1	1	1
Tracks per surface	612	733	733	733	612
Track density (TPI)	841	815	815	815	841
Maximum linear density (BPI)	13160	9398	9398	9398	19740
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Stepping Motor
Average positioning time (msec)	80 (including settling)	40	40	40	39 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	88.3	48.3	48.3	48.3	47.3
Data transfer rate (KBytes/sec)	625	625	625	625	937.5
FIRST CUSTOMER SHIPMENT	6/88	9/86	6/85	3/86	4/89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	Series/1	System unit for System/36 PC	RT PC	41.3 mm high IBM Industrial Computer

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8530-001	8550-031 5551-S09 5551-T09 8555-031	8560-041 8580-041	4956-G10(72 MB) 4956-H10(72 MB) 4956-J00(72 MB)	4965-E00
DISK/TREND GROUP	4	4	4	5	5
MARKET	Captive	Captive	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	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Microchannel	Microchannel	ST412	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 31.3	F: 31.3	F: 44.6	F: 72	F: 72
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	F: 12,800	F: 8,704	F: 17,664	F: 17,664
Data surfaces per spindle	4	4	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	612	612	733	582	582
Track density (TPI)	841	841	815	648	648
Maximum linear density (BPI)	19740	19740	9398	18942 BPI* 12628 FCI	18942 BPI* 12628 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	39 (including settling)	39 (including settling)	40	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	47.3	47.3	48.3	38.3	38.3
Data transfer rate (KBytes/sec)	937.5	937.5	625	1250	1250
FIRST CUSTOMER SHIPMENT	4/89	5/88	2Q87	2/88	2/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high PS/2 Model 30	41.3 mm high PS/2 Model 50, Model 55 SX	PS/2 Model 60 and Model 80	Series/1 *2,7 RLL Code	Storage expansion unit for Series/1 *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	5363-P10	5363-P20 5363-P22	6150-115 6150-125 6150-B25 6151-115 6151-125 6151-B25	7561 7562	8550-061 8570-A61, E61 8570-061 5551-T0A 8555-061 8573-061
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	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	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	Microchannel	Microchannel
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 67.56	F: 106.2	U: 85.0 F: 73.0	F: 60.8	F: 60.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,640	F: 16,640	F: 17,920	F: 13,312	F: 13,312
Data surfaces per spindle	7	7	7	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	580	914	582	762	762
Track density (TPI)	648	1000	648	1169	1169
Maximum linear density (BPI)	18942 BPI* 12628 FCI	19159 BPI* 12772 FCI	18942 BPI* 12628 FCI	21700 BPI* 14466 FCI	21700 BPI* 14466 FCI
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
Average positioning time (msec)	30	28	30	27	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	36.3	38.3	35.3	35.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1050	1050
FIRST CUSTOMER SHIPMENT	10/87	10/87	9/86	4/89	5/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	System unit for System/36 PC *2,7 RLL Code	System unit for System/36 PC *2,7 RLL Code	RT PC *2,7 RLL code	41.3 mm high IBM Industrial Computer	41.3 mm high PS/2 Model 50, Model 70, Model 55 SX, Model P70 386 *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	8560-071 8580-071 5571-TOA	671-284	4967-2CA 4967-2CB	5360-BXX	5364-003 5364-004 5364-023 5364-024
DISK/TREND GROUP	5	6	6	6	6
MARKET	Captive	OEM	Captive	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	14"	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI, SCSI	IBM	IBM	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 70	U: 284	F: 200.2	F: 200.2	F: 65.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 21,080	F: 25,088	F: 25,088	F: 16,640
Data surfaces per spindle	7	11	7	7	7
Heads per data surface	1	1	2	2	1
Tracks per surface	583	1225	1140	1140	580
Track density (TPI)	648	1168	485	485	648
Maximum linear density (BPI)	18942 BPI* 12628 FCI	21384 BPI* 14256 FCI	9751	9751	18942 BPI* 12628 FCI
Rotational speed (RPM)	3600	3283	2964	2964	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	21.5	25	25	30
Average rotational delay (msec)	8.3	9.14	10.1	10.1	8.3
Average access time (msec)	38.3	30.64	35.1	35.1	38.3
Data transfer rate (KBytes/sec)	1250	1250	1500	1500	1250
FIRST CUSTOMER SHIPMENT	2Q87	1Q88	7/83	7/83	2/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PS/2 Model 60 and Model 80  *2, 7 RLL Code	*2,7 RLL Code	Series/1  384 KB Cache	System/36  5360-BX4 uses 2 spindles, with total 400.4 MB	System unit for System/36 PC  *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	6150-13X 6150-B35 6150-4100 Opt. 6151-13X 6151-B35 6151-4100 Opt.	6156-001 6156-003	8102-A15	8570-121 8570-A21 8573-121 5551-TOB	8580-111 5571-TOB
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	210 mm OD 100 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	IBM	Microchannel	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 114	F: 114	F: 129.7	F: 120.5	F: 115
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	F: 17,920	F: 16,384	F: 16,384	F: 18,432
Data surfaces per spindle	7	7	11	8	7
Heads per data surface	1	1	1	1	1
Tracks per surface	915	915	720	920	915
Track density (TPI)	1000	1000	850	1302	1000
Maximum linear density (BPI)	19159 BPI* 12772 FCI	19159 BPI* 12772 FCI	8770	26700 BPI* 17800 FCI	19159 BPI* 12772 FCI
Rotational speed (RPM)	3600	3600	3125	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	28	27	23	28
Average rotational delay (msec)	8.3	8.3	9.6	8.3	8.3
Average access time (msec)	36.3	36.3	36.6	31.3	36.3
Data transfer rate (KBytes/sec)	1250	1250	1031	1275	1250
FIRST CUSTOMER SHIPMENT	4Q87	6/88	4/84	5/88	4Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	RT PC *2,7 RLL Code	Removable disk drive for RT PC 003 holds up to 3 disk modules. *2,7 RLL Code. 310 MB drive is optional	8100 System -A17 model is 2 spindles	41.3 mm high PS/2 Model 70, Model P70 386 *2,7 RLL Code	PS/2 Model 60 and Model 80 *2,7 RLL Code

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	9332-200 9332-220 9332-A11	9332-240 9332-250	0661	4967-3CA 4967-3CB	5360-BXA 5360-BXB 5360-C2X
DISK/TREND GROUP	6	6	7	7	7
MARKET	Captive	Captive	Captive, OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD	210 mm OD	95 mm OD	14"	14"
Recording medium	100 mm ID Oxide Coated	100 mm ID Oxide Coated	25 mm ID Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	MIG	Ferrite	Ferrite
Interface	IPI-3	SCSI	SCSI-2	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 200.3	F: 200.3	U: 371 F: 320.1	F: 358	F: 359.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 37,376	F: 37,376	F: 24,576	F: 25,088	F: 25,088
Data surfaces per spindle	4	4	14	7	7
Heads per data surface	1	1	1	1	2
Tracks per surface	1346	1346	949	2048	2048
Track density (TPI)	1096	1096	1201.5	869	869
Maximum linear density (BPI)	23100 BPI* 17325 FCI	23100 BPI* 17325 FCI	37341 BPI* 28006 FCI	9751	9751
Rotational speed (RPM)	3119	3119	4317.8	2964	2964
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	19.5	19.5	12.5	25	25
Average rotational delay (msec)	9.62	9.62	6.95	10.1	10.1
Average access time (msec)	29.12	29.12	19.45	35.1	35.1
Data transfer rate (KBytes/sec)	2500	2500	4000 max.	1500	1500
FIRST CUSTOMER SHIPMENT	8/86	2Q87	8/89	9/86	2/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	System/36 System/38 AS/400 *1,7 RLL Code Embedded Servo	RT PC *1,7 RLL Code Embedded Servo	41.3 mm high *1,7 RLL Code	Series/1	System/36 System uses multiple spindles

MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE	6150-4300 Opt. 6150-5300 Opt. 6151-4300 Opt. 6151-5300 Opt.	671-387	678-400	8580-311	9332-400 9332-402 9332-420
DISK/TREND GROUP	7	7	7	7	7
MARKET	Captive	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	210 mm OD 100 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI, SCSI	IPI-3, SCSI	ESDI	IPI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 310	U: 387	U: 476.5 F: 400.6	F: 314	F: 400.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	U: 21,080	U: 44,252 F: 37,376*	F: 17,408	F: 37,376
Data surfaces per spindle	15	15	8	15	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1225	1346	1225	1346
Track density (TPI)	1168	1168	1096	1168	1096
Maximum linear density (BPI)	21384 BPI* 14256 FCI	21384 BPI* 14256 FCI	23100 BPI** 17325 FCI	21384 BPI* 14256 FCI	23100 BPI* 17325 FCI
Rotational speed (RPM)	3283	3283	3119	3283	3119
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	21.5	21.5	19.5	21.5	19.5
Average rotational delay (msec)	9.14	9.14	9.62	9.14	9.62
Average access time (msec)	30.64	30.64	29.12	30.64	29.12
Data transfer rate (KBytes/sec)	1250	1250	2500	1250	2500
FIRST CUSTOMER SHIPMENT	7/88	1Q88	6/86	1Q88	7/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	RT PC *2,7 RLL Code	*2,7 RLL Code	*Outer 893 tracks **1,7 RLL Code Embedded Servo	PS/2 Model 80 *2,7 RLL Code	AS/400. 368 MB capacity when used with 9370 series. *1,7 RLL Code Embedded Servo



MANUFACTURER	IBM	IBM	IBM	IBM	IBM
DRIVE					
	9332-440 9332-450	9332-A12	9404-B10 9404-B20	3370-A02	9332-600 9332-602
DISK/TREND GROUP	7	7	7	8	8
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	130 mm OD 40 mm ID	14"	210 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI	IPI-3	SCSI	IBM	IPI-3
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 400.6	F: 400.6	F: 315.592	F: 729.8	F: 600
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 37,376	F: 37,376	F: 17,408	F: 31,744	F: 37,376
Data surfaces per spindle	8	8	15	12	8
Heads per data surface	1	1	1	2	1
Tracks per surface	1346	1346	1223	1916	2017
Track density (TPI)	1096	1096	1168	800	1500
Maximum linear density (BPI)	23100 BPI* 17325 FCI	23100 BPI* 17325 FCI	21384 BPI* 14256 FCI	12134 BPI* 8089 FCI	23570 BPI* 17677 FCI
Rotational speed (RPM)	3119	3119	3283	2964	3119
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	19.5	19.5	21.5	19	19.5
Average rotational delay (msec)	9.62	9.62	9.14	10.1	9.62
Average access time (msec)	29.12	29.12	30.64	29.1	29.12
Data transfer rate (KBytes/sec)	2500	2500	1250	1859	2500
FIRST CUSTOMER SHIPMENT	2Q87	8/86	3Q88	2Q84	9/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	RT PC *1,7 RLL Code Embedded Servo	System/36 System/38 *1,7 RLL Code Embedded Servo	AS/400 *2,7 RLL Code 2 or 3 drives per system	4341 4361 4381 *2,7 RLL Code	568 MB capacity when used with 9370 series *1,7 RLL Code Embedded Servo

MANUFACTURER	IBM	IBM	IBM	IBM	IMPRIMIS TECHNOLOGY
DRIVE	685-B01	3380-AJ4 3380-BJ4 3380-CJ2	3380-AK4 3380-BK4	9335-B01	9710 RSD
DISK/TREND GROUP	9	9	9	9	2
MARKET	OEM	Captive	Captive	Captive	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Removable Storage Drive
Nominal disk diameter	14"	14"	14"	14"	230 mm OD 100 mm ID
Recording medium	Oxide Coated	Oxide Coated	*	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	IBM	IBM	IBM	IBM	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,043.1 F: 855.9	F: 1,260.4	F: 3,781.4	F: 855.9	--
REMOVABLE	--	--	--	--	U: 82.9
Capacity per track (Bytes)	U: 44,280 F: 36,352	F: 47,476	F: 47,476	F: 36,352	U: 20,160
Data surfaces per spindle	6	15	15	6	5
Heads per data surface	2	2	2	2	1
Tracks per surface	3926	1770	5310	3924	823
Track density (TPI)	1600	*	*	1600	550
Maximum linear density (BPI)	16200 BPI* 10800 FCI	*	*	16200 BPI* 10800 FCI	10000 BPI* 6666 FCI
Rotational speed (RPM)	3623	3620	3620	3623	3600
PERFORMANCE					
Actuator type	Dual, Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	18	12	16	18	27
Average rotational delay (msec)	8.28	8.3	8.3	8.28	8.3
Average access time (msec)	26.28	24.3	24.3	26.28	35.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	1209
FIRST CUSTOMER SHIPMENT	6/86	10/87 (A,B)	10/87	8/86	1Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$4,915
COMMENTS	685-A01 has IPI-3 interface *2,7 RLL Code	*Not announced AJ4 & BJ4 have 2 spindles	*Not announced Drive has 2 spindles	System/38. AS/400. 9335-A01 has IPI-3 interface *2,7 RLL Code. Embedded Servo	*2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	9762 SMD	9766 SMD	94155-48 Wren II	94205-51 Wren II HH	94155-67 Wren II
DISK/TREND GROUP	2	2	4	4	5
MARKET	OEM, Captive	OEM, Captive	OEM	OEM	OEM
MEDIA: Generic type	Storage Module Drive	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	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	SMD	ST412, ESDI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	U: 48.1	U: 51.5	U: 67.4
REMOVABLE	U: 82.9	U: 315.2	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	5	19	5	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	823	823	925	989	925
Track density (TPI)	384	384	960	960	960
Maximum linear density (BPI)	6038	6038	9540	9400	9540
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
Average positioning time (msec)	30	30	30	28	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	36.3	38.3
Data transfer rate (KBytes/sec)	1209	1209	625	625	625
FIRST CUSTOMER SHIPMENT	3/75	3/76	2Q84	1Q86	2Q84
U.S. OEM PRICE FOR 100 UNITS	\$6,715	\$12,355	--	--	--
COMMENTS				41.3 mm high	

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE					
	94155-85 Wren II	94155-86 Wren II	94155-96 Wren II	94156-67 Wren II	94156-86 Wren II
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	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 85.3	U: 86.7	U: 96	U: 67.4	U: 86.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	9	9	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	925	1024	925	925
Track density (TPI)	980	960	960	960	960
Maximum linear density (BPI)	9400	9540	9540	9540	9540
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
Average positioning time (msec)	28	30	28	30	30
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	38.3	36.3	38.3	38.3
Data transfer rate (KBytes/sec)	625	625	625	625	625
FIRST CUSTOMER SHIPMENT	1986	2Q84	1986	2Q84	2Q84
U.S. OEM PRICE FOR 100 UNITS	--	\$650 (250)	\$650 (250)	--	--
COMMENTS					

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MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94204-65 Wren II HH	94204-71 Wren II HH	94205-77 Wren II HH	94155-135 Wren II	94161-182 Wren III
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	PC AT	ST412	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 65	F: 71	U: 77*	U: 135*	F: 169
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 13,824	U: 15,624*	U: 15,624*	F: 19,456
Data surfaces per spindle	5	5	5	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	941	1032	989	960	969
Track density (TPI)	960	960	960	960	960
Maximum linear density (BPI)	14300 BPI* 9533 FCI	14300 BPI* 9533 FCI	14100 BPI* 9400 FCI	14100 BPI* 9400 FCI	19058 BPI* 12705 FCI
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
Average positioning time (msec)	28	28	28	28	16.5
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	24.8
Data transfer rate (KBytes/sec)	937.5	937.5	937.5*	937.5*	1250
FIRST CUSTOMER SHIPMENT	7/88	7/88	3Q87	3Q87	--
U.S. OEM PRICE FOR 100 UNITS	--	--	\$390 (250)	\$670 (250)	\$1,065 (250)
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller	*With RLL controller	*2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94166-101 Wren III	94166-141 Wren III	94166-182 Wren III	94211 Wren III HH	94216 Wren III 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	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	ESDI, SCSI	ESDI, SCSI	ESDI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 101	U: 141	U: 182	F: 91	U: 106
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	U: 20,880	U: 20,880	F: 18,432	U: 20,880
Data surfaces per spindle	5	7	9	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	969	969	969	1024	969
Track density (TPI)	960	960	960	960	960
Maximum linear density (BPI)	19058 BPI* 12705 FCI	19058 BPI* 12705 FCI	19058 BPI* 12705 FCI	19058 BPI* 12705 FCI	19058 BPI* 12705 FCI
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
Average positioning time (msec)	16.4	16.4	16.4	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.7	24.7	24.7	26.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2Q86	2Q86	2Q86	2/87	2/87
U.S. OEM PRICE FOR 100 UNITS	--	--	\$995 (250)	--	\$845 (250)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94221-190 Wren V HH	94244-219 Wren VI HH	94246-182 Wren VI HH	94311-136 Swift	94311-136S 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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	MIG	MIG
Interface	SCSI	PC AT	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 190	F: 193	U: 182	F: 120	F: 120
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	**	F: 27,648	U: 31,320	*	*
Data surfaces per spindle	5	4	4	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1547	1747	1453	*	*
Track density (TPI)	1280	1460	1460	*	*
Maximum linear density (BPI)	*	*	*	*	*
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
Average positioning time (msec)	18	16	16	15	15
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	24.3	24.3	23.3	23.3
Data transfer rate (KBytes/sec)	1125-1875	1875	1875	1250	1250
FIRST CUSTOMER SHIPMENT	2/88	4/89	1/89	4Q89	1Q90
U.S. OEM PRICE FOR 100 UNITS	\$1,175 (250)	--	\$1,665 (250)	\$1,205	\$1,275
COMMENTS	41.3 mm high **Varies by zone *Not announced	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	26.7 mm high *Not announced	26.7 mm high *Not announced

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94314-136 Swift	94316-136 Swift	94351-111 Swift	94351-126 Swift	94351-133S 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	Ferrite	MIG
Interface	PC AT	ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 120	U: 136	F: 98	F: 111	F: 117
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	*	F: 18,432	F: 14,848	F: 18,432
Data surfaces per spindle	5	5	5	7	5
Heads per data surface	1	1	1	1	1
Tracks per surface	*	*	1068	1068	1268
Track density (TPI)	*	*	1350	1350	1543
Maximum linear density (BPI)	*	*	28103 BPI* 18735 FCI	22638 BPI* 15092 FCI	29000 BPI* 19333 FCI
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
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	1000	1250
FIRST CUSTOMER SHIPMENT	4Q89	2Q89	1Q89	1Q89	4Q89
U.S. OEM PRICE FOR 100 UNITS	\$1,205	\$1,085	\$1,095	\$850	\$1,225
COMMENTS	26.7 mm high *Not announced	26.7 mm high *Not announced	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code



	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
MANUFACTURER					
DRIVE					
	94351-155 Swift	94351-155S Swift	94351-160 Swift	94351-186S Swift	94351-200 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	Ferrite	MIG	MIG
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 138	F: 138	F: 142	F: 164	F: 177
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	F: 18,432	F: 18,432	F: 18,432
Data surfaces per spindle	7	7	9	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1068	1068	1068	1268	1068
Track density (TPI)	1350	1350	1350	1543	1350
Maximum linear density (BPI)	28103 BPI*	28103 BPI*	22638 BPI*	29000 BPI*	28103 BPI*
Rotational speed (RPM)	18735 FCI 3600	18735 FCI 3600	15092 FCI 3600	19333 FCI 3600	18735 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
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	1000	1250	1250
FIRST CUSTOMER SHIPMENT	1Q89	3Q89	1Q89	4Q89	1Q89
U.S. OEM PRICE FOR 100 UNITS	\$1,195	\$1,245	\$930	\$1,325	\$1,295
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE					
	94351-200S Swift	94351-230S Swift	94354-111 Swift	94354-126 Swift	94354-133 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	Ferrite	MIG
Interface	SCSI	SCSI	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 177	F: 211	F: 98	F: 111	F: 117
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	F: 18,432	F: 14,848	F: 18,432
Data surfaces per spindle	9	9	5	7	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1068	1268	1072	1072	1272
Track density (TPI)	1350	1543	1350	1350	1543
Maximum linear density (BPI)	28103 BPI*	29000 BPI*	28103 BPI*	22638 BPI*	29000 BPI*
Rotational speed (RPM)	18735 FCI 3600	19333 FCI 3600	18735 FCI 3600	15092 FCI 3600	19333 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
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	1000	1250
FIRST CUSTOMER SHIPMENT	3Q89	3Q89	1Q89	1Q89	4Q89
U.S. OEM PRICE FOR 100 UNITS	\$1,345	\$1,425	\$1,095	\$850	\$1,155
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94354-155 Swift	94354-160 Swift	94354-186 Swift	94354-200 Swift	94354-230 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	MIG	MIG	MIG
Interface	PC AT	PC AT	PC AT	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 138	F: 143	F: 164	F: 177	F: 211
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	F: 18,432	F: 18,432	F: 18,432
Data surfaces per spindle	7	9	7	9	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1072	1072	1272	1072	1272
Track density (TPI)	1350	1350	1543	1350	1543
Maximum linear density (BPI)	28103 BPI*	22638 BPI*	29000 BPI*	28103 BPI*	29000 BPI*
Rotational speed (RPM)	18735 FCI 3600	15092 FCI 3600	19333 FCI 3600	18735 FCI 3600	19333 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
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	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1Q89	1Q89	4Q89	1Q89	3Q89
U.S. OEM PRICE FOR 100 UNITS	\$1,195	\$930	\$1,255	\$1,295	\$1,355
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94355-100 Swift	94355-150 Swift	94356-111 Swift	94356-155 Swift	94356-200 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	MIG	MIG	MIG
Interface	ST412	ST412	ESDI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 100	U: 150	U: 111	U: 156	U: 201
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 15,624	U: 20,880	U: 20,880	U: 20,880
Data surfaces per spindle	9	9	5	7	9
Heads per data surface	1	1	1	1	1
Tracks per surface	1072	1072	1072	1072	1072
Track density (TPI)	1350	1350	1350	1350	1350
Maximum linear density (BPI)	14019	21030 BPI* 14020 FCI	28103 BPI* 18735 FCI	28103 BPI* 18735 FCI	28103 BPI* 18735 FCI
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
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)	625	938	1250	1250	1250
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	1Q89	1Q89	1Q89
U.S. OEM PRICE FOR 100 UNITS	\$770	\$840	\$975	\$1,075	\$1,175
COMMENTS	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	9715-160 FSD	94171-344 94171-376 Wren IV	94171-350 Wren IV	94181-385H Wren Runner	94186-383 Wren V
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	230 mm OD 100 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	Thin Film
DRIVE: Heads	Ferrite	Thin Film	Thin Film	Thin Film	
Interface	SMD	SCSI	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 165.9	F: 344	F: 320	F: 357	U: 383
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	**	**	**	U: 20,880
Data surfaces per spindle	10	9	9	15	13
Heads per data surface	1	1	1	1	1
Tracks per surface	823	1549	1365	**	1412
Track density (TPI)	550	1280	1412	**	1280
Maximum linear density (BPI)	9500 BPI* 6333 FCI	19500 BPI* 13000 FCI	19058 BPI* 12705 FCI	*	*
Rotational speed (RPM)	3600	3600	3600		3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	30	16.5	16.5	10.7	19.5
Average rotational delay (msec)	8.3	8.3	8.3		8.3
Average access time (msec)	38.3	24.8	24.8		27.8
Data transfer rate (KBytes/sec)	1209	1125-1875	1250-1875	1937.5	1250
FIRST CUSTOMER SHIPMENT	4Q82	10/87	3/87	1Q89	2/88
U.S. OEM PRICE FOR 100 UNITS	\$4,650	\$1,750 (250)	\$1,685	\$2,010 (250)	\$1,620 (250)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code **Varies by zone	*2,7 RLL Code **Varies by zone	*2,7 RLL Code **Not announced	*Not announced

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	94186-383H Wren V	94186-442 Wren V	94241-383 Wren VI HH	94244-383 Wren VI HH	ST (94246-383) Wren VI 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	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	ESDI	ESDI	SCSI	PC AT	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 383	U: 442	F: 350	F: 338	U: 383
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,880	U: 20,880	**	F: 27,648	U: 31,320
Data surfaces per spindle	15	15	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1412	1400	1747	1747
Track density (TPI)	1280	1280	1460	1460	1460
Maximum linear density (BPI)	*	*	*	*	*
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
Average positioning time (msec)	14.5	16	15	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.8	24.3	23.3	24.3	24.3
Data transfer rate (KBytes/sec)	1250	1250	2250-2500	1875	1875
FIRST CUSTOMER SHIPMENT	2/88	2/88	7/89	4/89	1/89
U.S. OEM PRICE FOR 100 UNITS	\$1,685 (250)	\$1,750 (250)	\$1,990 (250)	\$1,990 (5000)	\$1,925 (5000)
COMMENTS	*Not announced	*Not announced	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	9715-300 FSD	9715-340 FSD	9720-368 Sabre	94181-702 Wren V	94191-766 Wren VI
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	230 mm OD	230 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	SMD	SMD	SMD,SMD-E,SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 315	U: 344.0	U: 368	F: 638	F: 701
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,160	U: 30,240	**	F: 28,672
Data surfaces per spindle	9.5	12	10	15	15
Heads per data surface	2/1	2	1	1	1
Tracks per surface	1646	1422	1217	1546	1632
Track density (TPI)	1040	960	960	1280	1460
Maximum linear density (BPI)	10040 BPI* 6693 FCI	10027 BPI* 6684 FCI	15185 BPI* 10123 FCI	*	*
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
Average positioning time (msec)	20	18	18	16	16.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	26.3	26.3	24.3	24.8
Data transfer rate (KBytes/sec)	1209	1209	1815	1500-2000	1875
FIRST CUSTOMER SHIPMENT	4Q85	4Q83	11/85	5/88	--
U.S. OEM PRICE FOR 100 UNITS	\$5,290	\$5,815	\$3,155	\$2,335 (250)	\$2,990 (250)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*Not announced **Varies by zone	*2,7 RLL Code

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE					
	94196-766 Wren VI	94241-502 Wren VI HH	9715-500 FSD	9720-500 Sabre	9720-736 Sabre
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	230 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ESDI	SCSI	Mod.SMD, IPI-2	Mod.SMD, SCSI	Mod.SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 766	F: 436	U: 516	U: 500	U: 741
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,320	**	U: 30,240	U: 41,088	U: 30,240
Data surfaces per spindle	15	7	12	10	15
Heads per data surface	1	1	2	1	1
Tracks per surface	1632	1765	1422	1217	1635
Track density (TPI)	1460	1460	960	960	1289
Maximum linear density (BPI)	*	*	15159 BPI* 10106 FCI	19816 BPI* 13210 FCI	14981 BPI* 9987 FCI
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
Average positioning time (msec)	16.5	16	18	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	24.3	26.3	26.3	24.3
Data transfer rate (KBytes/sec)	1875	2250-2500	1825	2465	1815
FIRST CUSTOMER SHIPMENT	--	9/89	4Q83	2Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	\$2,860 (250)	\$2,080 (250)	\$6,165	\$3,740	\$4,440
COMMENTS	*2,7 RLL Code	41.3 mm high *2,7 RLL Code **Varies by zone	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code



MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	9720-850 Sabre	9771 XMD-I	9772 XMD-II	9775 FMD	94601-12G Wren VII
DISK/TREND GROUP	8	8	8	8	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed Module Drive	Fixed
Nominal disk diameter	210 mm OD	14"	14"	14"	130 mm OD
Recording medium	100 mm ID Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	40 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Thin Film
Interface	Mod.SMD, IPI-2	Modified SMD	SMD-E	SMD	SCSI
CAPACITY/RECORDING DENSITY				1.9 MB Fixed Head Option	
Total capacity (Mbytes) FIXED	U: 851	U: 825	U: 858	U: 675	F: 1,103
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,088	U: 50,400	U: 50,400	U: 20,160	**
Data surfaces per spindle	15	8	8	20	15
Heads per data surface	1	2	2	2	1
Tracks per surface	1381	2128	2128	1686	1931
Track density (TPI)	1089	960	960	660	1600
Maximum linear density (BPI)	19816 BPI* 13210 FCI	15400 BPI* 10266 FCI	15400 BPI* 10266 FCI	6350	33000 BPI* 24750 FCI
Rotational speed (RPM)	3600	2160	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	25	15
Average rotational delay (msec)	8.3	13.89	8.3	8.3	8.3
Average access time (msec)	24.3	29.89	24.3	33.3	23.3
Data transfer rate (KBytes/sec)	2465	1825	3000	1209	1875-2625
FIRST CUSTOMER SHIPMENT	3Q87	3Q83	10/85	4/80	5/89
U.S. OEM PRICE FOR 100 UNITS	\$4,615	\$9,000	\$9,000	\$15,155	\$4,485 (250)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code		*1,7 RLL Code  **Varies by zone

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY
DRIVE	9720-1230 Sabre	97200-11G Sabre 1123	97200-25G 97201-25G 97209-25G Sabre 2500	97229-11G Sabre 2HP 1150	97299-24G Sabre 2368
DISK/TREND GROUP	9	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD,SCSI,IPI-2	Mod. SMD	SMD,SCSI,IPI-2	IPI-2	IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,236	U: 1,123	U: 2,500	U: 1,154	U: 2,368
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 50,400	U: 45,792	U: 50,400	U: 50,400	U: 50,400
Data surfaces per spindle	15	15	19	14	19
Heads per data surface	1	1	1	1	1
Tracks per surface	1635	1635	2611	1635	2611
Track density (TPI)	1289	1289	1880	1289	1880
Maximum linear density (BPI)	25264 BPI* 16842 FCI	22955 BPI* 15303 FCI	25409 BPI* 16939 FCI	25264 BPI* 16842 FCI	25409 BPI* 16939 FCI
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
Average positioning time (msec)	16	16	13	16	13
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	21.3	24.3	21.3
Data transfer rate (KBytes/sec)	3000	2747	3000	6000	27000
FIRST CUSTOMER SHIPMENT	2Q88	3Q88	1Q90	4Q88	3Q90
U.S. OEM PRICE FOR 100 UNITS	\$6,105	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code 22 Mhz version of Sabre 1230	*2,7 RLL Code	*2,7 RLL Code 2 head parallel version of Sabre 1230	*2,7 RLL Code 9 head parallel version of Sabre 2500

MANUFACTURER	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	IMPRIMIS TECHNOLOGY	ISOT	ISOT
DRIVE	97500-12G 97509-12G Elite	97501-15G Elite	9772-13G XMD-III	CM 5400-00 CM 5400-01	CM 5410
DISK/TREND GROUP	9	9	9	1	1
MARKET	OEM	OEM	OEM	OEM	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	5440	5440
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"	14"	14"
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Ferrite	Ferrite
Interface	Mod. SMD, IPI-2	SCSI	Mod.SMD, IPI-2	Various Options	Various Options
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,205	F: 1,303	U: 1,359	U: 3.125	U: 5.75
REMOVABLE	--	--	--	U: 3.125	U: 5.75
Capacity per track (Bytes)	U: 33,582	**	U: 50,400	U: 7,812	U: 7,812
Data surfaces per spindle	17	17	9.5	4	4
Heads per data surface	1	1	2	1	1
Tracks per surface	2110	2110	2840	204	406
Track density (TPI)	1867	1867	1280	100	200
Maximum linear density (BPI)	33600 BPI* 22400 FCI	32000 BPI* 21333 FCI	15400 BPI* 10266 FCI	2200	2200
Rotational speed (RPM)	5400	5400	3600	2400/1500	2400/1500
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	12	12	16	50	50
Average rotational delay (msec)	5.56	5.56	8.3	12.5/20	12.5
Average access time (msec)	17.56	17.56	24.3	62.5/70	62.5
Data transfer rate (KBytes/sec)	3000	2250-4500	3000	312/195	312/195
FIRST CUSTOMER SHIPMENT	1Q90	2Q90	12/86	1979	1982
U.S. OEM PRICE FOR 100 UNITS	--	--	\$11,000	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code **Varies by zone	*2,7 RLL Code		

MANUFACTURER	ISOT	ISOT	ISOT	ISOT	JVC
DRIVE	ES 5066 ES 5067.01 ES 5067.02	ES 5067	CM 5508	ES 5300	JD-3824L
DISK/TREND GROUP	2	2	3	3	3
MARKET	OEM	OEM	Captive, OEM	Captive, OEM	OEM
MEDIA: Generic type	3336-1	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	14"	14"	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface			ST412	ST412	Proprietary
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	U: 12.76	U: 6.38	F: 21.44
REMOVABLE	F: 100	F: 200	--	--	--
Capacity per track (Bytes)	F: 13,030	F: 13,030	U: 10,416	U: 10,416	F: 17,408
Data surfaces per spindle	19	19	4	4	2
Heads per data surface	1	1	1	1	1
Tracks per surface	411	815	306	153	615
Track density (TPI)	192	370	345	254	849
Maximum linear density (BPI)	4040	4040	9073	7696	27410 BPI* 18273 FCI 2597
Rotational speed (RPM)	3600	3600	3600	3600	
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Rack & Pinion, DC Servo Motor
Average positioning time (msec)	30	30	85 (including settling)	85 (including settling)	68 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	11.6
Average access time (msec)	38.3	38.3	93.3	93.3	79.6
Data transfer rate (KBytes/sec)	806	806	625	625	937.5
FIRST CUSTOMER SHIPMENT	1980	1981	1987	1986	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					28.8 mm high *2,7 RLL Code Embedded Servo

1989 DISK/TREND REPORT

MANUFACTURER	JVC	JVC	JVC	JVC	JVC
DRIVE					
	JD-3824R	JD-3824T	JD-3824TA	JD-E2825P	JD-3848H
DISK/TREND GROUP	3	3	3	3	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	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		Ferrite	Ferrite
Interface	Proprietary	Proprietary	Proprietary	PCAT, Prop., SCSI	Proprietary
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.44	F: 21.44	F: 21.47	F: 21.45	F: 42.88
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,408	F: 17,408	F: 24,576	F: 18,432	F: 17,408
Data surfaces per spindle	2	2	2	2	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	436	581	615
Track density (TPI)	849	941	941	1300	941
Maximum linear density (BPI)	27410 BPI* 18273 FCI	25610 BPI* 17073 FCI	32331 BPI* 21855 FCI	39665 BPI* 26443 FCI	25610 BPI* 17073 FCI
Rotational speed (RPM)	2597	2593	2332	3109	2593
PERFORMANCE					
Actuator type	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor	Rack & Pinion, DC Servo Motor	Rotary, Voice Coil	Rack & Pinion, DC Servo Motor
Average positioning time (msec)	78 (including settling)	65 (including settling)	28 (including settling)	23	45 (including settling)
Average rotational delay (msec)	11.6	11.6	12.8	9.6	11.6
Average access time (msec)	89.6	76.6	40.8	32.6	56.6
Data transfer rate (KBytes/sec)	937.5	937.5	1250	1250	937.5
FIRST CUSTOMER SHIPMENT	2Q87	3Q88	3Q89	4Q89	3Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	28.9 mm high *2,7 RLL Code Embedded Servo	25.4 mm high *2,7 RLL Code Embedded Servo	25.4 mm high *2,7 RLL Code	19.1 mm high *2,7 RLL Code	31.4 mm high *2,7 RLL Code Embedded Servo

MANUFACTURER	JVC	JVC	KALOK	KALOK	KALOK
DRIVE					
	JD-3848HA	JD-E3848V	KL320 Octagon 20	KL330 Octagon 30	KL332 Octagon 30
DISK/TREND GROUP	4	4	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 Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	Proprietary	PC AT, SCSI	ST412	ST412	PS/2 (25/30)
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.95	F: 42.42	U: 25.62	U: 38.44*	F: 32.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 24,576	F: 24,576	U: 10,416	U: 15,624*	F: 13,312
Data surfaces per spindle	4	2	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	436	862	615	615	615
Track density (TPI)	941	1300	814	814	814
Maximum linear density (BPI)	32331 BPI* 21855 FCI 2332	38145 BPI* 25430 FCI 2332	13533 3600	20300 BPI* 13533 FCI 3600	20300 BPI* 13533 FCI 3600
Rotational speed (RPM)					
PERFORMANCE					
Actuator type	Rack & Pinion, DC Servo Motor	Rotary, Voice Coil	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	29 (including settling)	25	40 (including settling)	40 (including settling)	40 (including settling)
Average rotational delay (msec)	12.8	12.8	8.3	8.3	8.3
Average access time (msec)	41.8	37.8	48.3	48.3	48.3
Data transfer rate (KBytes/sec)	1250	1250	625	937.5*	937.5
FIRST CUSTOMER SHIPMENT	3Q89	3Q89	2Q88	2Q88	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--		--
COMMENTS	31.4 mm high *2,7 RLL Code	20.8 mm high *2,7 RLL Code	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *2,7 RLL Code

MANUFACTURER	KALOK	KALOK	KALOK	KALOK	KOVO (ARITMA)
DRIVE	KL340 Octagon 40	KL341 Octagon 40	KL343 Octagon 40	KL360 Octagon 60	Aritma 4080
DISK/TREND GROUP	4	4	4	5	2
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	3336-1
Nominal disk diameter	95 mm OD	95 mm OD	95 mm OD	95 mm OD	14"
Recording medium	25 mm ID Oxide Coated	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	SCSI	PC AT	ST412	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.24	F: 41.3	F: 42.5	U: 76.88*	--
REMOVABLE	--	--	--	--	F: 100.0
Capacity per track (Bytes)	U: 10,416	F: 15,360	F: 15,360	U: 15,625*	F: 13,030
Data surfaces per spindle	6	4	4	6	19
Heads per data surface	1	1	1	1	1
Tracks per surface	820	664	670	820	411
Track density (TPI)	925	814	814	925	192
Maximum linear density (BPI)	14720	23610 BPI* 15740 FCI	23610 BPI* 15740 FCI	22080 BPI* 14720 FCI	4040
Rotational speed (RPM)	3600	3375	3375	3600	3600
PERFORMANCE					
Actuator type	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor	Linear, Voice Coil
Average positioning time (msec)	25 (including settling)	40 (including settling)	40 (including settling)	25 (including settling)	30
Average rotational delay (msec)	8.3	8.8	8.8	8.3	8.3
Average access time (msec)	33.3	48.8	48.8	33.3	38.3
Data transfer rate (KBytes/sec)	625	1062.5	1062.5	937.5*	806
FIRST CUSTOMER SHIPMENT	2Q90	10/88	1/89	2Q90	1985
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller	

MANUFACTURER	KOVO (ARITMA)	KYOCERA	KYOCERA	KYOCERA	KYOCERA
DRIVE					
	Aritma 5080	KC 20A	KC 20B	KC 30A	KC 30B
DISK/TREND GROUP	2	3	3	4	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	3336-11	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 25.5	U: 25.5	U: 38.4*	U: 38.4*
REMOVABLE	F: 200.0	--	--	--	--
Capacity per track (Bytes)	F: 13,030	U: 10,416	U: 10,416	U: 15,624*	U: 15,624*
Data surfaces per spindle	19	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	815	616	615	616	615
Track density (TPI)	370	835	800	835	800
Maximum linear density (BPI)	4040	12268	13464	18402 BPI* 12268 FCI	20196 BPI* 13464 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Stepping Motor	Rotary, Stepping Motor
Average positioning time (msec)	30	65 (including settling)	62 (including settling)	65 (including settling)	62 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	38.3	73.3	70.3	73.3	70.3
Data transfer rate (KBytes/sec)	806	625	625	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	1986	1987	1987	1987	1987
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		41.3 mm high	41.3 mm high	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller



MANUFACTURER	MAGTRON	MAGTRON	MAGTRON	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL
DRIVE					
	MT4115	MT4140	MT4170	JU-106	JU-128
DISK/TREND GROUP	6	6	6	3	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	Ferrite	Ferrite
Interface	ESDI, SCSI	ESDI, SCSI	ESDI, SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 138	U: 172	U: 207	U: 20	U: 53.44
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 17,920	U: 17,920	U: 17,920	U: 20,877	U: 10,416
Data surfaces per spindle	4	5	6	2	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1600	1600	1600	615	733
Track density (TPI)	1460	1460	1460	880	1019
Maximum linear density (BPI)	20320 BPI*	20320 BPI*	20320 BPI*	26516	13171
Rotational speed (RPM)	13546 FCI 3800	13546 FCI 3800	13546 FCI 3800	2640	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	25	25	25	65	35
Average rotational delay (msec)	8.3	8.3	8.3	11.4	8.3
Average access time (msec)	33.3	33.3	33.3	76.4	43.3
Data transfer rate (KBytes/sec)	1250	1250	1250	937.5	625
FIRST CUSTOMER SHIPMENT	4/89	4/89	4/89	1988	1987
U.S. OEM PRICE FOR 100 UNITS	\$800	\$850	\$900	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	25.4 mm high	41.3 mm high

MANUFACTURER	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MATSUSHITA COMMUNICATION INDUSTRIAL	MAXTOR	MAXTOR
DRIVE	JU-128A	JU-1381	JU-1391	LXT-50	XT-1085
DISK/TREND GROUP	4	4	5	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	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	Ferrite	Ferrite
Interface	ST412	SCSI	SCSI	SCSI, PC AT	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 53.44	F: 40.4	F: 80.9	F: 48	U: 85.32
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 13,790	F: 13,790	F:	U: 10,416
Data surfaces per spindle	7	4	8	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	733	733	733	733	1024
Track density (TPI)	1019	1019	1019	1019	1070
Maximum linear density (BPI)	13171	22431	22431	26229 BPI* 17486 FCI	9934
Rotational speed (RPM)	3600	3367.6	3367.6	3600	3600
PERFORMANCE					
Actuator type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Rotary, Torque Motor	Rotary, Voice Coil
Average positioning time (msec)	30	30	30	27	27
Average rotational delay (msec)	8.3	8.9	8.9	8.3	8.3
Average access time (msec)	38.3	38.9	38.9	35.3	35.3
Data transfer rate (KBytes/sec)	625	150	150	1250	625
FIRST CUSTOMER SHIPMENT	1988	1988	1988	--	2Q83
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high *2,7 RLL Code	

## 1989 DISK/TREND REPORT

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	LXT-100	LXT-200	XT-1120R	XT-1140	XT-1240R
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	SCSI, PC AT	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 96	F: 202	U: 127.99*	U: 143.42	U: 239.98*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 14,848- 25,088	U: 15,624*	U: 10,416	U: 15,624*
Data surfaces per spindle	8	7	8	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	733	1473	1024	918	1024
Track density (TPI)	1019	1610	1070	1070	1070
Maximum linear density (BPI)	26229 BPI*	24872 BPI*	14901 BPI*	9280	14901 BPI*
Rotational speed (RPM)	17486 FCI 3600	18654 FCI 3600	9934 FCI 3600	3600	9934 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	29	15	27	25.8	27
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	23.3	35.3	34.1	35.3
Data transfer rate (KBytes/sec)	1250	1008-1680	937.5*	625	937.5*
FIRST CUSTOMER SHIPMENT	3Q88	4Q88	2Q87	2Q83	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *1,7 RLL Code 3 recording bands	*With RLL controller		*With RLL controller

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	XT-2190	XT-4170E	XT-4170S	XT-4280S	XT-4380E
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	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	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 191.23	U: 179.45	F: 157.93	F: 248.17	U: 384.53
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,940	F: 18,432	F: 18,432	U: 20,940
Data surfaces per spindle	15	7	7	11	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1224	1224	1224
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI)	11155	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI	21064 BPI* 14043 FCI
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
Average positioning time (msec)	28.9	14	14	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.2	22.3	22.3	24.3	24.3
Data transfer rate (KBytes/sec)	625	1250	1500	1500	1250
FIRST CUSTOMER SHIPMENT	3Q84	2Q87	2/86	2/86	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	XT-4380S	XT-8380E	XT-8380S	P1-08 Panther 1	P2-08S Panther 2
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	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	SMD-E,ESDI,IPI2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 338.41	U: 410.0	F: 360.97	U: 811	F: 664
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 31,410	F: 27,648	U: 50,638	**
Data surfaces per spindle	15	8	8	9	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1632	1632	1778	1778
Track density (TPI)	1070	1376	1376	1500	1500
Maximum linear density (BPI)	21064 BPI* 14043 FCI	31596 BPI* 21064 FCI	31596 BPI* 21064 FCI	52114 BPI* 39086 FCI	* **
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
Average positioning time (msec)	16	14.5	14.5	13	13
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	22.8	22.8	21.3	21.3
Data transfer rate (KBytes/sec)	1500	1875	1875	3040	3040-4000
FIRST CUSTOMER SHIPMENT	4Q87	1Q87	1Q88	9/89	3/90
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code  **Varies by zone

MANUFACTURER	MAXTOR	MAXTOR	MAXTOR	MAXTOR	MAXTOR
DRIVE					
	XT-8760E	XT-8760S	P1-12 Panther 1	P1-13 Panther 1	P2-12S Panther 2 Sprinter
DISK/TREND GROUP	8	8	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	SMD-E,ESDI,IPI2	SMD-E,ESDI,IPI2	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 768.9	F: 676.82	U: 1,234	U: 1,351	F: 1,065
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,410	F: 27,648	U: 46,254	U: 50,638	**
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1632	1778	1778	1254
Track density (TPI)	1376	1376	1500	1500	1500
Maximum linear density (BPI)	31596 BPI* 21064 FCI	31596 BPI* 21064 FCI	47603 BPI* 35702 FCI	52114 BPI* 39086 FCI	* **
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
Average positioning time (msec)	16.5	16.5	13	13	10.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	24.8	21.3	21.3	18.8
Data transfer rate (KBytes/sec)	1875	1875	2778	3040	3040-4000
FIRST CUSTOMER SHIPMENT	1Q87	1Q88	9/89	9/89	3/90
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code  **Varies by zone

MANUFACTURER	MAXTOR	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX
DRIVE	P2-17S Panther 2	3890-00J4	3890-01J4	3680	3680 HDP
DISK/TREND GROUP	9	8	8	9	9
MARKET	OEM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	14"	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI-2	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,424	F: 630.24	F: 630.24	F: 1,260	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	**	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	15	13.5	13.5	15	15
Heads per data surface	1	2	2	2	2
Tracks per surface	1778	990	990	1,768	1768
Track density (TPI)	1500	1193	1193	806	806
Maximum linear density (BPI)	*	25211 BPI*	25211 BPI*	15240 BPI*	15240 BPI*
Rotational speed (RPM)	** 3600	18908 FCI 3620	18908 FCI 3620	10160 FCI 3600	10160 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	13	12	12	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	21.3	20.3	20.3	24.3	24.3
Data transfer rate (KBytes/sec)	3040-4000	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	3/90	1989	1989	8/83	3Q85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*1,7 RLL Code	PCM 3380J	PCM 3380J	PCM 3380	PCM 3380
	**Varies by zone	Drive has 8 spindles	Drive has 16 spindles	Drive has 1 spindle	Drive has 8 spindles
		*1,7 RLL Code	*1,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX	MEMOREX TELEX	MICROPOLIS
DRIVE	3682	3835	3890-00K4	3890-01K4	1333A
DISK/TREND GROUP	9	9	9	9	4
MARKET	PCM	PCM	PCM	PCM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	14"	200 mm OD 63.5 mm ID	210 mm OD 100 mm ID	210 mm OD 100 mm ID	130 mm OD 40 mm ID
Recording medium	Oxide Coated	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	IBM	IBM	IBM	IBM	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 2,520	F: 855.8	F: 945.36	F: 945.36	U: 53.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 36,352	F: 47,476	F: 47,476	U: 10,416
Data surfaces per spindle	15	14	13.5	13.5	5
Heads per data surface	2	2	2	2	1
Tracks per surface	3540		1490	1490	1024
Track density (TPI)	1386	1368	1193	1193	1000
Maximum linear density (BPI)	16200 BPI* 10800 FCI 3600	23400 BPI* 15600 FCI 3656	25211 BPI* 18908 FCI 3620	25211 BPI* 18908 FCI 3620	9824
Rotational speed (RPM)					3600
PERFORMANCE					
Actuator type	Dual, Linear, Voice Coil	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	17	17.5	16	16	28
Average rotational delay (msec)	8.3	8.2	8.3	8.3	8.3
Average access time (msec)	25.3	25.7	24.3	24.3	36.3
Data transfer rate (KBytes/sec)	3000	3000	3000	3000	625
FIRST CUSTOMER SHIPMENT	12/86	3Q88	1989	1989	3Q84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	PCM 3380E *2,7 RLL Code Drive has 2 spindles	PCM 9335 *2,7 RLL Code Embedded Servo	PCM 3380K Drive has 8 spindles *1,7 RLL Code	PCM 3380K Drive has 16 spindles *1,7 RLL Code	



MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1334	1335	1353	1373	1373A
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	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 64	U: 85.3	U: 85.3	F: 72	F: 91
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 20,832	F: 18,432	F: 18,432
Data surfaces per spindle	6	8	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1016	1016
Track density (TPI)	1000	1000	1055	1055	1055
Maximum linear density (BPI)	9824	9824	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI
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
Average positioning time (msec)	28	28	23	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	31.3	31.3	31.3
Data transfer rate (KBytes/sec)	625	625	1250	1600	1600
FIRST CUSTOMER SHIPMENT	2Q84	3Q84	3Q85	1Q86	1Q86
U.S. OEM PRICE FOR 100 UNITS	--	\$550 (1000)	--	--	--
COMMENTS			*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1353A	1354	1354A	1355	1374
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	ESDI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 106.7	U: 128	U: 149	U: 170.6	F: 109
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	U: 20,832	U: 20,832	F: 18,432
Data surfaces per spindle	5	6	7	8	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1024	1024	1016
Track density (TPI)	1055	1055	1055	1055	1055
Maximum linear density (BPI)	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI
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
Average positioning time (msec)	23	23	23	23	23
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	31.3	31.3	31.3	31.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1600
FIRST CUSTOMER SHIPMENT	3Q85	3Q85	3Q85	3Q85	1Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$800 (1000)	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

## 1989 DISK/TREND REPORT

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1374A	1375	1554	1556-11	1576-11
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film/Ferr.	Thin Film/Ferr.
Interface	SCSI	SCSI	ESDI	ESDI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 127	F: 145.0	U: 280	U: 280	F: 243
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,432	U: 20,832	U: 20,832	F: 18,432
Data surfaces per spindle	7	8	11	11	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1016	1016	1224	1224	1220
Track density (TPI)	1055	1055	1075	1075	1075
Maximum linear density (BPI)	19804 BPI* 13202 FCI	19804 BPI* 13202 FCI	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI
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
Average positioning time (msec)	23	23	18	18	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	31.3	26.3	26.3	24.3
Data transfer rate (KBytes/sec)	1600	1600	1250	1250	4000 max.
FIRST CUSTOMER SHIPMENT	1Q86	1Q86	11/86	1Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	\$850 (1000)	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code SCSI version is model 1574	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1653-4	1653-5	1654-6	1654-7	1663-4
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film
Interface	ESDI	ESDI	ESDI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 104	U: 130	U: 156	U: 182	U: 220
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	U: 20,832	U: 20,832	U: 31,248
Data surfaces per spindle	4	5	6	7	4
Heads per data surface	1	1	1	1	1
Tracks per surface	1249	1249	1249	1249	1780
Track density (TPI)	1100	1100	1100	1100	
Maximum linear density (BPI)	21185 BPI* 14123 FCI	21185 BPI* 14123 FCI	21185 BPI* 14123 FCI	21185 BPI* 14123 FCI	*
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
Average positioning time (msec)	16	16	16	16	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	24.3	22.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	1875
FIRST CUSTOMER SHIPMENT	1Q88	1Q88	1Q88	1Q90	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high 2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1663-5	1664-6	1673-4	1673-5	1674-6
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.
Interface	ESDI	ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 275	U: 330	F: 90	F: 112	F: 135
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,248	U: 31,248	F: 18,432	F: 18,432	F: 18,432
Data surfaces per spindle	5	6	4	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1780	1780	1245	1245	1245
Track density (TPI)			1100	1100	1100
Maximum linear density (BPI)	*	*	21185 BPI* 14123 FCI	21185 BPI* 14123 FCI	21185 BPI* 14123 FCI
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
Average positioning time (msec)	14	14	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	22.3	22.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1875	1875	1250	1250	1250
FIRST CUSTOMER SHIPMENT	--	--	1Q88	1Q88	1Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1674-7	1683-4	1683-5	1557-12	1557-13
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	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	Thin Film	Thin Film/Ferr.	Thin Film/Ferr.
Interface	SCSI	SCSI	SCSI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 158	F: 193	F: 242	U: 305	U: 331
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 27,648	F: 27,648	U: 20,832	U: 20,832
Data surfaces per spindle	7	4	5	12	13
Heads per data surface	1	1	1	1	1
Tracks per surface	1245	1776	1776	1224	1224
Track density (TPI)	1100			1075	1075
Maximum linear density (BPI)	21185 BPI* 14123 FCI	*	*	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI
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
Average positioning time (msec)	16	14	14	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	22.3	22.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	4000 max.	4000 max.	1250	1250
FIRST CUSTOMER SHIPMENT	1Q88	--	--	1Q87	1Q87
U.S. OEM PRICE FOR 100 UNITS	\$800 (1000)	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1558-14	1558-15	1577-12	1577-13	1578-14
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/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.	Thin Film/Ferr.
Interface	ESDI	ESDI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 356	U: 382	F: 265	F: 287	F: 309
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	U: 20,832	F: 18,432	F: 18,432	F: 18,432
Data surfaces per spindle	14	15	12	13	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1224	1220	1220	1220
Track density (TPI)	1075	1075	1075	1075	1075
Maximum linear density (BPI)	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI	21231 BPI* 14154 FCI
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
Average positioning time (msec)	18	18	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1250	1250	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	4Q86	4Q86	2Q87	2Q87	2Q87
U.S. OEM PRICE FOR 100 UNITS	--	\$1,200 (1000)	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1578-15	1664-7	1684-6	1684-7	1516-10S
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	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	Thin Film	Thin Film	Thin Film
Interface	SCSI	ESDI	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 331	U: 385	F: 291	F: 340	U: 766
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 31,248	F: 27,648	F: 27,648	U: 41,664
Data surfaces per spindle	15	7	6	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	1220	1780	1776	1776	1840
Track density (TPI)	1075				
Maximum linear density (BPI)	21231 BPI* 14154 FCI	*	*	*	*
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
Average positioning time (msec)	16	14	14	14	13.5
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	22.3	22.3	22.3	21.8
Data transfer rate (KBytes/sec)	4000 max.	1875	4000 max.	4000 max.	2500
FIRST CUSTOMER SHIPMENT	2Q87	1Q89	--	1Q89	3Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	*2,7 RLL Code



MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE	1566-11	1567-12	1567-13	1568-14	1568-15
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	ESDI	ESDI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 561	U: 612	U: 663	U: 714	U: 765
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,250	U: 31,250	U: 31,250	U: 31,250	U: 31,250
Data surfaces per spindle	11	12	13	14	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	1632	1632	1632	1632
Track density (TPI)	1440	1440	1440	1440	1440
Maximum linear density (BPI)	31846 BPI* 21230 FCI	31846 BPI* 21230 FCI	31846 BPI* 21230 FCI	31846 BPI* 21230 FCI	31846 BPI* 21230 FCI
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
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	1875	1875	1875	1875	1875
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	2Q88	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$1,795 (1000)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1586-11	1587-12	1587-13	1588-14	1588-15
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	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	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 490	F: 535	F: 579	F: 624	F: 668
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	F: 27,648	F: 27,648	F: 27,648	F: 27,648
Data surfaces per spindle	11	12	13	14	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1628	1628	1628	1628	1628
Track density (TPI)	1440	1440	1440	1440	1440
Maximum linear density (BPI)	31846 BPI*	31846 BPI*	31846 BPI*	31846 BPI*	31846 BPI*
Rotational speed (RPM)	21230 FCI 3600	21230 FCI 3600	21230 FCI 3600	21230 FCI 3600	21230 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	16	16	16	16	16
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	24.3	24.3	24.3	24.3	24.3
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	2Q88	2Q88	2Q88	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$2,495 (1000)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS	MICROPOLIS
DRIVE					
	1596-10S	1597-13	1598-14	1517-13	1518-14
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	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	SCSI	ESDI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 766	F: 909	F: 979	U: 1,042	U: 1,122
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 36,864	F: 36,864	F: 36,864	U: 41,664	U: 41,664
Data surfaces per spindle	10	13	14	13	14
Heads per data surface	1	1	1	1	1
Tracks per surface	1834	1919	1919	1925	1925
Track density (TPI)					
Maximum linear density (BPI)					
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
Average positioning time (msec)	13.5	14	14	14	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	21.8	22.3	22.3	22.3	22.3
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	2500	2500
FIRST CUSTOMER SHIPMENT	3Q89	3Q89	3Q89	3Q89	3Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS					

MANUFACTURER	MICROPOLIS	MICROPOLIS	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	1518-15	1598-15	HH-325	HH-825	4050
DISK/TREND GROUP	9	9	3	3	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	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	
DRIVE: Heads	Thin Film	Thin Film	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,203	F: 1,049	U: 25.52	U: 25.5	U: 53.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 41,664	F: 36,864	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	15	15	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1925	1919	612	612	1024
Track density (TPI)			855	648	1250
Maximum linear density (BPI)			13014	9680	14445
Rotational speed (RPM)	3600	3600	3550	3550	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	14	14	80 (including settling)	65 (including settling)	18
Average rotational delay (msec)	8.3	8.3	8.45	8.45	8.3
Average access time (msec)	22.3	22.3	88.45	73.45	26.3
Data transfer rate (KBytes/sec)	2500	4000 max.	625	625	625
FIRST CUSTOMER SHIPMENT	3Q89	3Q89	3/85	5/87	3Q88
U.S. OEM PRICE FOR 100 UNITS	\$3,895	\$3,995	--	--	\$400
COMMENTS			41.3 mm high Embedded Servo	41.3 mm high Embedded Servo	41.3 mm high

## 1989 DISK/TREND REPORT

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
DRIVE	7040	HH-1050	HH-830	4060	4070
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	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium		Thin Film	Oxide Coated	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 47.2	U: 51.04	U: 38.28*	U: 80.0	U: 74.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	U: 10,416	U: 15,624*	U: 15,624	U: 10,416
Data surfaces per spindle	3	5	4	5	7
Heads per data surface	1	1	1	1	1
Tracks per surface	855	1024	612	1024	1024
Track density (TPI)	1250	960	648	1250	1250
Maximum linear density (BPI)	25406 BPI* 16937 FCI	10020	14520*	21668 BPI* 14445 FCI	14445 BPI* 9630 FCI
Rotational speed (RPM)	3600	3600	3550	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Linear, Voice Coil	Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	28	65 (including settling)	18	18
Average rotational delay (msec)	8.3	8.3	8.45	8.3	8.3
Average access time (msec)	26.3	36.3	73.45	26.3	26.3
Data transfer rate (KBytes/sec)	1250	625	937.5*	937.5	625
FIRST CUSTOMER SHIPMENT	1Q89	1/86	5/87	2Q89	1Q89
U.S. OEM PRICE FOR 100 UNITS	\$500	\$350	--	\$430	\$520
COMMENTS	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high	41.3 mm high *With RLL controller Embedded Servo	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
MANUFACTURER					
DRIVE					
	HH-1060	HH-1075	HH-1090	4090	5100
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	ST412	ST 412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 79.99*	U: 74.69	U: 95.81	U: 111.3	U: 124.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 10,416	U: 10,416	U: 15,624	U: 20,832
Data surfaces per spindle	5	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	1024	1314	1024	855
Track density (TPI)	960	1250	1250	1250	1250
Maximum linear density (BPI)	14935 BPI* 9957 FCI	9840	9840	21668 BPI* 14445 FCI	25406 BPI* 16937 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	28	28	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	26.3	26.3
Data transfer rate (KBytes/sec)	937.5*	625	625	937.5	1250
FIRST CUSTOMER SHIPMENT	2/86	2/88	9/87	2Q89	1Q89
U.S. OEM PRICE FOR 100 UNITS	\$380	\$525	\$525	\$570	\$850
COMMENTS	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL
MANUFACTURER					
DRIVE	6100	7100	HH-1095	HH-1120	HH-2120 F
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 Oxide Coated	40 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	ST412	ST412	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 110	F: 110	U: 112.0*	U: 143.71*	U: 149.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 18,432	F: 18,435	U: 15,624*	U: 15,664*	U: 20,832
Data surfaces per spindle	7	7	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	855	855	1024	1314	1024
Track density (TPI)	1250	1250	1250	1250	1250
Maximum linear density (BPI)	25406 BPI* 16937 FCI	25406 BPI* 16937 FCI	12696 BPI* 8464 FCI	14760 BPI* 9840 FCI	16896 BPI* 11264 FCI
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
Average positioning time (msec)	18	18	28	28	18
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	26.3
Data transfer rate (KBytes/sec)	1250	1250	937.5*	937.5*	1250
FIRST CUSTOMER SHIPMENT	2Q89	2Q89	2/88	10/87	5/88
U.S. OEM PRICE FOR 100 UNITS	\$885	\$885	\$575	\$575	\$720
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high *2,7 RLL Code

MANUFACTURER	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MICROSCIENCE INTERNATIONAL	MILTOPE	MILTOPE
DRIVE					
	HH-2160 F	HH-3120 F	HH-3160 F	RDS-1500	RDS-5000
DISK/TREND GROUP	6	6	6	3	4
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Special	Special
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	ESDI	SCSI	SCSI	SCSI, NTDS	SCSI, NTDS
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 186.08	F: 121.1	F: 169.5	F: 18.5	F: 47.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,833	F: 13,312	F: 18,432	F: 9,216	F: 9,216
Data surfaces per spindle	7	7	7	3	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1276	1314	1314	670	1024
Track density (TPI)	1250	1250	1250	680	1000
Maximum linear density (BPI)	17920 BPI* 11946 FCI	19443 BPI* 12962 FCI	19443 BPI* 12962 FCI	9890	9824
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	18	40	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	26.3	48.3	48.3
Data transfer rate (KBytes/sec)	1250	1250	1250	625	625
FIRST CUSTOMER SHIPMENT	10/88	2/88	10/88	5/84	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$925	\$820	\$1,025	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	Sold as militarized subsystem  Removable disk assembly	Sold as militarized subsystem  Removable disk assembly



MANUFACTURER	MILTOPE	MILTOPE	MILTOPE	MILTOPE	MINISCRIBE
DRIVE					
	RDS-1720	RDS-3100	RDS-3200	RDS-3800	8225
DISK/TREND GROUP	6	6	6	7	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Special	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	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI, NTDS	SCSI	SCSI	SCSI, NTDS	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 159.3	U: 125	U: 250	U: 382	U: 24.1*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 19,456	U: 16,896	U: 19,456	U: 19,456	U: 15,625*
Data surfaces per spindle	8	8	8	15	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	748	1348	1224	771
Track density (TPI)	960	980	1050	1075	898
Maximum linear density (BPI)	19794 BPI* 13196 FCI	23441 BPI* 15627 FCI	31800 BPI* 21200 FCI	19794 BPI* 13196 FCI	19900 BPI* 13266 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Average positioning time (msec)	23	25	19	18	68 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	33.3	27.3	26.3	76.3
Data transfer rate (KBytes/sec)	1250	1250	1500	1250	937.5*
FIRST CUSTOMER SHIPMENT	3Q86	2/89	12/89	12/89	1989
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	Sold as militarized and ruggedized subsystem. *2,7 RLL Code. Removable disk assembly	Sold as militarized and ruggedized subsystem. *2,7 RLL Code. Removable disk assembly	Sold as militarized and ruggedized subsystem. *2,7 RLL Code. Removable disk assembly	Sold as militarized and ruggedized subsystem. *2,7 RLL Code. Removable disk assembly	41.3 mm high *With RLL controller

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE	8225AT	8225S	8225XT	8425	8425F
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	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	PC XT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.4	F: 20.9	F: 21.4	U: 25.6	U: 25.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 14,336	F: 13,312	F: 13,312	U: 10,416	U: 10,416
Data surfaces per spindle	2	2	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	747	804	805	615	615
Track density (TPI)	898	898	898	804	804
Maximum linear density (BPI)	21227 BPI*	21227 BPI*	19900 BPI*	13412	13412
Rotational speed (RPM)	14151 FCI 3600	14151 FCI 3600	13266 FCI 3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	40 (including settling)	68 (including settling)	68 (including settling)	68 (including settling)	40 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	76.3	76.3	76.3	48.3
Data transfer rate (KBytes/sec)	1000	350	937.5	625	625
FIRST CUSTOMER SHIPMENT	4Q88	1989	2Q88	3Q84	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high	41.3 mm high

**1989 DISK/TREND REPORT**

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE	MINISCRIBE
DRIVE	8425S	8051A	8051S	8438	8450 RLL
DISK/TREND GROUP	3	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	SCSI	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20.9	F: 42.7	F: 45.1	U: 38.4*	U: 48.2*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,704	F: 14,336	F: 14,336	U: 15,624*	U: 15,625*
Data surfaces per spindle	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	612	745	799	615	771
Track density (TPI)	804	1109	1109	804	898
Maximum linear density (BPI)	13412	23202 BPI* 15468 FCI 3484	23202 BPI* 15468 FCI 3484	19900 BPI* 13266 FCI 3600	19900 BPI* 13266 FCI 3600
Rotational speed (RPM)	3600				
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	68 (including settling)	28	28	68 (including settling)	45 (including settling)
Average rotational delay (msec)	8.3	8.6	8.6	8.3	8.3
Average access time (msec)	76.3	36.6	36.6	76.3	53.3
Data transfer rate (KBytes/sec)	625	1000	1000	937.5*	937.5*
FIRST CUSTOMER SHIPMENT	3Q86	2Q88	1Q88	4Q85	1988
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller

MANUFACTURER	MINISCRIBE	MINISCRIBE	MINISCRIBE	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	8450AT	8450S	8450XT	MR335	MR533
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	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	PC XT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.7	F: 42.4	F: 42.8	U: 54.1	U: 30.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 14,336	F: 13,312	F: 13,312	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	4	7	3
Heads per data surface	1	1	1	1	1
Tracks per surface	745	809	805	743	977
Track density (TPI)	898	898	898	1042	1028
Maximum linear density (BPI)	21227 BPI*	21227 BPI*	19900 BPI*	13599	9358
Rotational speed (RPM)	14151 FCI 3600	14151 FCI 3600	13266 FCI 3600	3600	3600
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40 (including settling)	68 (including settling)	68 (including settling)	20	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	48.3	76.3	54.3	28.3	36.3
Data transfer rate (KBytes/sec)	1000	937.5*	937.5	625	625
FIRST CUSTOMER SHIPMENT	4Q88	1989	2Q88	4Q88	3Q86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high	41.3 mm high

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR535	MR535S	MR537S	MR548	M4870F
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	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	ST412	SCSI	SCSI	ST412	SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 50.85	U: 50.85	U: 76.27	U: 89.3	U: 251.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	U: 15,624	U: 10,416	U: 20,480
Data surfaces per spindle	5	5	5	7	12
Heads per data surface	1	1	1	1	1
Tracks per surface	977	977	977	1225	1023
Track density (TPI)	1028	1028	1028	1300	1000
Maximum linear density (BPI)	9358	9358	14037 BPI* 9358 FCI	9358	10000
Rotational speed (RPM)	3600	3600	3600	3600	3544
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	28	28	20	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.47
Average access time (msec)	36.3	36.3	36.3	28.3	28.47
Data transfer rate (KBytes/sec)	625	625	937	625	1209
FIRST CUSTOMER SHIPMENT	3Q86	3Q88	4Q88	3Q89	4/84
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high Compatible with RLL controllers	41.3 mm high Embedded SCSI	41.3 mm high Embedded SCSI *2,7 RLL Code	41.3 mm high	

MANUFACTURER	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION	MITSUBISHI ELECTRIC CORPORATION
DRIVE	MR3310S	MR3314S	MR5310E	M4875	E1880B E1880C E1880D
DISK/TREND GROUP	6	6	6	7	8
MARKET	OEM	OEM	OEM	OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	130 mm OD	210 mm OD	224 mm OD
Recording medium	25 mm ID Oxide Coated	25 mm ID Thin Film	40 mm ID Oxide Coated	100 mm ID Oxide Coated	100 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI, PC AT	SCSI	ESDI	Modified SMD	Mitsubishi
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 108.3	F: 120.7	U: 101.7	U: 408.5	F: 630
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,833	F: 16,384	U: 20,340	U: 30,720	F: 47,476
Data surfaces per spindle	7	8	5	13	15
Heads per data surface	1	1	1	1	2
Tracks per surface	743	921	977	1023	885
Track density (TPI)	1042	1295	1028	1000	1060
Maximum linear density (BPI)	27198 BPI* 18132 FCI	27198 BPI* 18132 FCI	18716 BPI* 12477 FCI	14100 BPI* 9400 FCI	21500 BPI* 14333 FCI
Rotational speed (RPM)	3600	3600	3600	3544	3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	20	23	28	20	13
Average rotational delay (msec)	8.3	8.3	8.3	8.47	8.3
Average access time (msec)	28.3	31.3	36.3	28.47	21.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1814	3000
FIRST CUSTOMER SHIPMENT	1Q90	1Q90	4Q86	3Q85	3Q88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code E1880B: 1 spindle E1880C: 4 spindles E1880D: 8 spindles

MANUFACTURER	MITSUMI ELECTRIC	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS	NATIONAL ADVANCED SYSTEMS
DRIVE	HD 320	7380-AD 7380-BD	7380-AJ 7380-BJ	7380-AE 7380-BE	7380-AJX 7380-BJX
DISK/TREND GROUP	3	8	8	9	9
MARKET	OEM	PCM	PCM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	14"	9.5"	14"	9.5"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.5	F: 630	F: 630	F: 1,260	F: 1,260
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	4	10	8	12	8
Heads per data surface	1	2	2	2	2
Tracks per surface	612	1327.5	1327.5	2212.5	2655
Track density (TPI)	1200	*	*	*	*
Maximum linear density (BPI)	12000	*	*	*	*
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Band, Stepping Motor	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	85 (including settling)	15	11	17	13
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	93.3	23.3	19.3	25.3	21.3
Data transfer rate (KBytes/sec)	625	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	3/88	3/86	7/88	4/86	7/88
U.S. OEM PRICE FOR 100 UNITS	--				
COMMENTS	41.3 mm high	PCM 3380D Drive has 4 spindles *Not announced	PCM 3380J 8 spindles per frame = 2 equivalent IBM units. *Not announced	PCM 3380E Drive has 4 spindles *Not announced	PCM 3380E 8 spindles per frame = 2 equivalent IBM units. *Not announced

MANUFACTURER	NATIONAL ADVANCED SYSTEMS	NEC	NEC	NEC	NEC
DRIVE	7380-AK 7380-BK	N7745	D3122	D3126	D3126H
DISK/TREND GROUP	9	2	3	3	3
MARKET	PCM	Captive	Captive	Captive, OEM	Captive, OEM
MEDIA: Generic type	Fixed	3336-11	Fixed	Fixed	Fixed
Nominal disk diameter	9.5"	14"	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IBM	NEC	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 1,890	--	U: 26.7	U: 25.62	U: 25.62
REMOVABLE	--	F: 200	--	--	--
Capacity per track (Bytes)	F: 47,476	F: 13,030	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	8	19	4	4	4
Heads per data surface	4	1	1	1	1
Tracks per surface	2655	815	642	615	615
Track density (TPI)	*	370	850	750	850
Maximum linear density (BPI)	*	4040	14000	15000	14000
Rotational speed (RPM)	3600	3600	3600	3564	3600
PERFORMANCE					
Actuator type	Linear, Voice Coil	Linear, Voice Coil	Rotary, Torque Motor	Linear, Band, Stepping Motor	Rotary, Torque Motor
Average positioning time (msec)	12.5	30	28	85 (including settling)	35
Average rotational delay (msec)	8.3	8.3	8.3	8.4	8.3
Average access time (msec)	20.8	38.3	36.3	93.4	43.3
Data transfer rate (KBytes/sec)	3000	806	625	625	625
FIRST CUSTOMER SHIPMENT	9/88	11/75	5/88	7/85	6/87
U.S. OEM PRICE FOR 100 UNITS		--	--	--	--
COMMENTS	PCM 3380K 8 spindles per frame = 2 equivalent IBM units. *Not announced		41.3 mm high	41.3 mm high	41.3 mm high



MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3821	D5126H	D5128	D3142	D3146H
DISK/TREND GROUP	3	3	3	4	4
MARKET	Captive	Captive, OEM	Captive, 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	95 mm OD	95 mm OD
Recording medium	25 mm ID Oxide Coated	40 mm ID Oxide Coated	40 mm ID Oxide Coated	25 mm ID Oxide Coated	25 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 22.52	U: 25.62	U: 25.62	U: 53.4	U: 51.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 12,800	U: 10,416	U: 10,416	U: 10,416	U: 10,416
Data surfaces per spindle	4	4	4	8	8
Heads per data surface	1	1	1	1	1
Tracks per surface	440	615	615	642	615
Track density (TPI)	850	700	700	850	850
Maximum linear density (BPI)	17000 BPI* 11333 FCI	9000	9000	14000	14000
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Linear, Torque Motor	Linear, Band, Stepping Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	28	40	85 (including settling)	28	35
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	48.3	93.3	36.3	43.3
Data transfer rate (KBytes/sec)	937.5	625	625	625	625
FIRST CUSTOMER SHIPMENT	5/88	4/86	10/87	1Q88	5/87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high

	NEC	NEC	NEC	NEC	NEC
MANUFACTURER					
DRIVE					
	D3741	D3841	D5127	D5127H	D5146H
DISK/TREND GROUP	4	4	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	95 mm OD	95 mm OD	130 mm OD	130 mm OD	130 mm OD
Recording medium	25 mm ID Oxide Coated	25 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	SCSI	ST412	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 54.9	F: 45.05	U: 38.43	U: 38.43	U: 51.24
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624	F: 12,800	U: 15,624	U: 15,624	U: 10,416
Data surfaces per spindle	8	8	4	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	440	440	615	615	615
Track density (TPI)	850	850	700	700	700
Maximum linear density (BPI)	17000 BPI*	17000 BPI*	13500 BPI*	13500 BPI*	9000
Rotational speed (RPM)	11333 FCI 3600	11333 FCI 3600	9000 FCI 3600	9000 FCI 3600	3600
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Linear, Band, Stepping Motor	Linear, Torque Motor	Linear, Torque Motor
Average positioning time (msec)	23	28	85 (including settling)	40	40
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	36.3	93.3	48.3	48.3
Data transfer rate (KBytes/sec)	970	937.5	937.5	937.5	625
FIRST CUSTOMER SHIPMENT	2Q89	12/87	4/87	4/87	4/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	D5147H	D5452	D2257	D3661	D3761
DISK/TREND GROUP	5	5	6	6	6
MARKET	Captive, OEM	Captive, 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	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	Ferrite	Ferrite
Interface	ST412	ST412	SMD	ESDI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 76.87	U: 85.72	U: 167.7	U: 134.5	F: 118.05
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624	U: 10,416	U: 20,480	U: 20,992	F: 17,920
Data surfaces per spindle	8	10	8	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	615	823	1024	915	915
Track density (TPI)	700	926	720	1311	1311
Maximum linear density (BPI)	13500 BPI* 9000 FCI	9307	9420	25484 BPI* 16989 FCI	25484 BPI* 16989 FCI
Rotational speed (RPM)	3600	3600	3510	3573	3573
PERFORMANCE					
Actuator type	Linear, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40	23	20	20	20
Average rotational delay (msec)	8.3	8.3	8.55	8.4	8.4
Average access time (msec)	48.3	31.3	28.55	28.4	28.4
Data transfer rate (KBytes/sec)	937.5	625	1198	1250	1250
FIRST CUSTOMER SHIPMENT	5/87	4/86	5/83	3Q88	2Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code			41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D3861	D5652	D5655	D5852	D2268H
DISK/TREND GROUP	6	6	6	6	7
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, 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 Thin Film	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	SCSI	ESDI	ESDI	SCSI	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 118.05	U: 172.76	U: 179.86	F: 147.48	U: 337.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,920	U: 20,992	U: 20,992	F: 17,920	U: 40,960
Data surfaces per spindle	7	10	7	10	10
Heads per data surface	1	1	1	1	1
Tracks per surface	915	823	1224	823	823
Track density (TPI)	1311	926	1240	925	780
Maximum linear density (BPI)	25484 BPI* 16989 FCI	18758 BPI* 12505 FCI	19610 BPI* 13073 FCI	18759 BPI* 12506 FCI	18900 BPI* 12600 FCI
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
Average positioning time (msec)	20	23	18	23	20
Average rotational delay (msec)	8.4	8.4	8.4	8.4	8.3
Average access time (msec)	28.4	31.4	26.4	31.4	28.3
Data transfer rate (KBytes/sec)	1250	1250	1250	1250	2460
FIRST CUSTOMER SHIPMENT	3/89	2/86	12/87	5/87	11/85
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D5662	D5862	D2352	D2352H	D2362
DISK/TREND GROUP	7	7	8	8	8
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Captive, OEM	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	230 mm OD	230 mm OD	230 mm OD
	40 mm ID	40 mm ID	100 mm ID	100 mm ID	100 mm ID
Recording medium	Oxide Coated	Oxide Coated	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	Modified SMD	Modified SMD	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 385.41	F: 329.01	U: 520	U: 520	U: 800
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,992	F: 17,920	U: 36,288	U: 36,288	U: 40,960
Data surfaces per spindle	15	15	9.5	9.5	11.5
Heads per data surface	1	1	2/1	2/1	2/1
Tracks per surface	1224	1221	1520	1520	1700
Track density (TPI)	1240	1240	1020	1020	1070
Maximum linear density (BPI)	19660 BPI*	19660 BPI*	18600 BPI*	18600 BPI*	21400 BPI*
	13106 FCI	13106 FCI	12400 FCI	12400 FCI	14266 FCI
Rotational speed (RPM)	3573	3573	3070	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	18	15	15	15
Average rotational delay (msec)	8.4	8.4	9.8	8.3	8.3
Average access time (msec)	26.4	26.4	24.8	23.3	23.3
Data transfer rate (KBytes/sec)	1250	1250	1859	2180	2460
FIRST CUSTOMER SHIPMENT	11/87	11/87	1/85	11/85	2/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

	NEC	NEC	NEC	NEC	NEC
MANUFACTURER					
DRIVE					
	D2366	D2462	D5682	D5882	N7755
DISK/TREND GROUP	8	8	8	8	8
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	230 mm OD 100 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	14"
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	IPI-2	SCSI	ESDI,SMD,IPI-2	SCSI	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 800	F: 737	U: 765.42	F: 664.7	F: 635.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	F: 37,888	U: 31,248	F: 27,136	F: 19,069
Data surfaces per spindle	11.5	11.5	16	16	15
Heads per data surface	2/1	2/1	1	1	2
Tracks per surface	1700	1700	1633	1633	2220
Track density (TPI)	1070	1070	1480	1480	960
Maximum linear density (BPI)	21400 BPI* 14266 FCI	21400 BPI* 14266 FCI	30760 BPI* 23070 FCI	30760 BPI* 23070 FCI	6400
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	15	16	16	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	23.3	23.3	24.3	24.3	28.3
Data transfer rate (KBytes/sec)	2460	2460	1875	1875	1198
FIRST CUSTOMER SHIPMENT	1Q87	2Q87	9/89	9/89	1979
U.S. OEM PRICE FOR 100 UNITS	--	--	\$2,000	\$2,000	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	Drive has 2 spindles

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE					
	N7756	N7757	N7759	N7761	D2363
DISK/TREND GROUP	8	8	8	8	9
MARKET	Captive	Captive	Captive	Captive	Captive, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD 100 mm ID	230 mm OD 100 mm ID	230 mm OD 100 mm ID	14"	230 mm OD 100 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Ferrite
Interface	NEC	NEC	NEC	NEC	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 486.2	F: 750.5	F: 972	F: 672.2	U: 1,132
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 34,036	F: 38,708	F: 38,708	F: 47,476	U: 40,960
Data surfaces per spindle	9.5	11.5	11.5	8	13.5
Heads per data surface	2/1	2	2/1	2	2/1
Tracks per surface	1506	1686	1686	1770	2048
Track density (TPI)	1000	1070	1070	800	1290
Maximum linear density (BPI)	18600 BPI* 12400 FCI	21400 BPI* 14266 FCI	21400 BPI* 14266 FCI	15300 BPI* 10200 FCI	21400 BPI* 14266 FCI
Rotational speed (RPM)	3070	3600	3600	3620	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	15	15	13	16	15
Average rotational delay (msec)	9.8	8.3	8.3	8.3	8.3
Average access time (msec)	24.8	23.3	21.3	24.3	23.3
Data transfer rate (KBytes/sec)	1860	2460	2460	3000	2460
FIRST CUSTOMER SHIPMENT	3Q84	1988	9/88	1983	1Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Drive has 2 spindles	*2,7 RLL Code Drive has 2 spindles	*2,7 RLL Code	*2,7 RLL Code Drive has 4 spindles	*2,7 RLL code

MANUFACTURER	NEC	NEC	NEC	NEC	NEC
DRIVE	D2367	D2373	D2377	D2463	N7765
DISK/TREND GROUP	9	9	9	9	9
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	Captive, OEM	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD	230 mm OD	230 mm OD	230 mm OD	14"
Recording medium	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	100 mm ID Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	IPI-2	SMD-E	IPI-2	SCSI	NEC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 1,132	U: 1,415	U: 1,415	F: 1,044	F: 1,344.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 40,960	U: 51,200	U: 51,200	F: 37,888	F: 47,476
Data surfaces per spindle	13.5	13.5	13.5	13.5	9.5
Heads per data surface	2/1	2/1	2/1	2/1	2
Tracks per surface	2048	2048	2048	2048	2982
Track density (TPI)	1290	1290	1290	1290	1200
Maximum linear density (BPI)	21400 BPI*	26800 BPI*	26800 BPI*	21400 BPI*	16100 BPI*
Rotational speed (RPM)	14266 FCI 3600	20100 FCI 3600	20100 FCI 3600	14266 FCI 3600	10733 FCI 3620
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	15	15	15	15	17
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	25.3
Data transfer rate (KBytes/sec)	2460	3070	3070	2460	3000
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	4Q87	3Q87	9/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code	*1,7 RLL Code	*1,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code Drive has 4 spindles



MANUFACTURER	NEC	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	N7767	8208X	8210X	8212X	8308
DISK/TREND GROUP	9	6	6	7	7
MARKET	Captive	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	230 mm OD	200 mm OD	200 mm OD	200 mm OD	200 mm OD
Recording medium	100 mm ID Thin Film	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Oxide Coated	63.5 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	NEC	SMD, SCSI	SMD, SCSI	SMD, SCSI	H/P-SMD, SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 635.3	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
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 32,768	U: 21,912	U: 21,912	U: 21,912	U: 34,300
Data surfaces per spindle	11.5	8	10	12	8
Heads per data surface	2	1	1	1	1
Tracks per surface	1686	1069	1069	1332	1439
Track density (TPI)	1070	1039	1039	1203	1236
Maximum linear density (BPI)	21400 BPI* 14266 FCI	10238	10238	10238	16200 BPI* 10800 FCI
Rotational speed (RPM)	3600	3313.5	3313.5	3313.5	3313.5
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	15	19.5 (256 byte sector)	19.5 (256 byte sector)	21 (256 byte sector)	20
Average rotational delay (msec)	8.3	9	9	9	9
Average access time (msec)	23.3	28.5	28.5	30	29
Data transfer rate (KBytes/sec)	19600	1209	1209	1209	1895
FIRST CUSTOMER SHIPMENT	1988	9/83	9/83	6/85	6/85
U.S. OEM PRICE FOR 100 UNITS	--	\$2,940	\$3,350	\$3,800	\$3,950
COMMENTS	*2,7 RLL Code  N7767 uses 8 spindles in parallel array with 5 GB total capacity	Embedded Servo	Embedded Servo	Embedded Servo	*2,7 RLL Code  Embedded Servo

	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
MANUFACTURER					
DRIVE					
	8312	8408	8412	8414	8508
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
Recording medium	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film	63.5 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	H/P-SMD, SCSI	SMD	SMD, SCSI, IPI-2	SMD, SCSI, IPI-2	SMD, SCSI, IPI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	SCSI(F): 529 (U): 592.2	U: 500	U: 750	U: 925	U: 588
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 34,300	U: 41,778	U: 41,778	U: 41,778	U: 49,200
Data surfaces per spindle	12	8	12	14	8
Heads per data surface	1	1	1	1	1
Tracks per surface	1439	1496	1496	1583	1496
Track density (TPI)	1236	1368	1368	1368	1368
Maximum linear density (BPI)	16200 BPI* 10800 FCI	19800 BPI* 13200 FCI	19800 BPI* 13200 FCI	20300 BPI* 13533 FCI	23300 BPI* 15533 FCI
Rotational speed (RPM)	3313.5	3656	3656	3656	3656
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Torque Motor
Average positioning time (msec)	18	17.5	17.5	17	17.5
Average rotational delay (msec)	9	8.2	8.2	8.2	8.2
Average access time (msec)	27	25.7	25.7	25.2	25.7
Data transfer rate (KBytes/sec)	1895	2550	2550	2550	3000
FIRST CUSTOMER SHIPMENT	12/85	1/87	1/87	11/87	3/87
U.S. OEM PRICE FOR 100 UNITS	\$4,400	\$4,050	\$4,600	\$5,000	\$4,200
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo

MANUFACTURER	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM	NORTHERN TELECOM
DRIVE	8512	8514	9514-SCSI	9514-SMD	9516-SCSI
DISK/TREND GROUP	8	9	9	9	9
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SMD, SCSI, IPI-2	SMD, SCSI, IPI-2	SCSI	SMD	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 883	U: 1,090	F: 1,515	U: 1,756	F: 1,950
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 49,200	U: 49,200	F: 42,496	U: 49,200	F: 42,496
Data surfaces per spindle	12	14	14	14	16
Heads per data surface	1	1	1	1	1
Tracks per surface	1496	1583	2549	2549	2871
Track density (TPI)	1368	1368	2270	2270	2270
Maximum linear density (BPI)	23300 BPI* 15533 FCI	23900 BPI* 15933 FCI	24000 BPI* 16000 FCI	24000 BPI* 16000 FCI	25296 BPI* 16864 FCI
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
Average positioning time (msec)	17.5	16	16.5	16.5	16.5
Average rotational delay (msec)	8.2	8.2	8.2	8.2	8.2
Average access time (msec)	25.7	24.2	24.7	24.7	24.7
Data transfer rate (KBytes/sec)	3000	3000	3000-5000	3000	3000-5000
FIRST CUSTOMER SHIPMENT	3/87	11/87	1Q90	1Q90	1Q90
U.S. OEM PRICE FOR 100 UNITS	\$4,900	\$5,200	\$6,700	\$6,400	\$7,300
COMMENTS	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo	*2,7 RLL Code Embedded Servo Perpendicular recording	*2,7 RLL Code Embedded Servo Perpendicular recording	*2,7 RLL Code Embedded Servo Perpendicular recording

MANUFACTURER	NORTHERN TELECOM	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
DRIVE	9516-SMD	PT251A	PT251R	PT251S	PT351
DISK/TREND GROUP	9	4	4	4	4
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	95 mm OD	95 mm OD
Recording medium	63.5 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	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SMD	PC AT	ST412	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 2,260	F: 43.7	U: 51.2*	F: 41.8	U: 51.2
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 49,200	F: 13,312	U: 15,624*	F: 12,800	U: 10,416
Data surfaces per spindle	16	4	4	4	6
Heads per data surface	1	1	1	1	1
Tracks per surface	2871	820	820	820	820
Track density (TPI)	2270	983	983	983	983
Maximum linear density (BPI)	25296 BPI*	21719 BPI*	21719 BPI*	21719 BPI*	14479
Rotational speed (RPM)	16864 FCI 3656	14479 FCI 3517	14479 FCI 3517	14479 FCI 3517	3517
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	16.5	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.2	8.5	8.5	8.5	8.5
Average access time (msec)	24.7	43.5	43.5	43.5	43.5
Data transfer rate (KBytes/sec)	3000	937.5	937.5*	937.5	625
FIRST CUSTOMER SHIPMENT	1Q90	1988	1988	1988	9/87
U.S. OEM PRICE FOR 100 UNITS	\$7,000	--	--	--	--
COMMENTS	*2,7 RLL Code Embedded Servo Perpendicular recording	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high Embedded Servo

## 1989 DISK/TREND REPORT

	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY	PERIPHERAL TECHNOLOGY
MANUFACTURER					
DRIVE					
	PT357A	PT357R	PT357S	PT376A	PT376R
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
	25 mm ID	25 mm ID	25 mm ID	25 mm ID	25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	ST412	SCSI	PC AT	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 49.1	U: 57.6*	F: 47.0	F: 65.5	U: 76.8*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	F: 12,800	F: 13,312	U: 15,624*
Data surfaces per spindle	6	6	6	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	820	820
Track density (TPI)	983	983	983	983	983
Maximum linear density (BPI)	18327 BPI*	18327 BPI*	18327 BPI*	21719 BPI*	21719 BPI*
	12212 FCI	12218 FCI	12218 FCI	14479 FCI	14479 FCI
Rotational speed (RPM)	3517	3517	3517	3517	3517
PERFORMANCE					
Actuator type	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor	Linear, DC Motor
Average positioning time (msec)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)	35 (including settling)
Average rotational delay (msec)	8.5	8.5	8.5	8.5	8.5
Average access time (msec)	43.5	43.5	43.5	43.5	43.5
Data transfer rate (KBytes/sec)	937.5	937.5*	937.5	937.5	937.5*
FIRST CUSTOMER SHIPMENT	1988	3Q86	1988	1988	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller Embedded Servo

MANUFACTURER	PERIPHERAL TECHNOLOGY	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT	PLUS DEVELOPMENT
DRIVE	PT376S	Hardcard 20	Plus Passport	Hardcard 40	Plus Passport
DISK/TREND GROUP	5	3	3	4	4
MARKET	OEM	PCM, OEM	PCM, OEM	PCM, OEM	PCM, OEM
MEDIA: Generic type	Fixed	Drive On Card	Removable Drive	Drive On Card	Removable Drive
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	25 mm ID	25 mm ID Thin Film	25 mm ID
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	IBM PC	IBM PC	IBM PC	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 62.7	F: 21.2	--	F: 42.26	--
REMOVABLE	--	--	F: 21.4	--	F: 42.6
Capacity per track (Bytes)	F: 12,800	F: 8,704	F: 14,336 and 17,408	F: 14,336 and 17,408	F: 14,336 and 17,408
Data surfaces per spindle	6	4	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	820	615	612	612	612
Track density (TPI)	983	812	812	812	812
Maximum linear density (BPI)	21719 BPI* 14479 FCI 3517	13917 BPI* 9278 FCI 3600	21524 and 22392* 3000	21524 and 22392* 3000	21524 and 22392* 3000
Rotational speed (RPM)					
PERFORMANCE					
Actuator type	Linear, DC Motor	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	35 (including settling)	49 (including settling)	40**	40	40**
Average rotational delay (msec)	8.5	8.3	10	10	10
Average access time (msec)	43.5	57.3	50	50	50
Data transfer rate (KBytes/sec)	937.5	625	843.7/1031	843.7/1031	843.7/1031
FIRST CUSTOMER SHIPMENT	1988	6/86	6/88	5/87	6/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code Embedded Servo	*2,7 RLL Code	*2,7 RLL Code Drive with adapter mounts in half high 5.25" slot **About 27 msec using cache	*2,7 RLL Code	*2,7 RLL Code Drive with adapter mounts in half high 5.25" slot **About 27 msec using cache

## 1989 DISK/TREND REPORT

MANUFACTURER	PRAIRIETEK	PRAIRIETEK	PRIAM	PRIAM	PRIAM
DRIVE	220	240	3804	803	7050
DISK/TREND GROUP	3	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	65 mm OD 20 mm ID	65 mm OD 20 mm ID	95 mm OD 25 mm ID	200 mm OD 63.5 mm ID	200 mm OD 63.5 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	MIG	Ferrite	Ferrite	Ferrite
Interface	SCSI, PC AT/XT	PC AT/XT	PC AT	Priam, SMD	Priam, SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 20	F: 42.8	F: 42.6	U: 85.68	U: 70.49
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 8,192	F: 17,408	F: 13,312	U: 20,160	U: 13,400
Data surfaces per spindle	4	4	4	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	612	615	771	850	1049
Track density (TPI)	1150	1350	898	960	960
Maximum linear density (BPI)	22500 BPI* 15000 FCI 3367	38452 BPI* 25634 FCI 3307	22386 BPI* 14924 FCI 3600	9167	6597
Rotational speed (RPM)				3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Stepping Motor	Linear, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	28	28	40 (including settling)	35	42
Average rotational delay (msec)	8.9	9.1	8.3	8.3	8.3
Average access time (msec)	36.9	37.1	48.3	43.3	50.3
Data transfer rate (KBytes/sec)	625	1250	937.5	1209	806
FIRST CUSTOMER SHIPMENT	4Q88	4Q89	3Q89	9/83	4Q81
U.S. OEM PRICE FOR 100 UNITS	--	--	--	\$2,950	\$3,280
COMMENTS	25.4 mm high *2,7 RLL Code Embedded Servo Ramp loaded heads	25.4 mm high *2,7 RLL Code Embedded Servo Ramp loaded heads	41.3 mm high *2,7 RLL Code Manufactured by Miniscribe		

MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE					
	519	617	628	717	728
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ESDI	ESDI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 191.2	U: 178.6	U: 280.7	F: 163.6	F: 258.6
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 20,832	U: 20,832	F: 19,456	F: 19,456
Data surfaces per spindle	15	7	11	7	11
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1225	1225	1225	1225
Track density (TPI)	1070	1070	1070	1070	1070
Maximum linear density (BPI)	10924	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI
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
Average positioning time (msec)	22	18	18	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	30.3	26.3	26.3	26.3	26.3
Data transfer rate (KBytes/sec)	625	1250	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1Q86	4Q86	4Q86	1Q87	4Q86
U.S. OEM PRICE FOR 100 UNITS	\$1,675	\$1,560	\$1,915	\$1,670	\$2,030
COMMENTS		*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code



MANUFACTURER	PRIAM	PRIAM	PRIAM	PRIAM	PRIAM
DRIVE					
	806	638	738	807	676
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	200 mm OD	130 mm OD	130 mm OD	200 mm OD	130 mm OD
Recording medium	63.5 mm ID Oxide Coated	40 mm ID Thin Film	40 mm ID Thin Film	63.5 mm ID Oxide Coated	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	Priam,SMD,SCSI	ESDI	SCSI	Priam,SMD,SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 227	U: 382.7	F: 353.5	U: 344	U: 765
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,160	U: 20,832	F: 19,456	U: 20,160	U: 31,250
Data surfaces per spindle	11	15	15	11	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1023	1225	1225	1552	1632
Track density (TPI)	1040	1070	1070	1040	1400
Maximum linear density (BPI)	9167	21848 BPI* 14565 FCI	21848 BPI* 14565 FCI	12096	32332 BPI* 24249 FCI
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
Average positioning time (msec)	20	18	18	25	14
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	28.3	26.3	26.3	33.3	22.3
Data transfer rate (KBytes/sec)	1210	1250	1250	1210	1875
FIRST CUSTOMER SHIPMENT	5/84	3Q86	4Q86	6/84	6/89
U.S. OEM PRICE FOR 100 UNITS	\$3,280	\$2,270	\$2,390	\$4,105	--
COMMENTS		*2,7 RLL Code	*2,7 RLL Code		*1,7 RLL Code

MANUFACTURER	PRIAM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	776	40AT ProDrive	40S ProDrive	80AT ProDrive	80S ProDrive
DISK/TREND GROUP	8	4	4	5	5
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 673.0	F: 42	F: 42	F: 84	F: 84
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 27,648	**	**	**	**
Data surfaces per spindle	15	3	3	6	6
Heads per data surface	1	1	1	1	1
Tracks per surface	1632	834	834	834	834
Track density (TPI)	1400	1000	1000	1000	1000
Maximum linear density (BPI)	32332 BPI* 24249 FCI	22050 BPI* 14700 FCI	22050 BPI* 14700 FCI	22050 BPI* 14700 FCI	22050 BPI* 14700 FCI
Rotational speed (RPM)	3600	3662	3662	3662	3662
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	14	19	19	19	19
Average rotational delay (msec)	8.3	8.2	8.2	8.2	8.2
Average access time (msec)	22.3	27.2	27.2	27.2	27.2
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	6/89	5/88	1/88	5/88	1/88
U.S. OEM PRICE FOR 100 UNITS	\$2,895	\$480	\$480	\$785	\$785
COMMENTS	*1,7 RLL Code	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *2,7 RLL Code **Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	QUANTUM
DRIVE	Q250	Q280	105S ProDrive	120AT ProDrive	120S ProDrive
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	130 mm OD	130 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	SCSI	SCSI	SCSI	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 53.4	F: 80.1	F: 105	F: 120	F: 120
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,384	F: 16,384	**	**	**
Data surfaces per spindle	4	6	6	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	815	815	1019	1123	1123
Track density (TPI)	876	876	1225	1414	1414
Maximum linear density (BPI)	20000 BPI* 15000 FCI	20000 BPI* 15000 FCI	22055 BPI* 14700 FCI	27740 BPI* 20805 FCI	27740 BPI* 20805 FCI
Rotational speed (RPM)	3600	3600	3662	3605	3605
PERFORMANCE					
Actuator type	Rotary, Torque Motor	Rotary, Torque Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	26	26	19	15	15
Average rotational delay (msec)	8.3	8.3	8.2	8.3	8.3
Average access time (msec)	34.3	34.3	27.2	23.3	23.3
Data transfer rate (KBytes/sec)	1250	1250	4000 max.	4000 max.	4000 max.
FIRST CUSTOMER SHIPMENT	4/86	4/86	--	4Q89	3Q89
U.S. OEM PRICE FOR 100 UNITS	\$750 (1000)	\$850 (1000)	\$895 (2000)	\$990	\$990
COMMENTS	41.3 mm high *1,7 RLL Code Embedded Servo	41.3 mm high *1,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *1,7 RLL Code **Varies by zone	41.3 mm high *2,7 RLL Code **Varies by zone

MANUFACTURER	QUANTUM	QUANTUM	QUANTUM	QUANTUM	RICOH
DRIVE	170AT ProDrive	170S ProDrive	210AT ProDrive	210S ProDrive	RH5130
DISK/TREND GROUP	6	6	6	6	1
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	5.25" Cartridge
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	Thin Film	Thin Film	Thin Film	Thin Film	Ferrite
Interface	PC AT	SCSI	PC AT	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 168	F: 168	F: 210	F: 210	--
REMOVABLE	--	--	--	--	U: 12.75
Capacity per track (Bytes)	**	**	**	**	U: 10,416
Data surfaces per spindle	7	7	7	7	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1123	1123	1156	1156	612
Track density (TPI)	1414	1414	1454	1454	612
Maximum linear density (BPI)	27740 BPI*	27740 BPI*	30000 BPI*	30000 BPI*	10894
Rotational speed (RPM)	20805 FCI 3605	20805 FCI 3605	22500 FCI 3605	22500 FCI 3605	3473
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rack & Pinion, Stepping Motor
Average positioning time (msec)	15	15	15	15	98 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.6
Average access time (msec)	23.3	23.3	23.3	23.3	106.6
Data transfer rate (KBytes/sec)	4000 max.	4000 max.	4000 max.	4000 max.	625
FIRST CUSTOMER SHIPMENT	4Q89	1Q89	4Q89	4Q89	3Q85
U.S. OEM PRICE FOR 100 UNITS	\$1,195	\$1,195	\$1,395	\$1,395	--
COMMENTS	41.3 mm high *1,7 RLL Code **Varies by zone	41.3 mm high *1,7 RLL Code **Varies by zone	41.3 mm high *1,7 RLL Code **Varies by zone	41.3 mm high *1,7 RLL Code **Varies by zone	41.3 mm high Embedded Servo DMA license

MANUFACTURER	RICOH	RICOH	RODIME	RODIME	RODIME
DRIVE	RH5260 RH5261	RH5500	20 Plus 200 RX	R0652B	45 Plus 450 RX
DISK/TREND GROUP	1	1	3	3	4
MARKET	OEM	OEM	PCM	OEM	PCM
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	96 mm OD 40 mm ID	96 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	Thin Film
Interface	ST506, SCSI	SCSI	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	--	F: 20.7	F: 20.7	F: 45.3
REMOVABLE	U: 25.5	F: 50.0	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 19,455	F: 16,896	F: 16,896	F: 13,312
Data surfaces per spindle	2	2	4	4	5
Heads per data surface	1	1	1	1	1
Tracks per surface	1224	1285	306	306	680
Track density (TPI)	1222	1200	600	600	1040
Maximum linear density (BPI)	10894	25750 BPI* 17166 FCI	22100 BPI* 14733 FCI	22100 BPI* 14733 FCI	18750 BPI* 12500 FCI
Rotational speed (RPM)	3473	3183	2700	2700	3433
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil
Average positioning time (msec)	98 (including settling)	25 (including settling)	85 (including settling)	85 (including settling)	28
Average rotational delay (msec)	8.6	9.4	11.1	11.1	8.7
Average access time (msec)	106.6	34.4	96.1	96.1	36.7
Data transfer rate (KBytes/sec)	625	2000	937.5	937.5	937.5
FIRST CUSTOMER SHIPMENT	1987	2Q89	1986	4Q85	1986
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high Embedded Servo RH5261 has SCSI interface	41.3 mm high Embedded Servo *2,7 RLL Code	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	41.3 mm high *2,7 RLL Code	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE	Cobra 45e Cobra 45i	R03045	R03055	R03058A	R03058T
DISK/TREND GROUP	4	4	4	4	4
MARKET	PCM	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	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	ST412	ST412	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 54.3 F: 45.3	U: 45.42	U: 54.5	F: 45.3	F: 45.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,608	U: 10,417	U: 10,417	F: 20,833	F: 17,408
Data surfaces per spindle	3	5	6	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	868	872	872	868	868
Track density (TPI)	1380	1040	1040	1380	1380
Maximum linear density (BPI)	23875 BPI* 15916 FCI	15072	15072	23875 BPI* 15916 FCI	23875 BPI* 15916 FCI
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
Average positioning time (msec)	18	28	28	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	36.3	36.3	26.3	26.3
Data transfer rate (KBytes/sec)	1250	625	625	1250	1250
FIRST CUSTOMER SHIPMENT	1989	1Q87	1Q87	--	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Macintosh PCM "e" external "i" internal	41.3 mm high	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

## 1989 DISK/TREND REPORT

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03059A	R03060R	60 Plus 600 RX	Cobra 70e Cobra 70i	R03059T
DISK/TREND GROUP	4	4	5	5	5
MARKET	OEM	OEM	PCM	PCM	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	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	ST412	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 46.7	U: 61.4	F: 69.9	U: 90.4 F: 75.5	F: 46.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	U: 15,625	F: 13,312	F: 17,608	**
Data surfaces per spindle	2	5	7	5	2
Heads per data surface	1	1	1	1	1
Tracks per surface	1216	750	680	868	1216
Track density (TPI)	1700	1040	1040	1380	1700
Maximum linear density (BPI)	*	19950 BPI* 13300 FCI	18750 BPI* 12500 FCI	23875 BPI* 15916 FCI	25804 BPI* 17202 FCI
Rotational speed (RPM)	3600	3600	3433	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	18	28	28	18	18
Average rotational delay (msec)	8.3	8.3	8.7	8.3	8.3
Average access time (msec)	26.3	36.3	36.7	26.3	26.3
Data transfer rate (KBytes/sec)	1250	937.5	937.5	1250	1500
FIRST CUSTOMER SHIPMENT	--	--	1987	1989	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *2,7 RLL Code	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	*2,7 RLL Code Macintosh PCM "e" external "i" internal	41.3 mm high *2,7 RLL Code **Varies by zone

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03065	R03075R	R03085R	R03088A	R03088T
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	95 mm OD	95 mm OD	95 mm OD	95 mm OD	95 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film	25 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	ST412	ST412	ST412	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 63.6	U: 73.7	U: 86.0	F: 75.6	F: 75.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,417	U: 15,625	U: 15,625	F: 20,833	F: 17,408
Data surfaces per spindle	7	6	7	5	5
Heads per data surface	1	1	1	1	1
Tracks per surface	872	750	750	868	868
Track density (TPI)	1040	1040	1040	1380	1380
Maximum linear density (BPI)	15072	19950 BPI* 13300 FCI	19950 BPI* 13300 FCI	23875 BPI* 15916 FCI	23875 BPI* 15916 FCI
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
Average positioning time (msec)	28	28	28	18	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	36.3	36.3	26.3	26.3
Data transfer rate (KBytes/sec)	625	937.5	937.5	1250	1250
FIRST CUSTOMER SHIPMENT	4Q86	--	--	--	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

1989 DISK/TREND REPORT



MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03089A	R03089T	R05090	100 Plus 1000 RX	140 Plus 1400 RX
DISK/TREND GROUP	5	5	5	6	6
MARKET	OEM	OEM	OEM	PCM	PCM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	95 mm OD	130 mm OD	95 mm OD	130 mm OD
Recording medium	25 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film	25 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI	ST412	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 70.0	F: 70.0	U: 89.3	F: 105.7	F: 144.1
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	**	U: 10,417	F: 14,848	F: 16,896
Data surfaces per spindle	3	3	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1216	1216	1224	1053	1219
Track density (TPI)	1700	1700	1100	1380	1100
Maximum linear density (BPI)	*	25804 BPI* 17202 FCI	10024	23775 BPI* 15850 FCI	20050 BPI* 13366 FCI
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
Average positioning time (msec)	18	18	28	24	24
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	36.3	32.3	32.3
Data transfer rate (KBytes/sec)	1250	1500	500	1060	1250
FIRST CUSTOMER SHIPMENT	--	--	2Q87	1987	1987
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *2,7 RLL Code  **Varies by zone	41.3 mm high	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external	*2,7 RLL Code Macintosh PCM "RX" internal "Plus" external

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	Cobra 100e Cobra 100i	Cobra 210e Cobra 210i	R03128A	R03128T	R03129A
DISK/TREND GROUP	6	6	6	6	6
MARKET	PCM	PCM	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	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	SCSI	PC AT	SCSI	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 126.6 F: 105.8	U: 250.7 F: 210.0	F: 105.8	F: 105.8	F: 105.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 17,608	F: 17,608	F: 20,833	F: 17,408	*
Data surfaces per spindle	7	9	7	7	5
Heads per data surface	1	1	1	1	1
Tracks per surface	868	1200	868	868	1091
Track density (TPI)	1380	1700	1380	1380	1700
Maximum linear density (BPI)	23875 BPI* 15916 FCI	27000 BPI* 18000 FCI	23875 BPI* 15916 FCI	23875 BPI* 15916 FCI	*
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
Average positioning time (msec)	18	18	18	18	18
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	26.3
Data transfer rate (KBytes/sec)	1250	1500	1250	1250	1250
FIRST CUSTOMER SHIPMENT	1989	1989	--	--	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	*2,7 RLL Code Macintosh PCM "e" external "i" internal	*2,7 RLL Code Macintosh PCM "e" external "i" internal	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *Varies by zone

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03129T	R03135A	R03139A	R03199A	R03199T
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	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	PC AT	PC AT	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 105.8	F: 112.5	F: 112.5	F: 163.4	F: 163.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	**	F: 20,833	*	*	**
Data surfaces per spindle	5	7	5	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1091	923	1168	1216	1216
Track density (TPI)	1700	1380	1700	1700	1700
Maximum linear density (BPI)	25804 BPI* 17202 FCI	24763 BPI* 16508 FCI	*	*	25804 BPI* 17202 FCI
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
Average positioning time (msec)	18	18	18	18	18
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	26.3
Data transfer rate (KBytes/sec)	1500	1250	1250	1250	1500
FIRST CUSTOMER SHIPMENT	--	--	--	--	--
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *2,7 RLL Code	41.3 mm high *Varies by zone	41.3 mm high *Varies by zone	41.3 mm high *2,7 RLL Code **Varies by zone

MANUFACTURER	RODIME	RODIME	RODIME	RODIME	RODIME
DRIVE					
	R03259A	R03259T	R05130R	R05178S	R05180E
DISK/TREND GROUP	6	6	6	6	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
Interface	PC AT	SCSI	ST412	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 210.0	F: 210.0	U: 133.9*	F: 144.2	U: 178.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	*	**	U: 15,625*	F: 17,408	U: 20,833
Data surfaces per spindle	9	9	7	7	7
Heads per data surface	1	1	1	1	1
Tracks per surface	1216	1216	1224	1219	1219
Track density (TPI)	1700	1700	1100	1100	1100
Maximum linear density (BPI)	*	25804 BPI* 17202 FCI	15036 BPI* 10024 FCI	20050 BPI* 13366 FCI	20050 BPI* 13366 FCI
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
Average positioning time (msec)	18	18	28	28	22
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	30.3
Data transfer rate (KBytes/sec)	1250	1500	750*	1250	1250
FIRST CUSTOMER SHIPMENT	1Q89	--	2/88	--	2/88
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *Varies by zone	41.3 mm high *2,7 RLL Code **Varies by zone	41.3 mm high *With RLL controller	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	RODIME	SAGEM	SAGEM	SAGEM	SAGEM
DRIVE					
	R05180S	MSA 240-25	MSA 240-50	MSA 250-50	MSA 250-100
DISK/TREND GROUP	6	3	4	4	6
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Special	Special
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	SCSI	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 144.2	F: 25	F: 50	--	--
REMOVABLE	--	--	--	F: 50	F: 100
Capacity per track (Bytes)	F: 16,896	F: 14,848	F: 14,848	F: 14,848	F: 14,848
Data surfaces per spindle	7	4	8	8	16
Heads per data surface	1	8	8	8	8
Tracks per surface	1219	464	464	464	464
Track density (TPI)	1100	620	620	620	620
Maximum linear density (BPI)	20050 BPI* 13366 FCI	13110	13110	13110	13110
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
Average positioning time (msec)	28	17	17	17	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	25.3	25.3	25.3	25.3
Data transfer rate (KBytes/sec)	1250	1500	1500	1500	1500
FIRST CUSTOMER SHIPMENT	2Q87	3Q87	3Q87	1Q87	1Q89
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	Militarized Subsystem	Militarized Subsystem	Militarized Subsystem  Removable Head/Disk Module	Militarized Subsystem  Removable Head/Disk Module

MANUFACTURER	SAGEM	SAMSUNG ELECTRONICS	SAMSUNG ELECTRONICS	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	MSA 252-200	SHD2040	SHD2041	ST124	ST125
DISK/TREND GROUP	6	4	4	3	3
MARKET	OEM	OEM, Captive	OEM, Captive	OEM	OEM
MEDIA: Generic type	Special	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	ST412	PC AT	ST412	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	--	U: 51.2*	F: 43.7	U: 25.6	U: 25.6
REMOVABLE	F: 200	--	--	--	--
Capacity per track (Bytes)	F: 23,040	U: 15,624*	F: 13,312	U: 10,416	U: 10,416
Data surfaces per spindle	16	4	4	4	4
Heads per data surface	8	1	1	1	1
Tracks per surface	720	820	820	615	615
Track density (TPI)	950	1065	1065	824	824
Maximum linear density (BPI)	19680	20196 BPI* 13464 FCI	20196 BPI* 13464 FCI	14953	14953
Rotational speed (RPM)	3600	3568	3568	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	17	35 (including settling)	29 (including settling)	40 (including settling)	28 (including settling)
Average rotational delay (msec)	8.3	8.4	8.4	8.3	8.3
Average access time (msec)	25.3	43.4	37.4	48.3	36.3
Data transfer rate (KBytes/sec)	1500	937.5*	937.5	625	625
FIRST CUSTOMER SHIPMENT	1Q89	4Q88	3Q89	3Q89	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	\$270
COMMENTS	Militarized Subsystem  Removable Head/Disk Module	41.3 mm high  *With RLL controller	41.3 mm high  *2,7 RLL Code	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST125A	ST125N	ST224N	ST225	ST225N
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	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 Oxide Coated	40 mm ID Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	PC AT	SCSI	SCSI	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.5	F: 21.5	F: 21.2	U: 25.6	F: 21.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 13,312	**	U: 10,416	F: 8,704
Data surfaces per spindle	4	4	2	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	404	407	**	615	615
Track density (TPI)	824	824	588	588	588
Maximum linear density (BPI)	16546 BPI*	16546 BPI*	18897 BPI*	9827	9827
Rotational speed (RPM)	11030 FCI 3600	11030 FCI 3600	12598 FCI 3000	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
Average positioning time (msec)	28 (including settling)	28 (including settling)	70 (including settling)	65 (including settling)	65 (including settling)
Average rotational delay (msec)	8.3	8.3	10	8.3	8.3
Average access time (msec)	36.3	36.3	80	73.3	73.3
Data transfer rate (KBytes/sec)	937.5	937.5	937.5	625	625
FIRST CUSTOMER SHIPMENT	2Q89	1Q88	4Q89	10/84	4Q85
U.S. OEM PRICE FOR 100 UNITS	\$320	\$320	--	\$220	\$285
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code **Unspecified	41.3 mm high	41.3 mm high

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST225R	ST3025A	ST3025N	ST325A	ST325N
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	PC AT	SCSI-2	PC AT	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 25.0*	F: 21.5	F: 21.5	F: 21.4	F: 21.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 18,750*	**	**	**	**
Data surfaces per spindle	2	1	1	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	667	***	***	**	**
Track density (TPI)	588	1760	1760	1015	1015
Maximum linear density (BPI)	18897 BPI* 12598 FCI	27000 BPI* 18000 FCI	27000 BPI* 18000 FCI	22762 BPI* 15175 FCI	22762 BPI* 15175 FCI
Rotational speed (RPM)	3000	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Rack, Stepping Motor	Rotary, Rack, Stepping Motor
Average positioning time (msec)	70 (including settling)	20	20	45 (including settling)	45 (including settling)
Average rotational delay (msec)	10	8.3	8.3	8.3	8.3
Average access time (msec)	80	28.3	28.3	53.3	53.3
Data transfer rate (KBytes/sec)	937.5*	1250-1750	1250-1750	1150	1150
FIRST CUSTOMER SHIPMENT	3Q88	1Q90	1Q90	1Q90	4Q89
U.S. OEM PRICE FOR 100 UNITS	\$205	--	--	--	--
COMMENTS	*With RLL controller	25.4 mm high *2,7 RLL Code **Varies by zone ***Unspecified	25.4 mm high *2,7 RLL Code **Varies by zone ***Unspecified	30 mm high *2,7 RLL Code **Unspecified Embedded Servo	31.5 mm high *2,7 RLL Code **Unspecified Embedded Servo



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)  
     Rotational speed (RPM)  
 PERFORMANCE  
     Actuator type  
     Average positioning time (msec)  
     Average rotational delay (msec)  
     Average access time (msec)  
     Data transfer rate (KBytes/sec)  
 FIRST CUSTOMER SHIPMENT  
 U.S. OEM PRICE FOR 100 UNITS  
 COMMENTS

SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
ST325X	ST1057A	ST1057N	ST137R	ST138
3	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
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
PC XT	PC AT	SCSI-2	ST412	ST412
F: 21.4	F: 49.1	F: 49.1	U: 38.4*	U: 38.4
--	--	--	--	--
**	**	**	U: 15,624*	U: 10,416
2	3	3	4	6
1	1	1	1	1
**	***	***	615	615
1015	1300	1300	824	824
22762 BPI* 15175 FCI 3600	21600 BPI* 14400 FCI 3528	21600 BPI* 14400 FCI 3528	22430 BPI* 14953 FCI 3600	14953 3600
Rotary, Rack, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
45 (including settling)	20	20	40 (including settling)	28 (including settling)
8.3	8.5	8.5	8.3	8.3
53.3	28.5	28.5	48.3	36.3
1150	1025-1500	1025-1500	937.5*	625
2Q89	4Q89	4Q89	4Q89	3Q87
--	--	--	--	\$325
30 mm high	41.3 mm high	41.3 mm high	41.3 mm high	41.3 mm high
*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*With RLL controller	
**Unspecified	**Varies by zone	**Varies by zone		
Embedded Servo	***Unspecified	***Unspecified		

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 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	ST412	ST412	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 32.1	F: 32.2	U: 38.4*	U: 50.8	F: 44.7
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 13,312	U: 15,624*	U: 10,416	F: 13,312
Data surfaces per spindle	4	4	4	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	604	615	615	977	560
Track density (TPI)	824	824	824	1300	824
Maximum linear density (BPI)	22430 BPI* 14953 FCI	22430 BPI* 14953 FCI	22430 BPI* 14953 FCI	14108	20280 BPI* 13520 FCI
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
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
U.S. OEM PRICE FOR 100 UNITS	\$355	\$355	\$300	\$380	\$390
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller	41.3 mm high	41.3 mm high *2,7 RLL Code

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST157N	ST157R	ST238R	ST250N	ST250R
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	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 48.6	U: 57.7*	U: 38.4*	F: 42.9	U: 50.0*
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	U: 15,624*	U: 15,624*	**	U: 18,750*
Data surfaces per spindle	6	6	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	615	615	615	**	667
Track density (TPI)	824	824	588	588	588
Maximum linear density (BPI)	22430 BPI*	22430 BPI*	14740 BPI*	18897 BPI*	18897 BPI*
Rotational speed (RPM)	14953 FCI 3600	14953 FCI 3600	9827 FCI 3600	12598 FCI 3000	12598 FCI 3000
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor
Average positioning time (msec)	28 (including settling)	28 (including settling)	65 (including settling)	70 (including settling)	70 (including settling)
Average rotational delay (msec)	8.3	8.3	8.3	10	10
Average access time (msec)	36.3	36.3	73.3	80	80
Data transfer rate (KBytes/sec)	937.5	937.5*	937.5*	937.5	937.5*
FIRST CUSTOMER SHIPMENT	3Q87	3Q87	1Q86	4Q89	3Q88
U.S. OEM PRICE FOR 100 UNITS	\$390	\$355	\$240	--	\$255
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high *2,7 RLL Code **Unspecified	41.3 mm high *With RLL controller

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE					
	ST251	ST252	ST3057A	ST3057N	ST4053
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	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	PC AT	SCSI-2	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.2	U: 51.2	F: 49.1	F: 49.1	U: 53.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	U: 10,416	**	**	U: 10,416
Data surfaces per spindle	6	6	3	3	5
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	***	***	1024
Track density (TPI)	777	777	1760	1760	1031
Maximum linear density (BPI)	9935	9935	27000 BPI* 18000 FCI	27000 BPI* 18000 FCI	9792
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Band, Stepping Motor	Rotary, Band, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil
Average positioning time (msec)	28 (including settling)	40 (including settling)	20	20	28
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	48.3	28.3	28.3	36.3
Data transfer rate (KBytes/sec)	625	625	1250-1750	1250-1750	625
FIRST CUSTOMER SHIPMENT	3Q87	4Q89	1Q90	1Q90	1/87
U.S. OEM PRICE FOR 100 UNITS	\$360	--	--	--	\$505
COMMENTS	41.3 mm high	41.3 mm high	25.4 mm high *2,7 RLL Code **Varies by zone ***Unspecified	25.4 mm high *2,7 RLL Code **Varies by zone ***Unspecified	

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST1096N	ST1102A	ST1102N	ST177N	ST277N
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	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	130 mm OD 40 mm ID
Recording medium	Thin Film	Thin Film	Thin Film	Thin Film	Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	SCSI	PC AT	SCSI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 83.9	F: 84.0	F: 84.0	F: 60.8	F: 64.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	**	**	F: 13,312	F: 17,408
Data surfaces per spindle	7	5	5	5	6
Heads per data surface	1	1	1	1	1
Tracks per surface	906	***	***	921	628
Track density (TPI)	1300	1300	1300	1300	777
Maximum linear density (BPI)	19893 BPI* 13262 FCI	21600 BPI* 14400 FCI	21600 BPI* 14400 FCI	19893 BPI* 13262 FCI	19869 BPI* 13246 FCI
Rotational speed (RPM)	3600	3528	3528	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Band, Stepping Motor
Average positioning time (msec)	24	20	20	24	28 (including settling)
Average rotational delay (msec)	8.3	8.5	8.5	8.3	8.3
Average access time (msec)	32.3	28.5	28.5	32.3	36.3
Data transfer rate (KBytes/sec)	937.5	1025-1500	1025-1500	937.5	1250
FIRST CUSTOMER SHIPMENT	1Q89	4Q89	4Q89	1Q89	1/87
U.S. OEM PRICE FOR 100 UNITS	\$725	--	--	\$600	\$480
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code **Varies by zone ***Unspecified	41.3 mm high *2,7 RLL Code **Varies by zone ***Unspecified	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY
DRIVE	ST277R	ST278R	ST296N	ST3096A	ST3096N
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	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	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ST412	ST412	SCSI	PC AT	SCSI-2
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 76.9*	U: 76.8*	F: 84.9	F: 84.0	F: 84.0
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 15,624*	U: 15,624*	F: 17,408	**	**
Data surfaces per spindle	6	6	6	3	3
Heads per data surface	1	1	1	1	1
Tracks per surface	820	820	820	***	***
Track density (TPI)	777	777	777	1760	1760
Maximum linear density (BPI)	14902 BPI* 9935 FCI	14902 BPI* 9935 FCI	19869 BPI* 13246 FCI	27000 BPI* 18000 FCI	27000 BPI* 18000 FCI
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, Voice Coil
Average positioning time (msec)	28 (including settling)	40 (including settling)	28 (including settling)	20	20
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	36.3	48.3	36.3	28.3	28.3
Data transfer rate (KBytes/sec)	937.5*	937.5*	1250	1250-1750	1250-1750
FIRST CUSTOMER SHIPMENT	3Q86	4Q89	4Q87	1Q90	1Q90
U.S. OEM PRICE FOR 100 UNITS	\$400	--	\$515	--	--
COMMENTS	41.3 mm high *With RLL controller	41.3 mm high *With RLL controller	41.3 mm high *2,7 RLL Code	25.4 mm high *2,7 RLL Code **Varies by zone ***Unspecified	25.4 mm high *2,7 RLL Code **Varies by zone ***Unspecified

MANUFACTURER	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SEAGATE TECHNOLOGY	SIEMENS
DRIVE	ST4096	ST1144A	ST1144N	ST4144R	2300
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	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	Ferrite	Ferrite	Ferrite	Ferrite	Thin Film
Interface	ST412	PC AT	SCSI-2	ST412	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 96	F: 125.8	F: 125.8	U: 144*	F: 261.4
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	**	**	U: 15,624*	F: 17,920
Data surfaces per spindle	9	7	7	9	12
Heads per data surface	1	1	1	1	1
Tracks per surface	1024	***	***	1024	1216
Track density (TPI)	1031	1300	1300	1031	1207
Maximum linear density (BPI)	9792	21600 BPI* 14400 FCI	21600 BPI* 14400 FCI	14688 BPI* 9792 FCI	19331 BPI* 12887 FCI
Rotational speed (RPM)	3600	3528	3528	3600	3524
PERFORMANCE					
Actuator type	Linear, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Linear, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28	20	20	28	25
Average rotational delay (msec)	8.3	8.5	8.5	8.3	8.5
Average access time (msec)	36.3	28.5	28.5	36.3	33.5
Data transfer rate (KBytes/sec)	625	1025-1500	1025-1500	937.5*	1250
FIRST CUSTOMER SHIPMENT	1Q86	4Q89	4Q89	3Q87	4/87
U.S. OEM PRICE FOR 100 UNITS	\$640	--	--	\$685	\$1,400
COMMENTS		41.3 mm high *2,7 RLL Code **Varies by zone ***Unspecified	41.3 mm high *2,7 RLL Code **Varies by zone ***Unspecified	*With RLL controller	*2,7 RLL Code

MANUFACTURER	SIEMENS	SIEMENS	SIEMENS	SIEMENS	SIEMENS
DRIVE					
	1300	4410	4420	5820	5810
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	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	ESDI	SCSI	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 310	U: 382.55	F: 322.15	F: 677	U: 777
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 21,280	U: 31,616	F: 26,624	F: 27,648	U: 31,740
Data surfaces per spindle	12	11	11	15	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1216	1100	1100	1632	1658
Track density (TPI)	1207	1207	1207	1476	1499
Maximum linear density (BPI)	19331 BPI* 12887 FCI 3524	26907 BPI* 17938 FCI 3558	26907 BPI* 17938 FCI 3558	29575 BPI* 19717 FCI 3558	29575 BPI* 19717 FCI 3558
Rotational speed (RPM)					
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	25	16.5	16.5	14	14
Average rotational delay (msec)	8.5	8.43	8.43	8.43	8.43
Average access time (msec)	33.5	24.93	24.93	22.43	22.43
Data transfer rate (KBytes/sec)	1250	1875	1875	1875	1875
FIRST CUSTOMER SHIPMENT	1Q86	1Q88	2Q88	3Q89	2Q89
U.S. OEM PRICE FOR 100 UNITS	\$1,400	\$1,470	\$1,470	\$2,100	\$2,100
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code



MANUFACTURER	SONY	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION	STORAGE TECHNOLOGY CORPORATION
DRIVE					
	SRD2040Z	8380-B04	8380-BP4	8380-RXX	8380E
DISK/TREND GROUP	4	9	9	9	9
MARKET	OEM	PCM, OEM	PCM, OEM	PCM	PCM, OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	95 mm OD	14"	14"	14"	14"
Recording medium	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads		Thin Film	Thin Film	Thin Film	Thin Film
Interface	SCSI	IBM	IBM	IBM	IBM
CAPACITY/RECORDING DENSITY				Subsystem: 10,080 to 30,240 in 2.52 increments	
Total capacity (Mbytes) FIXED	F: 42.1	F: 1,260	F: 1,260		F: 2,520.97
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 16,900	F: 47,476	F: 47,476	F: 47,476	F: 47,476
Data surfaces per spindle	4	15	15	15/15/19	15
Heads per data surface	1	2	2	2	2
Tracks per surface	624	1770	1770	1770/3540/4192	3540
Track density (TPI)	980	800	800	800/1400/1650	1400
Maximum linear density (BPI)	25500	15240 BPI* 10160 FCI	15240 BPI* 10160 FCI	15240 BPI* 10160 FCI	*
Rotational speed (RPM)	3600	3620	3620	3620	3620
PERFORMANCE					
Actuator type	Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	29	16	12	11/14/16	17
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	37.3	24.3	20.3	19.3/22.3/24.3	25.3
Data transfer rate (KBytes/sec)	1250	3000	3000	3000	3000
FIRST CUSTOMER SHIPMENT	1/89	1983	12/87	1988	6/86
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	PCM 3380 *2,7 RLL Code Drive has 2 spindles	PCM 3380J *2,7 RLL Code Drive has 2 spindles	PCM 3380J,E,K. *2,7 RLL Code. Subsystem has 8 spindles. 1X or 2X or 3X by pairs.	PCM 3380-BE4 *Not announced Drive has 2 spindles

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)

Rotational speed (RPM)

PERFORMANCE

Actuator type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

U.S. OEM PRICE FOR 100 UNITS

COMMENTS

STORAGE TECHNOLOGY CORPORATION	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	SYQUEST TECHNOLOGY	TEAC
8380F	SQ312RD	SQ319	SQ555	SD-521
9	1	1	1	3
PCM	OEM	OEM, PCM	OEM	OEM
Fixed	3.9" Cartridge	3.9" Cartridge	Syquest Q-Pak	Fixed
14"	100 mm OD 40 mm ID	100 mm OD 40 mm ID	130 mm OD 40 mm ID	130 mm OD 40 mm ID
Oxide Coated	Thin Film	Thin Film	Thin Film	Oxide Coated
Thin Film	Ferrite	Ferrite	Ferrite	Ferrite
IBM	ST412	IBM PC	SCSI	ST412
F: 3,780	--	--	--	U: 25.62
--	U: 12.75	U: 19.1	F: 44.5	--
F: 47,476	U: 10,416	U: 15,048	F: 17,408	U: 10,416
19	2	2	2	4
2	1	1	1	1
4192	615	615	1278	615
1650	741	741	1086	690
15240 BPI* 10160 FCI 3620	12608	18912	23316 BPI* 15544 FCI 3280	8940
3620	3545	3545	3280	3600
Dual, Linear, Voice Coil	Band, Stepping Motor	Band, Stepping Motor	Rotary, Voice Coil	Band, DC Motor
16	85 (including settling)	85 (including settling)	25	40 (including settling)
8.3	8.46	8.46	9.15	8.3
24.3	93.46	93.46	34.15	48.3
3000	625	937.5	1250	625
1Q89	7/84	7/86	3Q87	1987
--	\$550 (1000)	\$770	\$610 (1000)	--
PCM 3380K *2,7 RLL Code Drive has 2 spindles	41.3 mm high 4.8" wide Embedded Servo	Includes controller, software, and mounting hardware	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high

1989 DISK/TREND REPORT

MANUFACTURER	TEAC	TOKICO	TOKICO	TOKICO	TOSHIBA
DRIVE					
	SD-540	TD3041C	TD3042C	TD3081C	MK-132FA
DISK/TREND GROUP	4	4	4	5	3
MARKET	OEM	OEM	OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID	95 mm OD 25 mm ID
Recording medium	Oxide Coated	Thin Film	Thin Film	Thin Film	Oxide Coated
DRIVE: Heads	Ferrite	MIG	MIG	MIG	Ferrite
Interface	ST412	SCSI	SCSI	SCSI	ST412
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 51.25	F: 40	F: 40	F: 80	U: 22.9
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 10,416	F: 17,920	F: 22,528	F: 17,920	U: 10,416
Data surfaces per spindle	8	3	2	5	3
Heads per data surface	1	1	1	1	1
Tracks per surface	615	928	900	928	733
Track density (TPI)	690	1175	1175	1175	1000
Maximum linear density (BPI)	8940	28000 BPI* 18666 FCI	39000 BPI* 26000 FCI	28000 BPI* 18666 FCI	13600
Rotational speed (RPM)	3600	3600	2600	3600	3600
PERFORMANCE					
Actuator type	Band, DC Motor	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	40 (including settling)	20	28	20	25
Average rotational delay (msec)	8.3	8.3	11.5	8.3	8.3
Average access time (msec)	48.3	28.3	39.5	28.3	33.3
Data transfer rate (KBytes/sec)	625	1250	1250	1250	625
FIRST CUSTOMER SHIPMENT	1986	10/88	3Q89	10/88	3Q87
U.S. OEM PRICE FOR 100 UNITS	--	--	--	--	--
COMMENTS	41.3 mm high	41.3 mm high *2,7 RLL Code	25.4 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high

**1989 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)

Rotational speed (RPM)

PERFORMANCE

Actuator type

Average positioning time (msec)

Average rotational delay (msec)

Average access time (msec)

Data transfer rate (KBytes/sec)

FIRST CUSTOMER SHIPMENT

U.S. OEM PRICE FOR 100 UNITS

COMMENTS

TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
MK-232FB	MK-133FA	MK-134FA	MK-233FB	MK-56FB
4	4	4	5	5
OEM	OEM	OEM	OEM	OEM
Fixed	Fixed	Fixed	Fixed	Fixed
95 mm OD 25 mm ID Thin Film	95 mm OD 25 mm ID Oxide Coated	95 mm OD 25 mm ID Oxide Coated	95 mm OD 25 mm ID Thin Film	130 mm OD 40 mm ID Oxide Coated
Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
SCSI	ST412	ST412	SCSI	ST412
F: 45.4	U: 38.2	U: 53.4	F: 75.7	U: 86.5
--	--	--	--	--
F: 17,920	U: 10,416	U: 10,416	F: 17,920	U: 10,416
3	5	7	5	10
1	1	1	1	1
845	733	733	845	830
1016	1000	1000	1016	900
30590 BPI* 20393 FCI 3600	13600	13600	30590 BPI* 20393 FCI 3600	9383
3600	3600	3600	3600	3600
Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
25	25	25	25	25
8.3	8.3	8.3	8.3	8.3
33.3	33.3	33.3	33.3	33.3
1250	625	625	1250	625
1Q89	3Q87	3Q87	1Q89	3/85
--	--	\$505	--	\$880
41.3 mm high *2,7 RLL Code	41.3 mm high	41.3 mm high	41.3 mm high	

1989 DISK/TREND REPORT

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE					
	MK-156FA	MK-156FB	MK-186FB	MK-234FB	MK-256FA
DISK/TREND GROUP	6	6	6	6	7
MARKET	Captive, OEM	Captive, OEM	Captive, OEM	OEM	OEM
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD	130 mm OD	210 mm OD	95 mm OD	130 mm OD
Recording medium	40 mm ID Thin Film	40 mm ID Thin Film	100 mm ID Oxide Coated	25 mm ID Thin Film	40 mm ID Thin Film
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Ferrite	Ferrite
Interface	ESDI	SCSI	SMD	SCSI	ESDI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 172.9	F: 147.8	U: 165.9	F: 106.0	U: 382.5
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 20,832	F: 18,432	U: 20,160	F: 17,920	U: 31,248
Data surfaces per spindle	10	10	10	7	10
Heads per data surface	1	1	1	1	1
Tracks per surface	830	830	823	845	1223
Track density (TPI)	900	900	900	1016	1330
Maximum linear density (BPI)	18766 BPI*	18766 BPI*	9000 BPI*	30590 BPI*	27800 BPI*
Rotational speed (RPM)	12510 FCI 3600	12510 FCI 3600	6000 FCI 3600	20393 FCI 3600	20850 FCI 3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	23	23	18	25	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	31.3	33.3	26.3	33.3	26.3
Data transfer rate (KBytes/sec)	1250	1250	1210	1250	1875
FIRST CUSTOMER SHIPMENT	4/86	9/86	4Q83	1Q89	2Q88
U.S. OEM PRICE FOR 100 UNITS	\$1,190	\$1,225	\$2,600	\$890	\$1,860
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	*1,7 RLL Code

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA	TOSHIBA
DRIVE					
	MK-256FB	MK-286FC	MK-355FA	MK-355FB	MK-288FC
DISK/TREND GROUP	7	7	7	7	8
MARKET	OEM	Captive, OEM	OEM	OEM	Captive, 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	Modified SMD	ESDI	SCSI/SCSI-2	Modified SMD
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 316.4	U: 374.3	U: 459	F: 405.7	U: 510.3
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 26,112	U: 41,340	U: 31,248	F: 27,136	U: 41,340
Data surfaces per spindle	10	11	9	9	15
Heads per data surface	1	1	1	1	1
Tracks per surface	1223	823	1632	1632	823
Track density (TPI)	1330	765	1330	1330	765
Maximum linear density (BPI)	27800 BPI* 20850 FCI	19300 BPI* 12867 FCI	32200 BPI* 24150 FCI	32200 BPI* 24150 FCI	19300 BPI* 12867 FCI
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
Average positioning time (msec)	18	18	16	16	18
Average rotational delay (msec)	8.3	8.3	8.3	8.3	8.3
Average access time (msec)	26.3	26.3	24.3	24.3	26.3
Data transfer rate (KBytes/sec)	1875	2460	1875	1500/5000	2460
FIRST CUSTOMER SHIPMENT	3Q88	4/86	4Q89	4Q89	4/86
U.S. OEM PRICE FOR 100 UNITS	\$1,960	\$3,245	--	--	\$3,935
COMMENTS	*1,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code

MANUFACTURER	TOSHIBA	TOSHIBA	TOSHIBA	UNISYS	UNISYS
DRIVE					
	MK-358FA	MK-358FB	MK-388FA	9494-12	9494-24
DISK/TREND GROUP	8	8	8	9	9
MARKET	OEM	OEM	OEM	Captive	Captive
MEDIA: Generic type	Fixed	Fixed	Fixed	Fixed	Fixed
Nominal disk diameter	130 mm OD 40 mm ID	130 mm OD 40 mm ID	210 mm OD 100 mm ID	14"	14"
Recording medium	Thin Film	Thin Film	Oxide Coated	Oxide Coated	Oxide Coated
DRIVE: Heads	Ferrite	Ferrite	Ferrite	Thin Film	Thin Film
Interface	ESDI	SCSI/SCSI-2	Modified SMD	Burroughs	Burroughs
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	U: 765	F: 676.1	U: 720.6	F: 870	F: 1,740
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	U: 31,248	F: 27,136	U: 41,340	F: 32,781	F: 32,781
Data surfaces per spindle	15	15	15	15	15
Heads per data surface	1	1	1	2	2
Tracks per surface	1632	1632	1162	1768	3538
Track density (TPI)	1330	1330	1000	806	1386
Maximum linear density (BPI)	32200 BPI* 24150 FCI	32200 BPI* 24150 FCI	19367 BPI* 12917 FCI	15240 BPI* 10160 FCI	16200 BPI* 10800 FCI
Rotational speed (RPM)	3600	3600	3600	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Dual, Linear, Voice Coil	Dual, Linear, Voice Coil
Average positioning time (msec)	16	16	18	16	17
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	25.3
Data transfer rate (KBytes/sec)	1875	1500/5000	2480	3000	3000
FIRST CUSTOMER SHIPMENT	4Q89	--	12/87	1Q85	6/87
U.S. OEM PRICE FOR 100 UNITS	\$2,910	\$3,085	\$4,460	--	--
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	*2,7 RLL Code	B7900 B4900 A9,A10, A15,V300. *2,7 RLL Code. Drive has 2 spindles	*2,7 RLL Code Drive has 2 spindles

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD20ifc	WD93024-A	WD93024-X	WD93028-A	WD93028-X
DISK/TREND GROUP	3	3	3	3	3
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Drive On Card	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	IBM PC	PC AT	PC XT	PC AT	IBM PC
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 21.62	F: 21.62	F: 21.62	F: 21.62	F: 21.62
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	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	782	782	782
Track density (TPI)	1013	1021	1021	1013	1013
Maximum linear density (BPI)	21278 BPI*	22175 BPI*	22175 BPI*	21278 BPI*	21278 BPI*
Rotational speed (RPM)	14185 FCI 3557	14783 FCI 3329	14783 FCI 3329	14185 FCI 3557	14185 FCI 3557
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	61.6 (including settling)	19.3 (including settling)	28 (including settling)	61.6 (including settling)	61.6 (including settling)
Average rotational delay (msec)	8.4	9.0	9.0	8.4	8.4
Average access time (msec)	70	28.3	37	70	70
Data transfer rate (KBytes/sec)	937.5	640	640	200	937.5
FIRST CUSTOMER SHIPMENT	2/86	6/89	9/89	10/88	1/88
U.S. OEM PRICE FOR 100 UNITS	\$229 (2500)	\$240 (2500)	\$205 (2500)	\$205 (2500)	\$200 (2500)
COMMENTS	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code



MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD30ifc	WD40ifc	WD93034-X	WD93038-X	WD93044-A
DISK/TREND GROUP	4	4	4	4	4
MARKET	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM	OEM, PCM
MEDIA: Generic type	Drive On Card	Drive On Card	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	IBM PC	IBM PC	PC XT	IBM PC	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 32.43	F: 43.24	F: 32.43	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	4	4	4	4	4
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	782	782	782
Track density (TPI)	1013	1021	1021	1013	1021
Maximum linear density (BPI)	21278 BPI* 14185 FCI	22175 BPI* 14783 FCI	22175 BPI* 14783 FCI	21278 BPI* 14185 FCI	22175 BPI* 14783 FCI
Rotational speed (RPM)	3557	3329	3329	3557	3329
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor
Average positioning time (msec)	61.6 (including settling)	61.6 (including settling)	28 (including settling)	61.6 (including settling)	19.3 (including settling)
Average rotational delay (msec)	8.4	9.0	9.0	8.4	9.0
Average access time (msec)	60	70.6	37	60	28.3
Data transfer rate (KBytes/sec)	937.5	200	640	200	640
FIRST CUSTOMER SHIPMENT	4/86	7/88	9/89	6/88	6/89
U.S. OEM PRICE FOR 100 UNITS	\$249 (2500)	\$299 (2500)	\$235 (2500)	\$230 (2500)	\$290 (2500)
COMMENTS	*2,7 RLL Code	*2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL
DRIVE	WD93044-X	WD93048-A	WD93048-X	WDAC140	WDAC140L
DISK/TREND GROUP	4	4	4	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 XT	PC AT	IBM PC	PC AT	PC AT
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 43.24	F: 43.24	F: 43.24	F: 42.8	F: 42.8
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,824	F: 13,824	F: 13,824	F: 19,712	F: 19,712
Data surfaces per spindle	4	4	4	2	2
Heads per data surface	1	1	1	1	1
Tracks per surface	782	782	782	1079	1079
Track density (TPI)	1021	1013	1013	1379	1379
Maximum linear density (BPI)	22175 BPI*	21278 BPI*	21278 BPI*	32182 BPI*	32182 BPI*
Rotational speed (RPM)	14783 FCI 3329	14185 FCI 3557	14185 FCI 3557	21455 FCI 3647	21455 FCI 3647
PERFORMANCE					
Actuator type	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rack & Pinion, Stepping Motor	Rotary, Voice Coil	Rotary, Voice Coil
Average positioning time (msec)	28 (including settling)	61.6 (including settling)	61.6	19	23
Average rotational delay (msec)	9.0	8.4	8.4	8.2	8.2
Average access time (msec)	37	70	70	27.2	31.2
Data transfer rate (KBytes/sec)	640	200	200	680	680
FIRST CUSTOMER SHIPMENT	9/89	10/88	6/88	4/90	7/90
U.S. OEM PRICE FOR 100 UNITS	\$245 (2500)	\$245 (2500)	\$240 (2500)	\$310 (2500)	\$390 (2500)
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	25.4 mm high *2,7 RLL Code

MANUFACTURER	WESTERN DIGITAL	WESTERN DIGITAL	WESTERN DIGITAL	Y-E DATA	Y-E DATA
DRIVE					
	WDAC240	WDAC280	WDSC8320	YD-3042	YD-3082
DISK/TREND GROUP	4	4	7	4	5
MARKET	OEM, PCM	OEM, PCM	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	MIG	Ferrite	Ferrite
Interface	PC AT	PC AT	SCSI-2	SCSI	SCSI
CAPACITY/RECORDING DENSITY					
Total capacity (Mbytes) FIXED	F: 42.8	F: 85.1	U: 371 F: 320.1	F: 43.52	F: 87.04
REMOVABLE	--	--	--	--	--
Capacity per track (Bytes)	F: 13,312	F: 19,712	F: 24,576	F: 14,336	F: 14,336
Data surfaces per spindle	4	4	14	4	8
Heads per data surface	1	1	1	1	1
Tracks per surface	820	1079	949	788	788
Track density (TPI)	1051	1379	1201.5	1104	1104
Maximum linear density (BPI)	20616 BPI* 13744 FCI	32182 BPI* 21455 FCI	37341 BPI* 28006 FCI	22391 BPI* 14927 FCI	22391 BPI* 14927 FCI
Rotational speed (RPM)	3557	3647	4317.8	3600	3600
PERFORMANCE					
Actuator type	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, Voice Coil	Rotary, DC Motor	Rotary, DC Motor
Average positioning time (msec)	25	19	12.5	28	28
Average rotational delay (msec)	8.4	8.2	6.95	8.3	8.3
Average access time (msec)	33.4	27.2	19.45	36.3	36.3
Data transfer rate (KBytes/sec)	680	680	4000 max.	1062	1062
FIRST CUSTOMER SHIPMENT	1/90	4/90	8/89	2Q88	2Q88
U.S. OEM PRICE FOR 100 UNITS	\$300 (2500)	\$385 (2500)	--	--	--
COMMENTS	41.3 mm high *2,7 RLL Code	41.3 mm high *2,7 RLL Code	41.3 mm high *1,7 RLL Code Manufactured by IBM	41.3 mm high *2,7 RLL Code Embedded Servo	41.3 mm high *2,7 RLL Code Embedded Servo





## 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 "1988 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. "1988 total net sales" covers the fiscal year ending December 31, 1988, 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 1988 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>
France	Franc	5.96
Italy	Lira	1302.0
Japan	Yen	128.0
South Korea	Won	735.0
Taiwan	Dollar	26.6
United Kingdom	Pound	0.549
West Germany	Deutsch mark	1.76

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.  
2890 North First Street  
San Jose, CA 95134

Areal Technology was founded in February, 1988 by Jack Swartz, an industry veteran and co-founder of Maxtor. The company is developing 3.5" and 2.5" disk drives employing very high areal densities. The initial target is 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 has also been announced. The drives will be among the first to use glass substrates and are also unusual in their extensive use of glass-filled plastics for HDA components.

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 last year's 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 is still active, however, but in a development mode, working on new products.

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.

CENTURY DATA, INC.  
1270 North Kraemer Boulevard  
Anaheim, CA 92806

1988 disk sales: \$43,900,000

After several years of flat sales, Century Data Systems was sold in mid-1986 by Xerox to Cybernex Corporation. Cybernex had been restructured after an agreement with IBM, which included divestiture of all head manufacturing operations, and after several acquisitions has 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 has been in transition for years, as newer fixed disk drives gradually replace products in production before the acquisition by Xerox in 1979. Century is pinning its future 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.



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, but is continuing operations, as it attempts to increase Asian manufacturing.

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

1988 disk sales: \$253,800,000	
1988 Total net sales: \$256,639,000	Net income: \$19,768,000

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, co-founder 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, with first shipments in August, 1986, of a 3.5" 40 megabyte drive. 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 has established high volume production in Singapore, and in 1989 moved into a new headquarters building. Conner has 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 has responsibility for OEM sales in Europe. As of 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. Sales to Compaq have declined to about 33% of the Conner total in recent quarters, reflecting success in attracting new OEM business.

CONTROL DATA CORPORATION (See Imprimis Technology)

DATA GENERAL CORPORATION  
4400 Computer Drive  
Westboro, MA 01581

1988 disk sales: \$106,800,000  
1988 total net sales: \$1,364,734,000      Net income: (\$15,537,000)  
(FY ending 9/30/88)

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 has 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 is located in a new facility at Durham, New Hampshire. Data General has had difficulty in keeping up with its competition in recent years, and is expected to decrease the resources devoted to disk drive manufacturing in favor of using OEM drives in its systems.

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

Pertec, a pioneer manufacturer of OEM 14" disk cartridge drives, was acquired by Triumph-Adler in early 1980. After struggling to bring its disk drive line up to date, the initial 8" Winchester drives announced a few years ago were dropped in favor of a new series of 8" high capacity drives which now extends 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 now under the DDC Pertec name.

DIGITAL EQUIPMENT CORPORATION  
146 Main Street  
Maynard, MA 01754

1988 disk sales: \$906,800,000  
1988 total net sales: \$11,475,400,000      Net income: \$1,305,633,000  
(FY ending 6/30/88)

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 -- 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 and RA 71 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

1988 disk sales:	\$420,600,000	
1988 total net sales:	\$9,831,000,000	Net income: \$816,000,000
	(FY ending 10/31/88)	

Hewlett-Packard has an extensive manufacturing operation for captive disk drives at Boise, Idaho, established in 1977, supplemented in mid-1983 with a new \$50 million 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

1988 disk sales: \$49,500,000

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 has 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.

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

1988 disk sales: \$1,108,800,000  
1988 total net sales: \$3,628,300,000                      Net income: \$1,700,000

In early 1988, Control Data indicated that it was preparing to establish its Data Storage Products Group as a separate subsidiary, and in September of 1988, the new subsidiary was launched as Imprimis Technology. Imprimis is now the second largest producer of OEM rigid disk drives. In mid-1989, both firms announced a \$450 million deal in which Seagate Technology would acquire Imprimis. The purchase was completed in early October, 1989, creating a company which produced nearly a third of 1988's non-captive disk drive worldwide revenues.

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 the last several years, Control Data has 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, not by Imprimis.

INTERNATIONAL BUSINESS MACHINES CORPORATION  
Route 22  
Armonk, NY 10504

1988 disk sales: \$8,973,900,000  
1988 total net sales: \$59,681,000,000                      Net income: \$5,806,000,000

IBM manufactures 14", 8", 5.25" and 3.5" fixed disk drives at several factories in the United States, Europe, Japan and Brazil. The revenue leader in all of this activity is clearly the 3380 family. Positioned below the 3380, IBM in 1986 introduced the 9335, a 14" drive with 855 megabytes, and the 9332, a family of 8" models, now with 200, 400, or 600 megabytes. The "Lee," a 315 megabyte 5.25" drive was first shipped in early 1988 for use with high-end personal computers, and later with office systems and technical workstations. In 1989, the company made first shipments of the "Lightning," a 320 megabyte 3.5" drive initially sold only through resellers but expected to find wide usage in the same applications as the Lee.

After spending the first half of the 1980's in the doldrums, IBM's disk drive product development activity is now producing results, with much more to come. The industry is waiting for the "Soquel," the subject of the embarrassing July announcement which was called off at the last minute, and which will most likely be available for shipment early in 1990. The Soquel is a drive in the 10" range intended for high throughput mainframe applications. The "Sutter," expected in mid-1990, 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, 1990 will probably also see a double capacity 3.5" Lightning, and more high capacity 5.25" drives for office systems and file servers. In the low-end, IBM is expected to soon introduce new 3.5"

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20 and 30 megabyte single platter drives only 1" high, to lower costs for existing PS/2 requirements and to provide appropriate drives for future laptop portable computers.

IBM's first significant OEM sales of disk drives were made in 1984, and involved 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 3.5" diameter drives in the personal computer aftermarket through CMS Enhancements. In 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 has begun to use industry standard interfaces for products that have some OEM potential, but while making IBM products more saleable, they improve the ability of other vendors to sell drives for attachment to IBM systems. 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.

JOSEPHINE COUNTY TECHNOLOGY, INC.  
1899 N.W. Hawthorne  
Grants Pass, OR 97526

Josephine County Technology was started by disk drive industry veterans trying to escape the smog of San Fernando Valley. The firm started production at the close of 1984 with half high 5.25" Winchester drives, designed to be produced at extremely low cost. The company's activities remained on a small scale, limited by a lack of financing, and JCT was purchased by Maxcard in early 1989. Disk drive sales ceased in 1988. Maxcard is involved with development of a 'smart card' product.

KALOK CORPORATION  
1287 Anvilwood Avenue  
Sunnyvale, CA 94089

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 will begin in late 1989, but Kalok will also continue its manufacturing arrangements with OPC.

MAGNUM TECHNOLOGY CORPORATION  
 Subsidiary of Danbus Memory Systems, Inc.  
 5630B Kearney Mesa Road  
 San Diego, CA 92111

Magnum has been in existence since 1983, functioning primarily as a development company working to perfect a manufacturing process for thin film disks suitable for very high areal densities. In 1986, the firm bought a small disk production plant from National Micronetics, since supplemented with sputtering equipment purchased from Lanx when that firm failed and a disk substrate facility purchased from Seagate Technology. Extensive corporate merger activity ensued in 1988, when Magnum was merged into Danbus, a Canadian company which is publicly traded on the Vancouver stock exchange. Among other things, Magnum, Danbus and related companies now have a minority interest in Cardiff Peripherals, and various agreements covering future disk drive operations in China.

MAXTOR CORPORATION  
 150 River Oaks Parkway  
 San Jose, CA 95134

1988 disk sales: \$304,900,000  
 1988 total net sales: \$351,000,000      Net income: \$14,100,000  
 (FY ending 3/27/89)

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, and a 170 megabyte 3.5" drive, subsequently dropped. In 1987, the firm received wide attention in the industry for shipment delays in newer models of its 380 and 760 megabyte drives, blamed on a shortfall in promised deliveries of thin film heads. Maxtor added additional thin film head suppliers, and was able to resume normal shipments in early 1988. The delay, plus the large number of competitors in the 380 megabyte market, prevented Maxtor from obtaining the share of market it had anticipated. Another 3.5" drive, this time 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 drives with up to 1.4 gigabyte capacity.

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

1988 disk sales: \$94,400,000

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 at that time. 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 London, includes PCM marketing operations, the Memorex Communications Division, and the flexible media operations.

MFM TECHNOLOGY, INC.  
151 Essex Street  
Haverhill, MA 01813

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

1988 disk sales: \$349,300,000

1988 total net sales: \$353,057,000

Net income: \$(19,407,000)

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

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Micropolis' financial results during the last year. The firm has 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  
305 North Mathilda Avenue  
Sunnyvale, CA 94086

1988 disk sales: \$77,300,000

Microscience International started shipments in mid-1983 for its half high 5.25" drive using plated disks, and with several 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. The firm has joined with the Wearnes organization to establish a manufacturing facility in Singapore, now in production of stepping motor drives, and has started its own production in Taiwan for voice coil drives. Microscience appears to have weathered a management change in 1987, and is now in a growth period.

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 announced an agreement to acquire the disk drive product line of Vermont Research.

MINISCRIBE CORPORATION  
1871 Lefthand Circle  
Longmont, CO 80501

1988 disk sales: \$570,300,000

1988 total net sales: \$ N/A

Net income: \$ N/A

Production of Miniscribe's 5.25" Winchester drives started in late 1981, stayed at modest levels through most of 1982, then soared in late 1982 as IBM started taking 5.25" deliveries for the personal computer program. Other major OEM customers were subsequently added, but 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 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 is being forced to restate its financial results for several past years, while a new management attempts to restart the previous momentum. The company has indicated that all future product development will be concentrated on 1" high 3.5" drives.

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

1988 disk sales: \$68,200,000  
 1988 total net sales: \$5,407,500,000                      Net income: \$183,200,000

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 are supported with an active OEM sales program, which has been achieving some success. 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.

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

1988 disk sales: \$66,100,000

The Plus Hardcard is an innovative plug-in card for the IBM personal computer aftermarket, combining a 3.5" Winchester and all controller electronics on a single add-in card. The original version, first shipped in October, 1985, was 10 megabytes, supplemented in 1986 with a 20 megabyte model and in 1987 by a 40 megabyte model. Quantum set up Plus as a separately operated subsidiary, in order to provide concentration on the special design requirements involved, and to establish a specialized marketing and sales organization targeted at the PC market. Manufacturing has been contracted out to Matsushita-Kotobuki Electronics.

The Hardcard has 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.

PRAIRIETEK CORPORATION  
1830 Lefthand Circle  
Longmont, CO 80501

Another new start-up, PrairieTek announced the first of a new breed, the 2.5" rigid disk drive, in late 1988. The capacity of the initial drive is 20 megabytes, with an average 28 millisecond seek time. PrairieTek has 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. The firm was established in 1986 by Terry Johnson, founder of Miniscribe.

PRIAM CORPORATION  
20 West Montague Expressway  
San Jose, CA 95134

1988 disk sales:	\$116,600,000	
1988 total net sales:	\$141,979,000	Net income: \$543,000
	(FY ending 6/30/88)	

Priam became a significant supplier of OEM Winchester disk drives in 1981, as volume production was achieved for the firm's original line of mid-range 14" drives and shipments of 8" drives got underway. 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 has seen several management changes. The 5.25" product line now extends to 760 megabytes.

In 1987, Priam began manufacturing drives in Taiwan, the largest U.S. disk drive manufacturer yet to do so. Because a lack of resources has prevented the firm from developing its own 3.5" drives, Priam established a joint development program with Matsushita Communication Industrial which has not yet resulted in a product introduction. Priam also took an equity position in Comport and obtained an option to acquire Comport, but the relationship has been terminated.

QUANTUM CORPORATION  
1804 McCarthy Boulevard  
Milpitas, CA 95035

1988 disk sales: \$104,800,000  
1988 total net sales: \$208,017,000                      Net income: 12,887,000  
(FY ending 3/31/89)

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, for delivery before the end of 1985. 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. Quantum's OEM products now include 3.5" drives from 42 to 210 megabytes (formatted) capacity. Production of 5.25" drives ended in 1989. While Quantum has designed the drives, manufacturing is done in Japan by Matsushita-Kotobuki Electronics, except for drives with capacity of 120 megabytes and up. MKE has rights to distribute the drives it manufactures within Japan.

SEAGATE TECHNOLOGY  
920 Disc Drive  
Scotts Valley, CA 95066

1988 disk sales: \$1,346,600,000  
1988 total net sales: \$1,265,966,000                      Net income: \$77,317,000  
(FY ending 6/30/88)

The term "Seagate compatible" has become part of the industry's language. 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.

Seagate is attempting to diversify into 3.5" and higher capacity 5.25" drives, but during the last four years a major part of the firm's growth has come from the personal computer aftermarket. After IBM cut back purchases of Seagate drives in favor of internal captive production, Seagate launched a successful campaign to take the business away from IBM at the dealer level, with phenomenal success. But the company remains vulnerable

to the changes IBM has 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, has begun to cut into Seagate's shipment rate. The firm overestimated the market in early 1988, causing excess inventory accumulation and disappointing financial results. However, Seagate has already 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 mid-1989, Seagate announced an agreement with Control Data to acquire Imprimis Technology in a deal valued at \$450 million, and the purchase was completed in early October. The exact form of the resulting organization is not yet known, but it sold nearly a third of the non-captive worldwide disk drive shipments in 1988. There is little overlap between the product lines of Seagate and Imprimis, or between the two sets of distribution channels. Seagate's challenge will be to manage its transition to a multi-billion dollar company smoothly, while maintaining the aggressive product development pace required for survival in the disk drive industry.

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

1988 disk sales: \$161,600,000

1988 total net sales: \$873,952,000

Net income: \$44,235,000

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 if this program is executed well, it will go a long way to restoring STC's position in the storage products industry. 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.

SYQUEST TECHNOLOGY  
47923 Warm Springs Boulevard  
Fremont, CA 94538

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 has 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 Apple add-on market. In 1989, Syquest began operations in Singapore.

UNISYS CORPORATION  
Burroughs Place  
Detroit, MI 48232

1988 disk sales: \$218,300,000  
1988 total net sales: \$9,902,000,000                      Net income: \$680,600,000

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. Internally manufactured drives sold with Unisys systems on a captive basis currently consist of 3380 equivalent models equipped with controllers for use with Unisys systems, plus some remaining production of 3350-class drives previously produced by MPI for Sperry. In late 1986, the firm trimmed several U.S. manufacturing operations, and in 1987 announced a plant in Singapore to make large disk drives. Further trimming of operations in 1989 include closing the old Memorex plant in Santa Clara.

WESTERN DIGITAL CORPORATION  
2445 McCabe Way  
Irvine, CA 92714

1988 disk sales: \$131,400,000  
1988 total net sales: \$768,300,000                      Net income: \$43,400,000  
(FY ending 6/30/88)

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 consists of 3.5" drives in the 20 to 40 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 announced that it would remarket the IBM 320 megabyte (formatted) 3.5" drive.

XEBEC  
 3579 Highway 50 East  
 Carson City, NV 89701

1988 total net sales:	\$27,261,000	Net income:	(\$9,368,000)
	(FY ending 9/30/88)		

Xebec's management looked for an entry point into the disk drive manufacturing business for years, as an extension of the firm's success in producing high-volume controllers. In 1984, several programs were launched, including purchase of the Datapoint Sunnyvale operations, the Epelo start-up for high performance 5.25" disk drives, and the Owl, an internally manufactured half high 5.25" drive with an embedded SASI interface. However, Xebec ran short on the cash required to fund all of its expansion programs, and only the Owl series, ranging from 20 to 40 megabytes, remains in production. Reeling from loss of its controller contracts with IBM and unsettled by several lawsuits, the firm faces a substantial rebuilding job. All disk drive sales activities are now concentrated on the personal computer aftermarket, and the small remaining disk drive production is now being done in Asia on a contract manufacturing basis.

Asian Manufacturers

(All fiscal years end in March, 1988, unless otherwise noted. Firms are in Japan unless otherwise noted.)

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

1988 total net sales: \$2,894,328,000

Net income: \$64,664,000

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. In 1988, about 21% of Alps' shipments were computer peripherals, but these were 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 and a 50 megabyte version in 1988. A variant of these products is a removable disk drive that fits a half high 5.25" enclosure.

EPSON (See Seiko Epson)

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

1988 disk sales: \$36,900,000

1988 total net sales: \$4,353,469,000

Net income: \$52,359,000

Fuji Electric was established in 1923 and is the firm from which Fujitsu was born in 1935. Fuji Electric still owns about 16% of Fujitsu. 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. Fuji Electric has provided contract manufacturing services to Fujitsu and Nippon Peripherals for 5.25" and 3.5" 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.



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

1988 disk sales: \$1,689,400,000  
1988 total net sales: \$15,990,641,000                      Net income: \$329,023,000

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. Particularly effective in the OEM market has been the series of high performance 8" 48/84/168/337/690/824/1000/2000 megabyte drives, and the 10.5" "Eagle" series of high performance drives with up to 3.0 MB/second transfer rate. Fujitsu is also a major factor in the IBM plug compatible disk drive market with sales of Eagle series drives through Amdahl. Fujitsu is manufacturing some of its high performance drives at a major facility near Portland, Oregon, which is now in full operation.

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

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 (67%), computers and peripherals (10%), and other electronic equipment (23%). Already in volume floppy drive production, Goldstar began manufacturing 3.5" and half high 5.25" drives in 1988.

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

1988 disk sales: \$884,800,000  
1988 total net sales: \$38,868,016,000                      Net income: \$1,068,797,000

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 National Advanced Systems, now a subsidiary of Hitachi Data Systems, and in 1983 started selling 3380 equivalent drives for distribution in the European PCM market through BASF, and currently through Comporex, 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. In 1989, Hitachi introduced a 251 megabyte 3.5" drive.

**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 Brand in the U.S. and by Hyosung in the Far East. Sales by Brand were discontinued in 1988 after market prices took a sharp drop.

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

1988 disk sales:	\$39,900,000	
1988 total net sales:	\$5,605,227,000	Net income \$70,461,000

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 VTRs now account for almost 62% of total revenues. Matsushita Electric Industrial holds 50.6% ownership. JVC is now expanding into 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 new 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

1988 disk sales: \$72,000,000  
1988 total net sales: \$2,346,945,000                      Net income: \$177,164,000

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, but the corporate shell remains, under Prudential Bache control, to prosecute the Kyocera suit. Kyocera, undeterred by the legal maneuvering, has been producing the drives under its own name.

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 preparing to put them into production. The product line includes 115, 140, and 170 megabyte half high drives.

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

1988 total net sales: \$2,633,336,000                      Net income: \$64,633,000

Matsushita Communication Industrial is a member of the Matsushita Electric Industrial group, a worldwide giant in appliances and electronics. MEI holds 57.5% 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 extends to 81 megabytes, and MCI has a joint development agreement with Priam to cooperatively design 3.5" high-end drives.

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

1988 total net sales: \$1,635,266,000                      Net income: \$65,953,000

Matsushita-Kotobuki Electronics has concentrated primarily on production of VCRs on an OEM basis for a number of U.S. consumer electronics manufacturers and distributors, as well as for sale under the Matsushita "Panasonic" brand name. Matsushita Electric Industrial owns 57.3% of MKE. In 1985 Plus Development established a contract manufacturing arrangement with MKE for the "hardcard," which evolved during the last two years 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.

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

1988 disk sales: \$63,200,000  
1988 total net sales: \$18,502,180,000                      Net income: \$173,539,000

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" low-end drives, 5.25" low-end and mid-range drives, and 8" and 9" drives to 630 megabytes are in production as of mid-1989.

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

1988 total net sales: \$1,026,578,000                      Net income: \$289,000

Mitsumi is primarily a component manufacturer, but also manufactures floppy drives (about 10% of 1988 sales) and is beginning to manufacture 3.5" 25 megabyte drives as well. Mitsumi has had a rigid drive development program in place for some time, but so far has been late in having products ready to catch the start of the newest product cycles.

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

1988 disk sales: \$1,235,600,000  
1988 total net sales: \$21,208,875,000                      Net income: \$198,148,000

NEC has defined its product area as communications and computers, with computer products currently accounting for about 46% 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 have 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 765 megabytes.

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

1987 total net sales: \$145,886,000                      Net income: \$2,148,000

OPC, founded in 1953, is one of Korea's pioneering firms in the electronics industry. It is a major supplier of telecommunications equipment, video systems, and a volume producer of CRT terminals. About 22.1% of the firm's 1986 shipments was computer equipment. 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.

PERIPHERAL TECHNOLOGY INTERNATIONAL, LTD.  
22-1 Maekok-ri Hobup-myun Icheon-kun  
Kyungki-do, South 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.

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

1988 total net sales: \$5,267,328,000                      Net income: \$132,938,000

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. Its first products 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

1987 total net sales: \$3,239,880,000                      Net income: \$46,984,000

Samsung Electronics, founded in 1969, is Korea's largest electronics company, producing a variety of consumer, industrial and computer products. Samsung made a minority investment in Comport, a 1977 U.S. start-up, and manufactures Comport's 3.5" line of disk drives. Distribution rights in Korea have been retained by Samsung.

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

1988 disk sales: \$24,600,000

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. 1989 production of rigid drives is on an exclusive basis for other manufacturers.

SHINWA DIGITAL INDUSTRY CO., LTD.  
1036 Kawarabuki  
Ageo City, Saitama

Shinwa Digital is a manufacturer of electronic components and equipment, including cash registers, calculators, medical systems, printers and keyboards. The company started shipping half high 5.25" drives in 1986, and added 3.5" drives in 1987. The firm does some contract manufacturing for other Japanese companies. Konica is a major investor in the company. Production of rigid drives under the firm's own name ceased in 1988.

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

1988 total net sales: \$11,381,828,000                      Net income: \$286,984,000

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 has 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 the media standard, but not Sony's drives, 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 has been making similar drives for Xebec under a contract manufacturing agreement. Relatively few have been produced to date, 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

1988 total net sales: \$356,195,000                      Net income: \$4,477,000  
(FY ending 9/30/88)

TEAC has taken steps in recent years to expand 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 66% 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.

TOKICO, LTD.  
1-6-3, Fujimi  
Kawasakiku, Kawasaki 210

1988 total net sales: \$745,961,000                      Net income: \$13,578,000

Tokico, a member of the Hitachi group, 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 extended to 96 megabytes capacity and the 3.5" line to 94 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

1988 disk sales: \$254,000,000  
1988 total net sales: \$27,909,648,000                      Net income: \$474,305,000

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

## 1989 DISK/TREND REPORT



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. 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.

TOSOH CORPORATION  
1-7-7 Akasaka  
Minato-ku, Tokyo 107

1988 total net sales: \$1,789,734,000                      Net income: \$32,531,000

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

1988 total net sales: \$184,398,000                      Net income: (\$242,000)

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. Floppy drives remain the largest part of Y-E Data's business.

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 new 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.

ISOT  
 51, Chapaev St.  
 Sofia, Bulgaria

1988 disk sales: \$72,000,000

Disk drives manufactured by ISOT, the Bulgarian state computer organization, are exported throughout Eastern Bloc countries by Isotimpex, the foreign trade organization for Bulgarian computer equipment and other electronic products. Isotimpex is currently marketing drives compatible with IBM 2314 and 3330 disk pack drives, plus 14" disk cartridge drives and 14" 80 megabyte disk pack drives. ISOT, which operates disk drive 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

1988 disk sales: \$47,700,000

1988 total net sales: \$6,100,000,000

Net income: \$254,000,000

Olivetti's current management has undertaken numerous changes to modernize the company's product lines and delete older lines. The Olivetti Peripheral Equipment organization represented a consolidation of the firm's printer and disk memory activities in 1980. This organization established production for 5.25" and 3.5" Winchester disk drives at Ivrea, for both captive and OEM applications. The biggest impact on Olivetti during the past few years was purchase of a 25% share in the company by American Telephone and Telegraph, and adoption of an Olivetti-designed personal computer for distribution by AT&T. Production of small disk drives in support of this program grew substantially at Ivrea. All portions of the Rotating Memories Division of OPE were combined to form a new subsidiary, Lexikon, in February, 1987. 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, in 1988, and all production of the Lexikon disk drive models was discontinued. Conner Peripherals Europe is expected to move into a new plant by the end of 1989.

NEWBURY DATA RECORDING, LTD.  
 Subsidiary of Data Recording Instruments Co., Ltd.  
 Hawthorne Road, Staines  
 Middlesex TW18 3BJ  
 England

1988 disk sales: \$18,700,000

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.



rothes and Boca Raton to Singapore to improve production efficiency. Rodime has obtained some refinancing, and its new management has a chance to correct problems and 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

1988 total net sales: \$23,064,444,000                      Net income: \$443,889,000  
 (FY ending 9/30/88)

After many years of producing rigid disk drives of its own design in Munich for captive use with Siemens mainframe systems, several disk pack drives and a large fixed disk drive were phased out in favor of outside purchases of high performance drives, including IBM's 3380. In the meantime, 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. Siemens is selling the drives in the U.S. and European OEM disk drive market and the plug compatible aftermarkets. 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.

DISK/TREND ON DISK



## DISK/TREND ON DISK

### 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 by Lotus 1-2-3 on IBM or IBM-compatible computers running under the MS-DOS or PC-DOS operating system. All files contain data only -- manipulation of the data is the user's responsibility. Because some of the files can be very large, system memory of 640K or more is recommended. While the files supplied can be used with Lotus 1-2-3 versions 1A and up, we recommend the use of versions 2.0 and up in order to be able to take advantage of Lotus advanced features to manipulate data.

Two or three disks are used for each DISK/TREND disk drive report. The first disk contains the statistical tables. File names are keyed to the table numbers in the report for easy identification. The second and third disks contain the specification section in a data base format. Two disks are provided for specifications when the specification data base is too large to fit on a single 360 KB floppy disk. Both types of data are directly loadable by Lotus 1-2-3. 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, and MS-DOS, and do not cover their operation in this manual. This manual deals specifically with how to load and use the files supplied on the floppy disks.

Note: Please read the license information on the following page.



DISK/TREND ON DISK  
Information License

DISK/TREND supplies diskettes containing selected information from the 1989 DISK/TREND Report as a separately purchased option to subscribers to the corresponding 1989 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.

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.

## 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.

STATISTICAL TABLESLoading

1. Place the floppy disk marked 'Tables' in a floppy disk drive able to read 5.25" 360 KB 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. There may be special instructions 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

3. Now you are ready to start Lotus 1-2-3. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus 1-2-3 system disk in drive A. If you are using a rigid disk system, place the Lotus 1-2-3 system disk in floppy drive A. Now start Lotus 1-2-3 as usual. After obtaining the blank spreadsheet image on the screen, use the Lotus File Import Text command to select a file. The command is:

/FIT<filename>

The file names are in the format XYY.ZZX, 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 RT10.89R is 1989 Rigid Disk Drive Report Table 10  
 File FT2.87F is 1987 Flexible Disk Drive Report Table 2  
 File OT1.88O is 1988 Optical Disk Drive Report Table 1

The file selected will be loaded as a worksheet in text block format. You can use Lotus 1-2-3 commands to edit the worksheet and embed it in some other document or, using the Lotus 1-2-3 Data Parse commands, you can convert the numeric content to individual cells which can be manipulated or graphed using Lotus 1-2-3 commands. See the Lotus 1-2-3 reference manual for details on numerical manipulations and graphics.

### Data Parsing made easy

Most Lotus 1-2-3 users are not familiar with the 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.

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:

- o FORMLINA.PRN      Used with Table 1 and the Revenue and Unit Shipment tables found in the product group sections of the reports.
- o FORMLINB.PRN      Used with Table 2.
- o FORMLINC.PRN      Used with Tables 3 through 8.
- o FORMLIND.PRN      Used with Application tables.

There are no FORMLIN format files for disk diameter tables or market share tables (if any), as these are variable in format. You will have to construct the format line directly, but after you have seen how it is done in the other tables, this should not be too big a job.

A step by step process for parsing and an example are shown on the following pages.



Optional: The sample format line can now be deleted if you wish. It is not needed for further operations. You will have to quit the Data Parse mode, delete the line, and re-enter Data Parse mode, so you may wish to wait until done with parsing operations.

8. Create the input range. Select the Input-Column command and then move the cursor to column 'A' of the format line. Anchor the cursor with a period and then set the range to include all columns from 'A' to the right side of the table and all rows from the format line to the bottom of the table by using the arrow keys.

Be careful not to include footnotes or other similar material in the input range, because the parsing process will cause unusual spacing to appear in text sentences or paragraphs.

9. Create the output range. This is where the parsed data will appear. It is convenient to locate it a few rows below the input range and directly in line with the input range. Select the Output-Range command and locate the cursor in the 'A' column a few rows below the input range, then hit 'Return'. Now expand the 'A' column to 27 spaces in width to accommodate the left margin labels. (You will have to leave the parse mode to do this.)
10. Return to the Data Parse mode. Select the GO command. The parsed data will appear in the output range. You will have to use the /RF (range format) command on the output data to obtain a consistent format because figures terminating in .0 will drop the decimal places unless the format is prescribed with a decimal place. You may also have to reformat some lines containing percentages in some tables.
11. You now have a table in which all of the elements may be manipulated, but there are no formulas. You must create your own formulas.

Optional: You can delete the input range now if you wish. This will bring the newly parsed data up to the headers at the top of the page for easier reading.

While the procedure described above seems complex, it is not difficult or time consuming in practice. After you have done it once or twice, it will take only two or three minutes per table to do data parsing.

SPECIFICATION TABLES

The 1989 rigid disk drive specifications are supplied on two diskettes. Diskette 1 contains the specifications for DISK/TREND groups one through five. The second diskette contains groups six through nine. If your computer has enough available 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 comments below.

Loading

1. Place the floppy disk marked 'Specifications' in a floppy disk drive able to read 5.25", 360 KB 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 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. If you are using a two floppy system, place the DISK/TREND disk in drive B and the Lotus 1-2-3 system disk in drive A. If you are using a rigid disk system, place the Lotus 1-2-3 system disk in floppy drive A. Now start Lotus 1-2-3 as usual. After obtaining the blank spreadsheet image on the screen, use the Lotus File Retrieve command to select a file. The 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.

Examples: FS189 Flexible disk specification table  
RS189 Rigid disk spec table: Groups 1-5  
RS289 Rigid disk spec table: Groups 6-9

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.

### 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 a single row of the DISK/TREND report.

The database 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 specs.

### 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 RS188A from specification diskette 1 into a new worksheet. Move the cursor to column A and the row immediately below the last manufacturer's name.
2. Load the worksheet RS188B from specification diskette 2 using the Lotus 1-2-3 command /FCC.
3. Edit the worksheet to remove the header and criterion 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 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 comments column.
6. Quit the DQ menu. You are ready to use the new worksheet. It would be a good idea to save it in a new file name first so that you can easily reload it if you inadvertently make an unrecoverable alteration.

### Saving time

The rigid disk specification data bases are large and take 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 Lotus 1-2-3 file extract and file combine commands for this purpose.

Another way to save time is to use the SORT capabilities of Lotus 1-2-3 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, etc.

Make sure that when you save a worksheet using the /FS 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.

